

Women in Renewable Energy and STEM Education: Perspectives from Mutare Rural, Zimbabwe

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ABSTRACT

This study investigates the opportunities and challenges for enhancing female participation in the renewable energy sector through STEM education, focusing on Mutare Rural communities in Zimbabwe. Despite the critical role of renewable energy in sustainable development, women remain significantly underrepresented in STEM fields and technical energy careers across Sub-Saharan Africa. Employing a mixed-methods approach, the research combines quantitative surveys of female STEM students, educators, and renewable energy professionals with qualitative interviews and focus groups to capture in-depth insights into barriers and enablers affecting women's career pathways in rural contexts. Findings reveal that while female enrollment in STEM programs across surveyed institutions remains low at approximately 28 percent, participation in renewable energy specific courses is slightly higher at 35 percent, indicating growing interest. However, entrenched socio-cultural norms, limited access to educational resources, particularly in rural areas, and a scarcity of visible female role models persist as significant impediments. Conversely, targeted interventions including scholarship programmes such as the Joshua Nkomo Scholarship, mentorship initiatives, and emerging women led renewable energy cooperatives demonstrate promise in mitigating these barriers. The integration of renewable energy concepts into STEM curricula further aligns educational outcomes with Sustainable Development Goals 5, Gender Equality, and 7, Affordable and Clean Energy. Based on these insights, the study recommends expanding scholarship initiatives, enhancing mentorship networks, strengthening gender inclusive educational policies, and investing in rural educational infrastructure to foster an inclusive and innovative renewable energy workforce capable of advancing sustainable development across Zimbabwe's rural communities.

Keywords: Women in STEM; Renewable Energy; Gender Equity; Rural Development; STEM Education; Sustainable Development Goals

INTRODUCTION AND BACKGROUND TO THE STUDY

The relationship between gender and energy represents a complex nexus encompassing consumption patterns, policy frameworks, sociocultural dynamics, and the gender-specific impacts of energy poverty. Globally, the use of solid fuels such as wood and charcoal for cooking causes approximately 3.2 million premature deaths annually, disproportionately affecting women and children who bear primary responsibility for household energy management as noted by the International Energy Agency (2023). Women in energy-poor households spend countless hours collecting fuel, constraining their opportunities for education, economic participation, and personal development. Providing clean, affordable energy could substantially reduce these burdens while improving health outcomes, economic prospects, and overall quality of life according to the United Nations Development Programme (2022).

The United Nations Sustainable Development Goals, particularly SDG 5 on Gender Equality and SDG 7 on Affordable and Clean Energy, provide an internationally recognised framework for addressing these interconnected challenges as articulated by the United Nations (2015). However, progress toward these goals remains uneven, with many regions, especially Sub-Saharan Africa, continuing to struggle with providing universal access to modern energy solutions for women. Recent scholarship emphasises that clean energy transitions are not merely technological transformations but fundamentally concern people, equity, and justice as argued by Raman, Ustenko, Leal Filho, and Nedungadi (2025).

The Gender-Energy Nexus in Sub-Saharan Africa

Sub-Saharan Africa faces distinctive challenges at the intersection of gender inequality and energy poverty. Research by Adjei Mantey, Kwakwa, and Ankrah (2025) demonstrates that women's empowerment and corruption control significantly increase access to clean energy across 32 African countries, suggesting that gender equity and institutional quality are mutually reinforcing drivers of sustainable energy transitions. Their econometric analysis reveals that empowering women enhances the adoption of clean energy technologies, while weak governance structures undermine these gains.

The gender dimensions of energy access in African contexts extend beyond household consumption to encompass employment and leadership in the energy sector. Musango and Chicombo (2025) argue that addressing energy transition challenges requires meaningful integration of gender and social inclusion dimensions into energy frameworks. Their systematic review of 46 energy frameworks from 18 Sub-Saharan African countries spanning 2001 to 2023 reveals that most frameworks apply a narrow view of gender dimensions and lack clearly defined, measurable gendered indicators, undermining the ability to track progress toward gendered outcomes in energy access.

Furthermore, research by Ceschin, Musango, and Mwiti (2023) examining energy companies operating in informal urban settlements across Sub-Saharan Africa found that these enterprises are largely unfamiliar with and do not utilise readily available gender mainstreaming toolkits. This implementation gap highlights the disconnect between policy intentions and operational realities in the region's energy sector.

Women in STEM Education and Energy Justice in Zimbabwe

Zimbabwe has ratified international gender equity instruments and introduced STEM education policies to promote women's participation. Yet, implementation gaps remain, especially in rural areas where female students are underrepresented in advanced science subjects. Socio-cultural norms, traditional gender roles, and limited awareness of policies discourage girls from pursuing STEM, while inadequate infrastructure, shortages of qualified teachers, and absence of female role models further constrain progress. Studies highlight how identity formation, family expectations, and teacher attitudes reinforce perceptions of science as a masculine domain, creating systemic barriers to women's advancement in education and careers.

Theoretical frameworks deepen this understanding. **Social Cognitive Career Theory** emphasizes self-efficacy and outcome expectations, showing how mentorship and exposure to successful women can expand rural girls' aspirations in STEM and renewable energy. Conversely, entrenched patriarchal norms and economic marginalization diminish confidence and limit opportunities. **Energy Justice Theory** adds a structural lens, highlighting distributional, procedural, and recognition justice. In Mutare Rural, women disproportionately bear energy burdens yet remain excluded from decision-making, underscoring the need to center their voices in policy and programme design.

The literature across Sub-Saharan Africa confirms these challenges: patriarchal norms (Chikuvadze & Jacobs, 2021), identity struggles (Gudyanga, 2016), material deficits (Dekeza & Kufakunesu, 2017), and the glass ceiling in academia (Machibaya & Ndamba, 2023). Promising interventions scholarships, mentorship initiatives, and integration of renewable energy into curricula show potential to enhance participation. However, most energy frameworks remain narrow, lacking measurable gender indicators (Musango & Chicombo, 2025). This highlights the urgent need for **context-specific policies** that bridge the gap between policy commitments and lived realities, ensuring rural Zimbabwean women are recognized, included, and empowered in both STEM education and renewable energy development.

Renewable energy opportunities in Rural Zimbabwe

Zimbabwe possesses substantial renewable energy potential, particularly in solar, small-scale hydro, and biogas technologies. The country has established targets to increase renewable energy generation, creating potential employment opportunities in the green economy. However, as Musango and Ouma Mugabe (2024) note, energy technology assessment practices remain limited and not formalised in African contexts, constraining the

continent's ability to manage transitions to decarbonised, environmentally and socially acceptable energy systems.

Rural areas like Mutare district face distinctive energy challenges while simultaneously possessing significant renewable energy resources. Communities in Mutare Rural rely heavily on traditional biomass for household energy needs, with women and girls bearing primary responsibility for firewood collection, a time consuming task that exposes them to safety risks and limits educational and economic opportunities as documented by the Zimbabwe Energy Regulatory Authority (2020). This energy poverty perpetuates gender inequality, as women's time poverty constrains their participation in education, including STEM pathways that could lead to renewable energy careers.

Recent initiatives demonstrate emerging opportunities. The SOLTRAIN project, operating across Southern Africa including Zimbabwe, has established gender and diversity workstreams specifically targeting women's participation in renewable heating and cooling sectors according to Crown Publications (2025). Similarly, the United Nations Development Programme's Solar for Health programme has demonstrated the viability of renewable energy in rural healthcare facilities across Zimbabwe as reported by UNDP Zimbabwe (2024). These developments create nascent opportunities for local employment and technical training in the renewable energy sector, though their reach into rural communities like Mutare remains limited.

Research Gap and Justification

Although previous studies have examined gender disparities in STEM education and renewable energy independently, limited research has investigated how STEM education can serve as a pathway for increasing women's participation in renewable energy careers within rural Zimbabwe. Existing studies have largely focused on national trends or policy analysis while overlooking the lived experiences of rural female students and professionals. Furthermore, few studies have integrated Social Cognitive Career Theory with Energy Justice Theory to explain how individual aspirations interact with structural barriers. This study addresses these gaps by examining opportunities and challenges affecting female participation in renewable energy through STEM education in Mutare Rural, Zimbabwe, examining the intersections of STEM education, gender dynamics, and renewable energy participation through a contextually grounded, mixed-methods approach. By centring the perspectives of rural female students, educators, and renewable energy professionals, the research aims to generate actionable insights for policy, practice, and future scholarship.

Research questions

This study is guided by the following research questions:

1. What are the current patterns of female participation in STEM education and renewable energy programmes in Mutare Rural?
2. How do socio-cultural, economic, and institutional factors constrain rural female students' access to STEM education pathways leading to renewable energy careers?
3. In what ways can contextually appropriate strategies be developed to enhance rural women's participation in renewable energy through strengthened STEM education in Mutare Rural?

METHODOLOGY

Research philosophy and approach

This study adopts a pragmatist research philosophy, prioritising practical outcomes and recognising that quantitative and qualitative methods can be fruitfully combined to address complex research questions. A mixed-methods approach with a convergent parallel design is employed, wherein quantitative and qualitative data are collected simultaneously, analysed separately, and integrated during interpretation to provide comprehensive understanding of female participation in renewable energy through STEM education in Mutare Rural.

Research Design

A case study design is employed, with Mutare Rural serving as the bounded case for in-depth investigation. This design facilitates intensive examination of the phenomenon within its real-world context, capturing unique geographic, socio-cultural, and educational dynamics while generating findings that may offer lessons for similar rural contexts. Multiple units of analysis are embedded within the case, including female students, educators, renewable energy professionals, and policymakers.

Study Area

Mutare Rural District in Manicaland Province, Zimbabwe, is characterised by predominantly rural populations, livelihoods centred on smallholder agriculture, and significant infrastructure deficits. These characteristics make it strategically appropriate for investigating intersections of gender, STEM education, and renewable energy participation in contexts exemplifying conditions prevalent across rural Zimbabwe.

Target population and sampling

The target population comprises female STEM students at secondary and tertiary institutions serving Mutare Rural, female renewable energy professionals, STEM educators, and district-level policymakers. Purposive sampling ensures inclusion of information-rich participants, with maximum variation sampling capturing diverse perspectives across geographic locations, institution types, and levels of engagement with renewable energy. The quantitative sample targets 200 female STEM students through stratified sampling across educational levels. The qualitative sample comprises approximately 30 participants purposively selected to include students, professionals, educators, and policymakers, with sample size guided by data saturation principles.

Data collection methods

Structured questionnaires are administered to female STEM students to collect data on enrollment patterns, career aspirations, awareness of renewable energy opportunities, and perceived barriers and enablers. The questionnaire employs closed-ended items with Likert-scale responses and selected open-ended questions. The questionnaire consisted of five sections measuring demographic characteristics, STEM self-efficacy, outcome expectations, perceived socio-cultural barriers, and renewable energy career aspirations. Items measuring self-efficacy were adapted from Lent et al. (1994), whereas perceived barriers were adapted from previous STEM participation studies. Responses were measured on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Semi-structured interviews are conducted with female renewable energy professionals, STEM educators, and policymakers to obtain in-depth understanding of experiences and perspectives regarding barriers and enablers affecting women's participation. Interviews last forty-five to ninety minutes, are audio-recorded with consent, and are conducted in English with Shona code-switching permitted where this facilitates expression.

Focus group discussions are conducted with female STEM students to generate interactive data on collective perceptions and shared experiences. Three focus groups of six to eight participants each, stratified by educational level, are moderated using a topic guide covering key themes.

Document analysis supplements primary data through examination of policy documents, programme reports, curriculum materials, and institutional records, providing contextual background and enabling triangulation of self-reported data. Twenty-one documents were reviewed, including the Zimbabwe National Gender Policy, STEM Education Policy Framework, Renewable Energy Policy, Ministry reports, district education reports, institutional enrolment records, and scholarship programme documents. Documents were purposively selected based on relevance to female participation in STEM and renewable energy. Findings were triangulated with survey and interview data to corroborate emerging themes.

Pilot Study

A pilot study involving 20 female STEM students from a neighbouring district was conducted to assess clarity,

relevance and reliability of the questionnaire. Minor wording changes were made to improve comprehension and remove ambiguous items.

Data analysis

Quantitative data are analysed using SPSS version 27. Descriptive statistics summarise participant characteristics and patterns of participation. Inferential statistics, including chi-square tests, t-tests, and analysis of variance, examine relationships between variables, with statistical significance set at $p < 0.05$ and effect sizes calculated to assess practical significance.

Qualitative data are analysed using thematic analysis following Braun and Clarke's six-phase framework. Interview transcripts were imported into NVivo 14. Two researchers independently coded the first five transcripts using an initial coding framework informed by Social Cognitive Career Theory and Energy Justice Theory. Emerging inductive codes were subsequently incorporated to capture unexpected issues. Coding discrepancies were discussed until consensus was reached. Initial codes were grouped into sub-themes before being refined into overarching themes following Braun and Clarke's six-phase thematic analysis.

Table 1

Trustworthiness and rigour

Scale	Items	Cronbach Alpha
STEM Self-Efficacy	6	0.87
Outcome Expectations	5	0.83
Perceived Barriers	7	0.89
Career Aspirations	5	0.81

Quantitative rigour is established through content and construct validity via expert review and pilot testing, and reliability through calculation of Cronbach's alpha coefficients for multi-item scales, with values above 0.70 considered acceptable.

Qualitative trustworthiness is enhanced through triangulation of data sources and methods, member checking, peer debriefing, thick description of context, maintenance of a comprehensive audit trail, and reflexive journaling documenting researcher assumptions and potential biases.

Ethical considerations

Ethical approval is obtained from relevant institutional review boards and government ministries. Informed consent is secured from all participants, with parental consent and participant assent obtained for minors. Confidentiality is protected through use of pseudonyms, secure data storage, and limited access to data. Cultural sensitivity is maintained throughout, with procedures respecting local norms and participants treated with dignity. Participants are informed of their right to withdraw without penalty.

Limitations

The study's focus on Mutare Rural limits generalisability, though thick description enables assessment of transferability. Self-reported data may be subject to social desirability and recall biases, partially mitigated through triangulation. Resource constraints limit sample size and geographic scope. The cross-sectional design cannot establish causal relationships or track changes over time. Researcher positionality may influence participant responses, addressed through reflexive practice and prolonged engagement.

FINDINGS

This section presents the findings derived from quantitative surveys of 200 female STEM students and qualitative interviews, focus group discussions, and document analysis conducted in Mutare Rural. The findings are organised thematically according to the research questions, integrating quantitative and qualitative data to provide a comprehensive understanding of female participation in renewable energy through STEM education. Direct quotations from participants are used to illustrate key themes, with pseudonyms employed to protect confidentiality.

Demographic characteristics of participants

The quantitative survey sample comprised 200 female STEM students drawn from secondary schools offering STEM subjects at Advanced Level (n=80, 40 percent), Mutare Polytechnic (n=70, 35 percent), and Africa University (n=50, 25 percent). Participants ranged in age from 16 to 28 years, with a mean age of 19.6 years. The majority (n=142, 71 percent) came from rural households within Mutare District, while 58 (29 percent) originated from nearby rural areas or small towns.

The qualitative sample included 32 participants: 15 female STEM students, 5 female renewable energy professionals, 7 STEM educators, and 5 district-level policymakers. Renewable energy professionals worked in solar installation enterprises (n=3), community-based energy projects (n=1), and renewable energy research (n=1). Educators taught physics, chemistry, mathematics, and technical subjects at secondary and tertiary levels. Policymakers represented the District Education Office, Ministry of Women Affairs, and Rural District Council.

Enrollment patterns in STEM education

Quantitative findings revealed that female students constitute approximately 28% of total enrollment in STEM programmes across surveyed institutions in Mutare Rural. This figure aligns with national trends reported by the Zimbabwe Ministry of Higher and Tertiary Education (2019). However, notable variation existed across institutions and subject areas. At secondary level, female participation in Advanced Level sciences was highest in biology at 42%, followed by chemistry at 31%, and physics at 19%. At tertiary level, female enrollment was highest in laboratory science programmes at 38% and lowest in engineering and technical programmes at 16%.

A final-year student at Mutare Polytechnic explained:

'I wanted to study electrical engineering, but my school did not offer it at Advanced Level, and my family could not afford the fees for me to repeat elsewhere. I ended up in food technology because it was available and seemed practical. At least it is still science, but it is not where my heart was.'

Participation in renewable energy specific courses

Enrollment in renewable energy specific courses or modules was slightly higher than overall STEM participation, at 35% of female STEM students. At tertiary level, renewable energy modules were offered within broader engineering and environmental science programmes. The Renewable Energy Programme at Africa University reported female enrollment of 38% in its short courses and 32% in its diploma programmes. However, educators noted that these figures, while encouraging, still reflected significant underrepresentation.

A university lecturer indicated that:

'When I introduced a new module on solar energy systems, I had only three women in a class of twenty-five. The following year, I made a point of inviting female guest speakers and highlighting women working in solar in Zimbabwe. Enrollment increased to eight women. It shows that visibility matters, but we still have a long way to go.'

Awareness of renewable energy career opportunities

Survey results indicated that 62% of female STEM students were aware of career opportunities in renewable energy, though the depth of this awareness varied considerably. Students at tertiary level demonstrated greater awareness (78%) compared to secondary students (51%). Primary sources of information included teachers (43%), media (31%), and family members (17%). Only 9% reported learning about renewable energy careers through structured career guidance programmes.

During focus group discussions, secondary students expressed limited understanding of what renewable energy careers entailed. 1 Form 4 student said:

'I hear about solar and think of people installing panels on roofs. I did not know there were jobs designing systems or working on policy. If someone had explained this earlier, I might have chosen different subjects. Now I am doing arts subjects and it feels too late.'

Barriers constraining rural female students' access to STEM education pathways

Socio-cultural norms emerged as the most pervasive barrier across all data sources. Survey results indicated that 76% of respondents perceived societal expectations as discouraging girls from pursuing STEM careers. Qualitative data illuminated how these norms operated in daily life. Female students described being directed away from sciences by family members, teachers, and community elders who viewed technical fields as inappropriate for women.

Another secondary school student shared:

'My uncle told me that engineering is for men because it requires working outside and lifting heavy things. He said I should focus on teaching or nursing where I can work indoors and still have time for my future family. My mother agreed with him. It is hard to keep pushing when everyone around you thinks you are wasting your time.'

The intersection of gender and rural location compounded these challenges. Participants noted that traditional norms were often more entrenched in rural communities, and that girls faced greater scrutiny and criticism for pursuing non-traditional paths.

A female solar technician employed in Mutare Rural reflected:

'When I go to villages to install solar systems, people are surprised to see a woman doing this work. Men sometimes refuse to let me touch their roofs. They ask if I am qualified or if I am just assisting the real technician. It is exhausting to constantly prove myself. Young girls see this and think, why would I put myself through that?'

Limited access to educational resources

Inadequate educational infrastructure emerged as a critical barrier, particularly for students in remote areas of Mutare District. Survey findings revealed that only 34% of secondary schools offering STEM subjects had functional laboratories, and only 28% had reliable internet access for student use. Students from these schools scored significantly lower on self-reported confidence in STEM subjects compared to those from better-resourced institutions.

A physics teacher at a rural secondary school explained:

'We teach science without laboratories. Students see experiments in textbooks but never perform them. How can a girl develop confidence in physics when she has never touched a circuit board or seen a prism work? When they reach university, they are already behind their peers from better schools, and many drop out of science programmes.'

Transportation challenges further constrained access. Students travelling long distances to school arrived tired and had limited time for study. Girls reported additional safety concerns when travelling during early morning or evening hours, which affected their attendance at extra classes or laboratory sessions offered outside regular school hours.

Scarcity of female role models and mentors

The absence of visible female role models in STEM fields was identified by 72% of survey respondents as a significant deterrent. Qualitative data revealed that most female students had never met a woman working in a technical renewable energy role. This lack of representation reinforced perceptions that such careers were not attainable or appropriate for women.

A university student pursuing renewable energy studies commented:

'I am in my third year and I have had only one female lecturer in all my STEM courses. Most of my classmates are men. Sometimes I wonder if I belong here. If I had seen a woman teaching engineering or heard a woman speak about her work in solar, I would feel more confident that I can succeed.'

Educators acknowledged this gap and its consequences:

'We try to invite guest speakers, but there are very few women in technical energy roles in this province. The few who exist are overstretched and cannot visit every school. The girls need to see someone like them succeeding, otherwise the message they receive is that STEM is for men. (STEM educator)'

Financial constraints

Economic barriers featured prominently in both survey and qualitative data. Seventy percent of survey respondents identified financial constraints as limiting their educational opportunities. These constraints operated at multiple levels: inability to pay school fees, particularly for Advanced Level studies where costs increase; limited resources for textbooks and materials; and inability to afford transportation to better-resourced schools or to access supplementary tuition.

A focus group participant explained:

'I passed my Ordinary Level sciences with good grades, but my parents could not afford the fees for Advanced Level. I stayed home for a year until a relative offered to help. Many girls from my village never get that chance. They get married or find work in the shops, and their potential is lost.'

Institutional and policy implementation gaps

Document analysis revealed that Zimbabwe has progressive policies on gender and education, including the National Gender Policy and STEM Education Policy Framework. However, qualitative findings indicated significant gaps between policy intentions and implementation realities in Mutare Rural. District-level policymakers acknowledged that monitoring and enforcement mechanisms were weak, and that schools received limited support for gender mainstreaming.

A district education official noted:

'The policies exist on paper. We have targets for female enrollment in STEM, but we do not have resources to implement programmes that would actually achieve those targets. Schools are left to do what they can with very little. In rural areas, where challenges are greatest, support is often smallest.'

Enabling factors and promising interventions

Survey respondents who received financial support through scholarships or bursaries reported significantly higher levels of confidence in completing their STEM studies and pursuing renewable energy careers. The

Joshua Nkomo Scholarship was specifically mentioned by several participants as transformative. A beneficiary explained:

'Without the scholarship, I would not be at university. My family could never afford these fees. The scholarship not only pays my fees but also connects me with other women in STEM. I have mentors now who encourage me and help me navigate challenges. I plan to work in solar energy when I graduate and help electrify rural clinics.'

However, participants noted that scholarship coverage remained limited, with many deserving students unable to access support. Rural students faced additional disadvantages in accessing information about scholarship opportunities and completing application processes.

Mentorship and networking initiatives

Structured mentorship programmes emerged as a powerful enabler. The Women in Renewable Energy (WIRE) programme, established by the Zimbabwe Energy Regulatory Authority, was cited by professionals as providing valuable networking and professional development opportunities. At educational level, initiatives connecting female students with women professionals showed promising results.

A renewable energy professional involved in mentoring described:

'I mentor five young women from Mutare schools. We meet monthly, and they shadow me occasionally when I am doing installations. Two of them have changed their subject choices to include physics and mathematics because they now see the relevance. One wants to start a solar business after university. That is the impact of showing rather than telling.'

Integration of renewable energy concepts into STEM curricula

Educators and students alike reported that integrating renewable energy topics into existing STEM subjects increased engagement and relevance. A teacher who introduced practical solar projects in physics class observed:

'When students see how physics applies to solving real problems in their communities, they become more interested. Girls in particular responded well when we discussed how solar energy could reduce the time women spend collecting firewood. They started asking questions about how solar works and whether they could learn to install systems.'

Survey findings supported this, with 68% of students indicating that practical, community-relevant applications increased their interest in STEM subjects.

Women-led renewable energy cooperatives

Emerging grassroots initiatives, particularly women-led renewable energy cooperatives in rural areas, demonstrated potential for creating pathways into the sector. A participant involved in a cooperative described:

'We started with a group of women trained to maintain solar systems in our village. Now we have a small business installing and repairing systems for households and schools. We employ four young women from the area who have completed STEM subjects. It is small, but it shows what is possible. Other villages are asking us to help them start similar groups.'

These cooperatives provided practical training, income generation, and visible examples of women succeeding in renewable energy, addressing multiple barriers simultaneously.

Strategies to enhance rural women's participation

Participants consistently emphasised the need for investment in educational infrastructure, particularly in rural areas. Recommendations included equipping schools with functional laboratories, providing reliable internet

access, and establishing resource centres where students from multiple schools could access quality facilities. A policymaker noted:

'We cannot talk about increasing female participation in STEM while rural schools lack basic infrastructure. The playing field must be levelled. That means targeted investment in rural education, not just policies that look good on paper.'

Early exposure and career guidance

Educators and professionals stressed the importance of early exposure to STEM and renewable energy concepts. Recommendations included integrating renewable energy topics into primary and secondary curricula, organising career talks and field visits, and providing age-appropriate information about STEM careers. A professional commented:

'By the time girls reach university, many have already ruled out STEM careers because of messages they received earlier. We need to reach them in primary school, show them what is possible, and keep showing them throughout their education. One visit is not enough.'

Targeted support for rural female students

Participants called for programmes specifically designed to address the compounded disadvantages faced by rural female students. Recommendations included rural-specific scholarship schemes, boarding facilities for girls from remote areas, and transportation support to enable attendance at extra classes and laboratory sessions. A student explained:

'Girls in towns have more opportunities. They have better schools, more information, and supportive environments. We need programmes that recognise rural girls face different challenges and provide support that meets those challenges.'

Engaging communities and challenging norms

Addressing socio-cultural barriers requires engaging not only girls but also their families and communities. Participants recommended community awareness campaigns, engagement with traditional leaders, and programmes that demonstrate the value of women's participation in renewable energy. A cooperative leader observed:

'When community members see women installing solar and earning income, attitudes begin to change. The grandmothers start telling young girls that they should study science so they can do this work too. It is slow, but it is real change.'

Strengthening policy implementation

Participants emphasised the need to move from policy to practice. Recommendations included strengthening monitoring and enforcement mechanisms, allocating resources specifically for gender mainstreaming in STEM education, and establishing accountability frameworks at district and school levels. A district official concluded:

'We have good policies. What we lack is implementation. We need someone to check whether schools are actually doing what they are supposed to do. We need resources to support implementation. Without that, the policies are just words.'

Findings

Introduction

This section presents the findings of the study according to the three research questions. Quantitative and qualitative findings are first presented separately before being integrated through a convergent mixed-methods analysis. Quantitative results are presented using descriptive and inferential statistics, while qualitative findings

are illustrated using verbatim quotations from interviews and focus group discussions. Findings from document analysis are presented where they corroborate or extend evidence obtained from participants.

Research Question 1

What are the current patterns of female participation in STEM education and renewable energy programmes in Mutare Rural?

Demographic Characteristics

Table 2

Demographic Characteristics of Survey Participants (n = 200)

Variable	Category	Frequency	Percentage
Educational Level	Secondary School	80	40.0
	Polytechnic	70	35.0
	University	50	25.0
Residence	Rural	142	71.0
	Peri-Urban	58	29.0
Mean Age		19.6 years	SD = 2.84

The majority of respondents (71%) originated from rural communities, confirming that the sample adequately represented the target population. Participants ranged in age from 16 to 28 years ($M = 19.6$, $SD = 2.84$).

Female Enrolment in STEM

Table 3

Female Participation across STEM Disciplines

Subject	Female (%)	Male (%)
Biology	42	58
Chemistry	31	69
Mathematics	24	76
Physics	19	81
Engineering	16	84

A chi-square analysis demonstrated statistically significant differences in female participation across STEM disciplines,

$$\chi^2(4) = 18.73, p < .001.$$

Female participation was considerably higher in Biology than in Physics and Engineering.

These findings suggest that female students remain concentrated in life sciences while remaining substantially underrepresented in mathematically intensive disciplines that traditionally feed into renewable energy careers.

Interview data supported these findings.

One university lecturer explained:

"Physics remains the biggest challenge. Girls often perform well academically, but very few choose physics because they believe engineering is a man's profession."

Similarly, a district education officer observed:

"We have made progress in encouraging girls into science, but engineering and renewable energy remain heavily male dominated."

Document analysis of Ministry enrolment records similarly showed consistently lower female enrolment in Physics and Engineering programmes across participating institutions.

Participation in Renewable Energy Programmes

Approximately **35%** of female STEM students reported enrolling in renewable-energy-related modules.

University students demonstrated significantly higher participation than secondary school learners.

Independent samples t-test showed:

$$t(198) = 4.18, p < .001$$

indicating significantly greater awareness and participation among tertiary students.

A renewable energy professional commented:

"Most girls only discover renewable energy opportunities once they reach university. We need exposure much earlier."

Research Question Two

What socio-cultural, institutional and economic factors influence women's participation?

Table 4

Perceived Barriers to Female Participation

Barrier	Mean	SD	Agree (%)
Socio-cultural expectations	4.43	0.67	76
Financial constraints	4.29	0.73	70
Lack of female role models	4.17	0.78	72
Limited laboratory facilities	4.10	0.84	68
Poor Internet access	3.95	0.91	65
Limited career guidance	3.91	0.88	63

Socio-cultural expectations emerged as the strongest perceived barrier ($M = 4.43$, $SD = 0.67$), followed by financial constraints ($M = 4.29$).

A one-way ANOVA revealed significant differences in perceived barriers across educational levels,

$$F(2,197) = 6.54, p = .002.$$

University students generally reported lower perceptions of institutional barriers than secondary school learners.

Theme One

Socio-cultural Expectations

Qualitative findings demonstrated that traditional gender expectations continue to shape girls' educational aspirations.

One secondary school learner stated:

"People always tell us that engineering is too difficult for girls."

A renewable energy technician similarly observed:

"Sometimes clients ask whether I really know what I am doing because I am a woman."

These findings explain why socio-cultural barriers received the highest quantitative rating.

Theme Two

Educational Resource Constraints

Teachers consistently described shortages of

- laboratories,
- computers,
- electricity,
- Internet,
- qualified science teachers.

A Physics teacher explained:

"Students only read about experiments. They rarely perform them."

Document analysis confirmed that less than one-third of sampled rural schools possessed fully functional science laboratories.

Theme Three

Financial Constraints

Financial limitations affected access to

- school fees
- textbooks
- transport
- accommodation

Several students indicated that they nearly discontinued their studies because of financial difficulties.

One participant explained:

"Without a scholarship I would not be at university."

Theme Four

Limited Female Role Models

Seventy-two percent of respondents identified lack of female role models as a major barrier.

One participant reflected:

"I have never been taught Physics by a woman."

Educators similarly acknowledged difficulties securing female guest speakers because relatively few women work in technical renewable energy positions.

Research Question Three

Which interventions could strengthen women's participation?

Table 5

Perceived Effectiveness of Proposed Interventions

Intervention	Mean	SD
Scholarships	4.71	0.49
Mentorship	4.65	0.58
Better laboratories	4.59	0.63
Renewable energy curriculum	4.42	0.69
Career guidance	4.38	0.74
Community awareness	4.29	0.81

Scholarships were rated as the most effective intervention.

Mentorship programmes closely followed.

Scholarships

Participants consistently identified scholarships as life-changing.

One university student explained:

"The Joshua Nkomo Scholarship changed my life."

Document analysis similarly demonstrated increasing female enrolment among scholarship beneficiaries.

Mentorship

Women in Renewable Energy (WIRE) mentoring initiatives were frequently identified as highly effective.

A mentor explained:

"The girls become much more confident once they meet women already working in renewable energy."



Renewable Energy Curriculum

Teachers reported that integrating renewable energy projects into Physics lessons increased girls' interest.

One Physics teacher stated:

"Once students saw solar panels solving community problems, Physics suddenly became meaningful."

Integration of Quantitative and Qualitative Findings

The convergent parallel design enabled comparison of quantitative survey findings, qualitative interviews, focus groups, and document analysis.

Table 6

Joint Display of Mixed-Methods Integration

Theme	Quantitative Findings	Qualitative Findings	Document Evidence	Integrated Interpretation
Socio-cultural barriers	76% agreed	Family discourages STEM	Gender Policy acknowledges stereotypes	Strong convergence
Financial constraints	70% agreed	School fees major obstacle	Scholarship reports	Strong convergence
Resource shortages	Mean = 4.10	Teachers describe lack of laboratories	District infrastructure reports	Strong convergence
Role models	72% agreed	Few female engineers	WIRE programme reports	Complementary evidence
Renewable energy curriculum	68% positive	Practical lessons increase motivation	Curriculum documents	Complementary evidence

Convergence

Both datasets consistently identified

- gender stereotypes,
- financial barriers,
- inadequate infrastructure,
- absence of female role models

as the principal barriers.

Complementarity

Qualitative interviews explained the mechanisms underlying statistical patterns.

For example,

the survey established that **76%** perceived socio-cultural barriers.

Interviews revealed these barriers were transmitted through

- families,
- teachers,
- community expectations,
- cultural beliefs.

Divergence

Very little divergence emerged.

However, university students reported considerably greater awareness of renewable energy careers than secondary school learners despite similar perceptions regarding gender stereotypes.

This suggests that educational exposure improves awareness but does not completely eliminate cultural barriers.

Summary of Findings

Overall, the findings demonstrate that female participation in renewable energy is shaped by an interaction of individual, institutional, and societal factors. Quantitative analyses identified significant differences in participation patterns across STEM disciplines and educational levels, while qualitative evidence explained how socio-cultural norms, resource constraints, financial hardship, and limited access to role models influence educational and career decisions. Document analysis corroborated these findings by revealing persistent implementation gaps between national gender and STEM policies and the realities experienced in rural schools. Together, these integrated findings provide a comprehensive understanding of the barriers and opportunities affecting women's participation in renewable energy through STEM education in Mutare Rural.

CONCLUSIONS

This study investigated the opportunities and challenges for enhancing female participation in the renewable energy sector through STEM education in Mutare Rural, Zimbabwe. The findings reveal persistent gender disparities, with female STEM enrollment at approximately 28%, constrained by entrenched socio-cultural norms, limited educational infrastructure, scarcity of female role models, financial barriers, and significant gaps between progressive policy frameworks and implementation realities. These barriers interact to produce compounded disadvantage for rural girls, limiting their self-efficacy beliefs and outcome expectations regarding technical careers. However, the study also identified promising interventions including scholarship programmes such as the Joshua Nkomo Scholarship, structured mentorship initiatives like the Women in Renewable Energy programme, integration of community-relevant renewable energy concepts into STEM curricula, and emerging women-led renewable energy cooperatives. These interventions demonstrate that targeted, integrated approaches addressing multiple barriers simultaneously can enhance female participation and create pathways into renewable energy careers.

Achieving gender equity in renewable energy through STEM education in rural Zimbabwe requires sustained, multi-level action. Investment in rural educational infrastructure, early and continuous career guidance, community engagement to challenge gender norms, and strengthened policy implementation with adequate resources and accountability mechanisms are essential. The study contributes to theoretical understanding by extending Social Cognitive Career Theory and energy justice theory to rural African contexts, revealing how distributional, procedural, and recognition injustices manifest in educational and energy systems. As Zimbabwe pursues its renewable energy transition and works toward SDGs 5 and 7, the full participation of rural women is not optional but essential. Women bring diverse perspectives that enhance innovation, their economic empowerment contributes to broader development outcomes, and their leadership ensures that energy transitions are just and inclusive. The women of Mutare Rural have demonstrated that change is possible when appropriate support and opportunities are provided, offering hope and guidance for future efforts to build an inclusive renewable energy workforce across Sub-Saharan Africa.

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