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Research Article

Analysis of the Relationship Between Gender Equality, Energy Consumption Patterns, and Environmental Sustainability Impact in Indonesia

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ABSTRACT

This study investigates the relationships between gender equality, energy consumption patterns, and environmental sustainability in Indonesia. The primary aim is to understand how gender equality influences energy consumption behaviors and, in turn, impacts environmental sustainability, with a specific focus on the mediating role of energy consumption patterns. Utilizing a quantitative approach, data were collected through a survey distributed to 500 respondents, with 433 valid responses used for analysis. Path analysis was employed to test the proposed hypotheses, examining direct and indirect effects among the variables. The key findings indicate that gender equality positively impacts both energy consumption patterns and environmental sustainability. Specifically, gender equality leads to more energy-efficient practices, which subsequently enhance environmental outcomes. The study also reveals that energy consumption patterns mediate the relationship between gender equality and environmental sustainability, demonstrating how improvements in gender equality can foster more sustainable energy practices. This research contributes to the theoretical framework by integrating gender perspectives into environmental and energy studies, highlighting the complex interactions between social equity and sustainability. Practically, the findings underscore the importance of incorporating gender equality into environmental policies to achieve more effective sustainability outcomes. The novelty of this study lies in its demonstration of how gender equality not only affects energy consumption patterns directly but also influences environmental sustainability through these patterns, offering new insights for both policy and academic discourse.

Keywords: Gender Equality, Energy Consumption Patterns, Environmental Sustainability, Indonesia

INTRODUCTION

In recent decades, the nexus between gender equality, energy consumption patterns, and environmental impact has garnered significant scholarly attention [1]. This is particularly pertinent in Indonesia, a country characterized by its rich natural resources, rapid economic growth, and a complex social fabric [2]. Understanding how gender dynamics influence energy use and the subsequent environmental consequences is crucial for devising effective policies that address both social equity and sustainability [3]. Gender equality and environmental sustainability are often seen as interconnected challenges, with the potential for their intersection to reveal deeper insights into sustainable development practices [4]–[6].

Gender roles and expectations can significantly affect energy consumption patterns within households and communities [7]. In many societies, traditional gender roles dictate the types and quantities of energy used, often leading to unequal energy consumption and, consequently, varied environmental impacts [8], [9]. For instance,

women, who typically bear the responsibility for household management, might engage in different energy consumption practices compared to men [10]–[12]. This disparity can influence both the efficiency and sustainability of energy use, which in turn impacts the broader environment [13], [14]. Therefore, analyzing these patterns in the Indonesian context is essential for understanding how gender roles shape energy consumption and environmental outcomes [15]–[17].

The Global Gender Gap Report 2021 by the World Economic Forum highlights the persistent issue of gender inequality worldwide, projecting that gender parity will not be achieved for another 135 years, with the COVID-19 pandemic exacerbating the situation [18]. Indonesia ranked 101st out of 156 countries, dropping 16 places from the previous year, having closed 68.8% of its overall gender gap. Among Southeast Asian nations, Indonesia ranks 7th out of 11, trailing behind Vietnam, Thailand, and Timor-Leste, with the Philippines leading the region. The decline in Indonesia's score is mainly driven by a sharp decrease in female representation in senior economic roles, where women's participation fell from 54.9% to 29.8%. Additionally, 81.8% of women work in the informal sector, and the gender gap in political empowerment widened due to a decrease in female ministerial positions. Despite these setbacks, positive developments were noted in health and survival as well as educational attainment, though primary education participation remains among the lowest in the G20. Addressing gender-based job segregation and enhancing women's career pathways are critical to improving future opportunities for Indonesian women (see Figure 1).

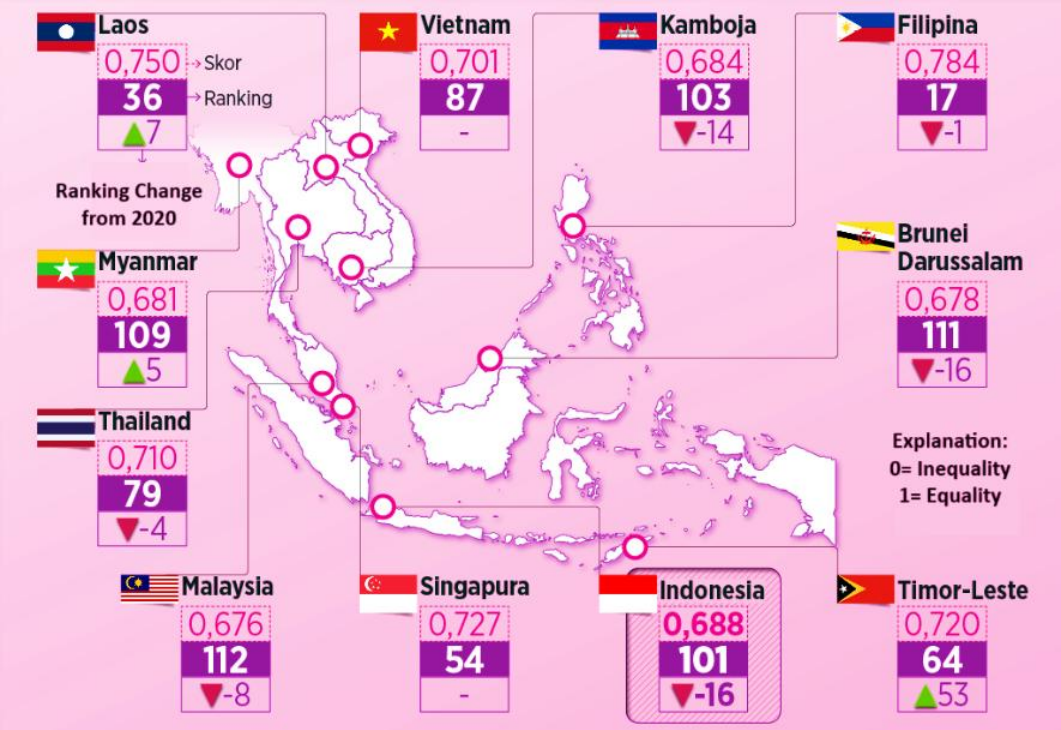

Figure 1. Global Gender Gap Score in Southeast Asia

Source: [18]

In Indonesia, gender disparities in energy consumption are evident across various sectors [19], [20]. Women and men often have differing access to and control over energy resources, which can lead to unequal benefits and burdens. For example, women in rural areas may rely more on traditional biomass fuels, which are less efficient and have more detrimental environmental effects than modern energy sources. Conversely, urban men might have better access to cleaner energy options, reflecting a disparity that influences both energy efficiency and environmental sustainability. Investigating these differences can shed light on how gendered access to energy resources affects overall energy consumption and environmental health [21]–[23].

Moreover, energy consumption patterns in Indonesia are closely linked to the country's rapid economic development and urbanization [24]–[26]. As the economy grows, energy demand increases, leading to greater environmental strain. Gender equality in energy access and consumption becomes crucial in this context, as equitable access to

energy can lead to more sustainable energy use and reduced environmental impact [27]. By exploring how gender equality interacts with energy consumption patterns, policymakers can develop strategies that promote both social equity and environmental sustainability [28].

The environmental impact of energy consumption in Indonesia is a pressing concern, particularly in light of the country's commitment to international climate agreements and sustainable development goals [29]–[31]. High levels of energy consumption, coupled with inefficient use of resources, contribute to significant environmental degradation, including deforestation, air pollution, and greenhouse gas emissions. Gendered differences in energy use can exacerbate these issues, making it essential to consider gender perspectives when evaluating environmental impacts and formulating policies [32], [33].

Research indicates a complex relationship between gender equality, energy consumption, and environmental sustainability. Gender differences exist in sustainable consumption behaviors and motivations, influenced by stereotypes and norms [34]. The energy-gender transition nexus requires nuanced understanding of contextual factors shaping energy access and gender issues [35]. While gender inclusion is improving in sustainability research, gender issues remain marginal in some fields like industrial ecology [36]. Studies often equate "gender" with "women," overlooking intersectionality with other demographic characteristics [36].. However, both demographic and structural gender diversity in organizations are significant predictors of environmental sustainability initiatives [37]. To address these gaps, researchers recommend approaching gender critically, using theoretical lenses from gender studies to better assess environmental impacts on diverse populations in changing work and consumption patterns [36].

Analyzing the relationship between gender equality, energy consumption patterns, and environmental impact in Indonesia requires a multidimensional approach. This involves examining how gender influences energy choices, access, and consumption, and how these factors affect the environment. By integrating gender analysis into environmental and energy policy frameworks, Indonesia can advance towards more inclusive and sustainable development. This approach ensures that both women's and men's need and contributions are considered in efforts to mitigate environmental impacts.

This research aims to provide a comprehensive analysis of the interplay between gender equality, energy consumption, and environmental impact in Indonesia. By focusing on this intersection, the study seeks to highlight how gender dynamics shape energy use and environmental outcomes, offering insights for more effective and equitable policy interventions. Understanding these relationships is critical for advancing Indonesia's sustainability goals and promoting a more inclusive approach to environmental and energy management.

The findings of this research will not only contribute to academic discourse but also inform policymakers and stakeholders about the importance of integrating gender considerations into energy and environmental strategies. Addressing gender disparities in energy consumption can lead to more equitable and sustainable outcomes, ultimately supporting Indonesia's broader goals of social equity and environmental stewardship.

LITERATURE REVIEW

The Relationship between Gender Equality and Energy Consumption Patterns

According to [38], gender equality encompasses the principle that all individuals, regardless of gender, should have equal rights, opportunities, and access to resources. In the context of energy consumption, this principle extends to ensuring that both women and men have equal access to energy resources, technologies, and decision-making processes. Meanwhile, [39] argue that gender equality aims to eliminate disparities in how energy resources are accessed, used, and managed, which can influence overall efficiency and sustainability in energy use. Achieving gender equality requires addressing systemic barriers that limit access and opportunities for certain genders, thereby enabling a more equitable distribution of energy resources and benefits [40].

Swan & Ugursal (2009) define that energy consumption patterns refer to the ways in which energy is utilized across different sectors and demographic groups. These patterns are influenced by various factors, including socio-economic status, cultural norms, and geographic location. In many societies, traditional gender roles significantly impact how energy is consumed and managed [42]. For example, women often bear the primary responsibility for household tasks, which can influence their energy usage patterns, such as relying on less efficient cooking methods. Conversely,

men might have more access to and control over modern energy technologies, leading to differences in energy efficiency and consumption [43].

The relationship between gender equality and energy consumption patterns is evident in how gender roles and norms shape access to and use of energy resources [44]. In many regions, women, especially in rural or low-income areas, may have limited access to modern energy services and technologies. This disparity can lead to a reliance on traditional and less efficient energy sources, such as biomass, which have higher environmental and health impacts. On the other hand, men in more affluent or urban settings might benefit from greater access to cleaner and more efficient energy options, reflecting a gendered disparity in energy consumption [45].

Gender equality also influences decision-making processes related to energy use and management [46]. In contexts where gender inequalities persist, women may have limited influence over household and community energy choices. This lack of decision-making power can hinder the adoption of energy-efficient technologies and practices, affecting overall energy efficiency. By addressing gender disparities and ensuring equal participation in energy decision-making, policies can promote more sustainable and equitable energy consumption patterns [47].

Finally, the intersection of gender equality and energy consumption has significant implications for environmental sustainability. Gendered differences in energy use can contribute to varying environmental impacts, such as differing levels of greenhouse gas emissions and resource depletion. Promoting gender equality in energy access and management can lead to more balanced and efficient energy consumption, ultimately contributing to reduced environmental degradation. Integrating gender perspectives into energy policies and planning is essential for achieving both social equity and environmental sustainability, ensuring that energy use benefits all members of society while minimizing negative environmental outcomes [48]. Thus, based on previous research, the hypotheses we propose are as follows:

H1: Gender Equality impacts on Energy Consumption Patterns

The Relationship between Gender Equality and Environmental Sustainability

Gender equality and environmental sustainability are intricately linked, as gender dynamics can significantly influence environmental outcomes and vice versa. Cornwall & Rivas (2015) assert that gender equality involves ensuring that individuals of all genders have equal rights, opportunities, and access to resources, which can profoundly affect how environmental resources are managed and utilized. In many societies, traditional gender roles and norms shape individuals' interactions with the environment, influencing both resource consumption and environmental impact.

One of the key aspects of this relationship is the role of women in environmental management and conservation [50]. In many developing regions, women are often the primary managers of natural resources such as water, fuel, and land. Their roles in household and community management give them unique insights into sustainable resource use and conservation practices. However, gender inequalities can limit women's access to decision-making processes and resources, which can undermine their ability to contribute effectively to environmental sustainability. By promoting gender equality and empowering women in environmental decision-making, societies can benefit from their valuable knowledge and experience, leading to more effective and sustainable environmental management [51].

Gender equality also affects patterns of resource consumption and environmental impact [52]. In many cases, women and men have different consumption patterns and energy use practices due to varying responsibilities and roles. For instance, women might use traditional energy sources that are less efficient and more polluting, while men might have access to cleaner and more efficient technologies. These differences can lead to unequal environmental impacts, with certain gender groups contributing more to environmental degradation than others. Addressing these disparities through gender-sensitive policies can help reduce overall environmental impact and promote more sustainable practices [53].

Moreover, gender equality can enhance resilience to environmental challenges [54]. Women often play crucial roles in community-based adaptation and resilience-building efforts, particularly in the face of climate change and environmental degradation. By ensuring that women have equal access to resources, education, and decision-making, communities can better adapt to environmental changes and build resilience. Gender equality thus contributes to more effective and equitable responses to environmental challenges, improving overall sustainability and community well-being [55].

Finally, integrating gender perspectives into environmental policies and programs is essential for achieving sustainable development goals [56]. Gender-sensitive approaches can identify and address the unique needs and contributions of different genders, leading to more inclusive and effective environmental strategies. By considering gender dynamics in environmental planning and implementation, policymakers can create more equitable and sustainable solutions that benefit all members of society and enhance overall environmental sustainability [57]. Building on prior research, the hypotheses we suggest are as follows:

H2: Gender Equality impacts on Environmental Sustainability

The Relationship between Energy Consumption Patterns and Environmental Sustainability

[58] explain that environmental sustainability is the capacity to maintain and improve environmental quality over the long term while meeting current needs without compromising the ability of future generations to meet their own needs. It involves managing natural resources responsibly, reducing environmental impact, and maintaining ecological balance. Key aspects of environmental sustainability include minimizing pollution, conserving natural resources, and promoting practices that enhance ecosystem health [59].

[60] assert that energy consumption patterns play a crucial role in determining environmental sustainability, as they directly influence the extent of resource depletion and environmental degradation. The type and amount of energy consumed affect emissions of greenhouse gases, pollution levels, and the overall environmental footprint. For instance, reliance on fossil fuels such as coal, oil, and natural gas typically results in higher greenhouse gas emissions and environmental pollution compared to cleaner energy sources like wind, solar, and hydroelectric power [61].

The efficiency of energy use is another critical factor in this relationship. High energy efficiency means that less energy is required to perform the same tasks, leading to lower resource consumption and reduced environmental impact [62]. Energy-efficient technologies and practices can significantly decrease the amount of energy needed and, consequently, lower emissions and waste. For example, energy-efficient appliances, better insulation in buildings, and advanced industrial processes contribute to reduced energy consumption and a smaller environmental footprint.

Changes in energy consumption patterns can also reflect broader shifts towards more sustainable practices [63]. For instance, the increasing adoption of renewable energy sources and the implementation of energy-saving measures indicate a move towards greater environmental sustainability. Conversely, patterns such as increased reliance on high-carbon energy sources and inefficient technologies can exacerbate environmental problems, such as climate change and resource depletion [64].

The relationship between energy consumption and environmental sustainability is also influenced by socio-economic factors and policy decisions. Access to clean energy technologies and energy-efficient solutions can be unevenly distributed, affecting different populations differently. Policies that promote renewable energy, energy efficiency, and sustainable practices are essential for aligning energy consumption patterns with sustainability goals. Effective policies and incentives can drive changes in consumption patterns, encourage the adoption of cleaner technologies, and support efforts to minimize environmental impacts [65].

In summary, energy consumption patterns are central to achieving environmental sustainability. By understanding and managing how energy is consumed and improving efficiency, societies can reduce their environmental impact and work towards long-term sustainability. Shifting towards cleaner energy sources, enhancing energy efficiency, and implementing supportive policies are critical steps in aligning energy practices with environmental goals and ensuring a sustainable future for all [66]. Drawing from earlier studies, the hypotheses we put forward are as follows:

H3: Energy Consumption Patterns impacts on Environmental Sustainability

Energy Consumption Patterns as Mediator

Energy consumption patterns act as a vital mediator in the relationship between gender equality and environmental sustainability. Gender equality influences how energy is accessed, managed, and utilized, which in turn impacts environmental outcomes [67]. In many societies, traditional gender roles determine who controls energy resources and how they are used, often resulting in unequal access to modern and efficient technologies. When gender equality is promoted, women gain better access to these technologies, leading to changes in energy consumption patterns that can contribute to more sustainable environmental practices [68].

As gender equality improves, women often have greater opportunities to influence energy management and consumption [69]. This shift can result in the adoption of more efficient and cleaner energy technologies. For example, women who gain access to modern cooking stoves or renewable energy sources may use energy more efficiently, reducing reliance on traditional and polluting energy sources. These changes in energy consumption patterns directly impact environmental sustainability by lowering greenhouse gas emissions and reducing pollution [70].

Energy consumption patterns also mediate the impact of socio-economic changes driven by gender equality [71]. Increased economic opportunities for women often lead to higher incomes and better access to energy-efficient technologies. This socioeconomic shift can promote more sustainable energy use, as higher income levels enable individuals to invest in cleaner and more efficient energy solutions. Consequently, energy consumption patterns influenced by these socio-economic factors help mediate the relationship between gender equality and improved environmental outcomes [72].

Furthermore, energy policies that incorporate gender perspectives can enhance their effectiveness in achieving both gender equality and environmental sustainability [73]. Policies that address gender disparities in energy access and decision-making can lead to more equitable and efficient energy consumption patterns. For instance, programs that support women's involvement in energy planning and provide financial incentives for adopting clean technologies can drive changes in consumption patterns, thereby improving environmental sustainability. These integrated approaches ensure that gender equality efforts contribute positively to environmental goals [74].

In summary, energy consumption patterns play a crucial mediating role between gender equality and environmental sustainability. By influencing how gender equality affects energy use and how these patterns impact the environment, understanding this mediation can help in creating more effective policies and strategies. Addressing gender disparities in energy access and management not only promotes social equity but also advances environmental sustainability, highlighting the interconnectedness of these critical issues [75]. Based on prior research, the proposed hypotheses are outlined as follows:

H4: Energy Consumption Patterns mediate the relationship between Gender Equality and Environmental

Figure 2 illustrates the research model used in this study, highlighting the hypothesized relationships between gender equality, energy consumption patterns, and environmental sustainability. This model serves as the framework for analyzing how gender equality influences energy behaviors and environmental outcomes, and it incorporates the mediating role of energy consumption patterns in this dynamic.

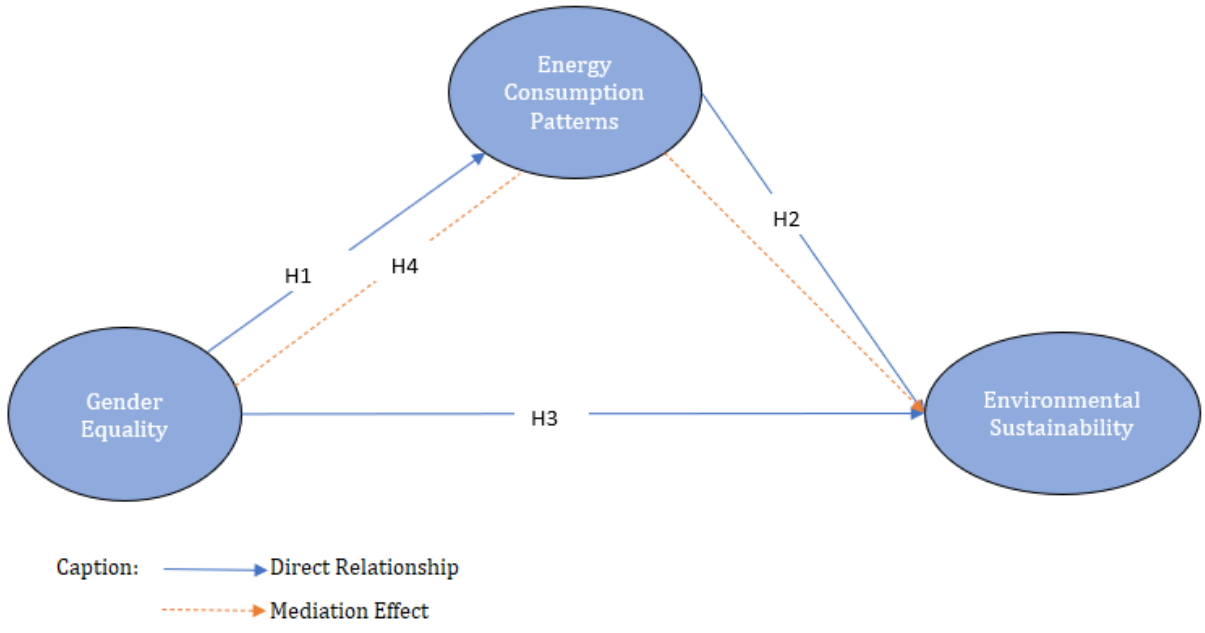

Figure 2. Research Model

METHODOLOGY

Research Design

This study adopts a quantitative research design and employs path analysis to investigate the mediating role of energy consumption patterns between gender equality and environmental sustainability. The primary objective is to assess how gender equality impacts energy consumption patterns and how these patterns subsequently affect environmental sustainability. Path analysis is chosen to delineate the direct and indirect relationships among these variables, allowing for a nuanced understanding of how energy consumption mediates the effects of gender equality on environmental outcomes.

Data Collection

Data collection involves a structured questionnaire designed to capture information on gender equality, energy consumption patterns, and environmental sustainability. The survey utilizes Likert scale items ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) to gauge various dimensions of these constructs. The gender equality section includes questions on access to energy resources, decision-making roles, and involvement in energy-related activities. The energy consumption patterns section measures types of energy used, energy efficiency practices, and any changes linked to gender equality. The environmental sustainability section evaluates respondents' perceptions of environmental impact and sustainability practices.

The survey was distributed to a sample of 500 respondents through a combination of online and in-person methods. Online surveys were sent via email and social media, while in-person surveys were conducted in community centers and public spaces to ensure broad coverage. Out of the 500 distributed surveys, 449 completed responses were returned. After preliminary checks for completeness and validity, 436 responses were deemed suitable for further analysis. This sample size ensures sufficient power for the path analysis, allowing for a robust examination of the relationships among the study variables [76].

Data Analysis

Descriptive statistics summarize the responses, providing insights into the characteristics of gender equality, energy consumption patterns, and environmental sustainability. Measures such as means, standard deviations, and frequency distributions offer an overview of the data [77]. Correlation analysis is then performed to explore the relationships between gender equality, energy consumption patterns, and environmental sustainability. Pearson or Spearman correlation coefficients are calculated to determine the strength and direction of these relationships.

Path analysis is conducted to model the direct and indirect effects of gender equality on environmental sustainability through energy consumption patterns. The path model is constructed with gender equality as the independent variable, energy consumption patterns as the mediator, and environmental sustainability as the dependent variable. Path coefficients are estimated to evaluate the significance and strength of the relationships, with model fit assessed using fit indices (Sharma et al., 2005).

Data Validity and Reliability

Validity of the survey instrument is ensured through expert reviews and pre-testing [79]. Subject matter experts assess the content validity of the survey items, confirming that they effectively measure gender equality, energy consumption patterns, and environmental sustainability. Reliability is evaluated using internal consistency measures, such as Cronbach’s alpha, to verify the consistency of the Likert scale items. Standardized data collection procedures are followed to minimize variability and bias, enhancing the reliability of the results.

Ethical Considerations

Ethical considerations include obtaining informed consent from all participants and ensuring the confidentiality of their responses. Participants are informed about the purpose of the study, their right to withdraw, and the handling of their data. Data is anonymized and securely stored to protect participants' privacy. The study adheres to ethical guidelines and institutional review board standards to uphold the integrity and ethical conduct of the research.

REISULTS AND FINDING

Statistics Descriptive

Table 1 presents the descriptive statistics for the latent variables: Energy Consumption Patterns, Environmental Sustainability, and Gender Equality, based on 436 observations. The median values for all three variables are negative, with -0.610 for Energy Consumption Patterns, -0.435 for Environmental Sustainability, and -0.303 for Gender Equality. This indicates that the central tendency of respondents' responses tends to be below the neutral point on the scale used.

The range of responses for each variable is measured from the minimum to the maximum values. Gender Equality has the widest range, with a minimum value of -4.921 and a maximum of 1.121, indicating significant variability in respondents' perceptions. Energy Consumption Patterns range from -4.008 to 1.089, while Environmental Sustainability ranges from -3.823 to 1.247. This variability reflects substantial differences in respondents' views on each variable.

The distribution of all three variables shows positive skewness, with values of 0.773 for Energy Consumption Patterns, 0.655 for Environmental Sustainability, and 0.603 for Gender Equality. Positive skewness suggests that the data distribution is skewed to the right, meaning that most respondents gave lower scores, while a few gave higher scores. This results in a longer tail on the right side of the distribution, indicating the presence of some higher values pulling the average toward higher scores.

The excess kurtosis values for each variable are 1.510 for Energy Consumption Patterns, 1.360 for Environmental Sustainability, and 1.304 for Gender Equality. These values suggest that the distributions of these variables are more peaked and have heavier tails compared to a normal distribution. Excess kurtosis indicates the presence of more extreme values or outliers in the data, meaning there is greater variability around the central values and in the tails of the distribution.

Overall, these descriptive statistics depict variability in respondents' perceptions of gender equality, energy consumption patterns, and environmental sustainability. Although the central tendency of scores is below the neutral point, the right-skewed distributions and excess kurtosis indicate that some respondents have higher perceptions and that there is significant variability in the data. These findings suggest that while many respondents have lower views on these variables, there is also a group of respondents with more positive perceptions, as well as the presence of extreme values that influence the overall distribution. In addition, Figure 3 presents a Box Plot and Bar Chart illustrating data distribution and category comparisons. Meanwhile, Figure 4 features a Heatmap and 3D Density Plot, offering an in-depth visualization of data intensity and distribution in three-dimensional space.

Table 1. Latent Variable Descriptives

Variable	No of Obs.	Median	Min	Max	Excess Kurtosis	Skewness
Energy Consumption Patterns	436	-0.610	-4.008	1.089	1.510	0.773
Environmental Sustainability	436	-0.435	-3.823	1.247	1.360	0.655
Gender Equality	436	-0.303	-4.921	1.121	1.304	0.603

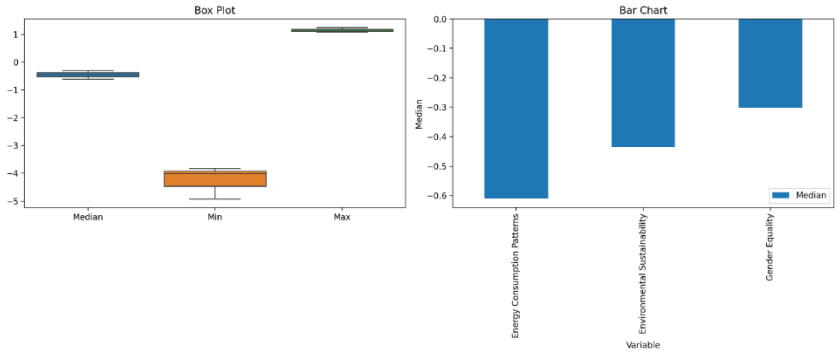

Figure 3. Box Plot and Bar Chart

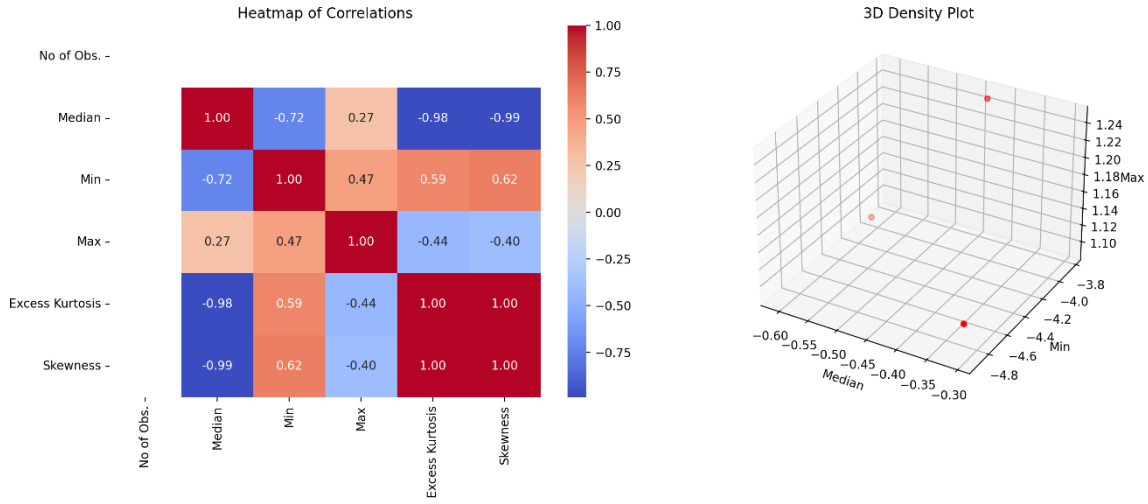

Figure 4. Heatmap and 3D Density Plot

Validity and Reliability

The Confirmatory Factor Analysis (CFA) results for the constructs Gender Equality, Energy Consumption Patterns, and Environmental Sustainability are presented in Table 2, where each construct is measured using multiple indicators. The analysis includes outer loadings, Cronbach's Alpha, rho_A, Composite Reliability (CR), and Average Variance Extracted (AVE) values, which collectively assess the reliability and validity of the constructs.

For Gender Equality, the construct is composed of ten indicators, all of which exhibit strong outer loadings ranging from 0.880 to 0.929. This suggests a robust correlation between the indicators and the overall construct. Moreover, the Cronbach's Alpha for Gender Equality is notably high at 0.976, indicating excellent internal consistency among the items. Furthermore, both the rho_A and Composite Reliability (CR) values, which are 0.977 and 0.979 respectively, further affirm the construct's reliability, while the Average Variance Extracted (AVE) stands at 0.824, meaning that more than 82% of the variance in the indicators is captured by the construct, thereby demonstrating strong convergent validity.

Moving to the Energy Consumption Patterns construct, it consists of ten indicators, with outer loadings ranging from 0.705 to 0.996. Although the loading for ECP9 is slightly lower at 0.705, the remaining indicators display extremely high outer loadings, with several approaching or reaching 0.991. This reflects a strong association between these indicators and the construct. The Cronbach's Alpha is impressively high at 0.991, suggesting exceptional internal consistency. In addition, both rho_A and Composite Reliability (CR) are also very high, at 0.994 and 0.993 respectively. The AVE is calculated at 0.932, which indicates that 93.2% of the variance in the indicators is explained by the construct, showcasing excellent convergent validity.

Similarly, the Environmental Sustainability construct is measured by ten indicators, with outer loadings ranging from 0.865 to 0.932. The Cronbach's Alpha for this construct is 0.973, which indicates high internal consistency among the items. Furthermore, the rho_A value is 0.974, and the Composite Reliability (CR) is 0.976, both of which underscore the construct's reliability. Additionally, the AVE is 0.802, suggesting that 80.2% of the variance in the indicators is captured by the construct, thus confirming strong convergent validity.

In summary, the CFA results suggest that all three constructs—Gender Equality, Energy Consumption Patterns, and Environmental Sustainability—are not only reliable but also valid measures of their respective concepts. This is demonstrated by the high internal consistency, reliability, and convergent validity as reflected in the outer loadings, Cronbach's Alpha, rho_A, CR, and AVE values, which provide a solid foundation for subsequent analysis in the study.

Table 2. Confirmatory Factor Analysis

Construct	**Items**	**Indicators**	**Outer Loading**	**Cronbach's Alpha**	**rho_A**	**CR**	**AVE**
Gender Equality	GE1	I have an equal say in household decisions, including those related to energy use and resource allocation	0.923	0.976	0.977	0.979	0.824
	GE2	I have equal access to financial resources, energy, and other necessary resources within my household	0.911				
	GE3	Men and women in my community have equal access to education and training programs	0.896				
	GE4	My workplace provides equal opportunities for career advancement and skill development for both men and women	0.929				
	GE5	Women and men are equally involved in community decision-making processes, including those related to environmental initiatives	0.880				
	GE6	In my workplace, men and women are paid equally for the same job roles and responsibilities	0.885				
	GE7	Women and men in my community have equal access to healthcare services, including reproductive health	0.928				
	GE8	I feel that men and women are treated equally in social, economic, and political contexts	0.912				

	GE9	My household supports an equal distribution of responsibilities between men and women in managing work and family life	0.904				
	GE10	Both men and women equally participate in decisions regarding energy conservation and efficiency at home	0.907				
Energy Consumption Patterns	ECP1	I regularly use energy-efficient appliances and technologies in my home	0.991	0.991	0.994	0.993	0.932
	ECP2	I use renewable energy sources (e.g., solar, wind) as part of my household energy consumption	0.990				
	ECP3	I consistently practice energy-saving habits, such as turning off lights and unplugging electronics when not in use	0.991				
	ECP4	I am aware of how much energy my household consumes on a regular basis	0.989				
	ECP5	I am willing to invest in energy-efficient products or home improvements to reduce energy consumption	0.996				
	ECP6	I actively participate in community or government programs that promote energy efficiency and conservation	0.987				
	ECP7	I monitor and track my household's energy consumption to identify areas for improvement	0.990				
	ECP8	I play an active role in managing my household's energy use, including setting thermostats and managing appliance use	0.991				
	ECP9	I consider energy costs an important factor in making household decisions related to energy use	0.705				
	ECP10	I am open to adopting new energy-saving technologies or practices in my household	0.987				

Environmental Sustainability	ES1	I regularly separate and recycle waste materials such as paper, plastic, and glass	0.897	0.973	0.974	0.976	0.802
	ES2	I make a conscious effort to reduce the use of single-use plastics in my daily life	0.932				
	ES3	I consistently practice water-saving techniques, such as using low-flow fixtures and reducing water wastage	0.925				
	ES4	I actively support or participate in local environmental sustainability initiatives, such as tree planting or community clean-up events	0.890				
	ES5	I prefer using sustainable modes of transportation, such as biking, walking, or public transport, over driving a car	0.907				
	ES6	I am aware of my carbon footprint and take steps to reduce it, such as using energy-efficient appliances and reducing meat consumption	0.886				
	ES7	I prefer purchasing products that are environmentally friendly or sustainably sourced	0.880				
	ES8	I support efforts to protect local wildlife and biodiversity, either through personal actions or community programs	0.898				
	ES9	I am aware of how my lifestyle and consumption choices impact the environment	0.876				
	ES10	I advocate for or support policies and regulations that promote environmental sustainability at the local or national level	0.865				

Table 3 presents the Fornell-Larcker Criterion, which is used to assess the discriminant validity among the constructs: Energy Consumption Patterns (ECP), Environmental Sustainability (ES), and Gender Equality (GE). The

values on the diagonal represent the square root of the Average Variance Extracted (AVE) for each construct, while the off-diagonal values indicate the correlations between the constructs.

Starting with Energy Consumption Patterns, the square root of the AVE is 0.965, indicating a high level of internal consistency within the construct. The correlation between Energy Consumption Patterns and Environmental Sustainability is 0.655, showing a moderate positive relationship between these two constructs. Meanwhile, the correlation between Energy Consumption Patterns and Gender Equality is stronger, at 0.924, suggesting a significant positive association between these variables.

For Environmental Sustainability, the square root of the AVE is 0.896, which also reflects a solid internal consistency. The correlation between Environmental Sustainability and Gender Equality is 0.702, indicating a moderately strong positive relationship. This suggests that as Gender Equality improves, there is a corresponding enhancement in Environmental Sustainability.

Lastly, Gender Equality has a square root of the AVE of 0.908, further confirming the construct's reliability. The correlations with the other constructs—Energy Consumption Patterns at 0.924 and Environmental Sustainability at 0.702—underscore the interconnectedness between gender equality, energy consumption patterns, and environmental sustainability. Overall, the Fornell-Larcker Criterion demonstrates that each construct is distinct yet interrelated, with significant correlations that underscore the importance of considering these variables in relation to one another within the context of the study.

Table 3. Fornell-Larcker Criterion

Construct*)	**ECP**	**ES**	**GE**
Energy Consumption Patterns	0.965		
Environmental Sustainability	0.655	0.896	
Gender Equality	0.924	0.702	0.908
*) GE= Gender Equality; ECP= Energy Consumption Patterns; ES= Environmental Sustainability			

Table 4 presents the Heterotrait-Monotrait Ratio (HTMT), which is another measure used to assess discriminant validity among the constructs: Energy Consumption Patterns (ECP), Environmental Sustainability (ES), and Gender Equality (GE). This ratio helps determine whether constructs are sufficiently distinct from each other, with values above 0.85 generally indicating potential issues with discriminant validity.

For Energy Consumption Patterns, the HTMT value with Environmental Sustainability is 0.670. This indicates a moderate correlation between these two constructs but remains below the threshold that would suggest problematic overlap. The HTMT value with Gender Equality is 0.737, which also reflects a moderate level of correlation, yet still within acceptable limits for discriminant validity.

The HTMT value between Environmental Sustainability and Gender Equality is 0.719. This demonstrates a relatively strong association between these constructs but remains below the critical value of 0.85, suggesting that they are distinct enough from one another. In summary, the HTMT values in Table 4 support the conclusion that while there are notable correlations between the constructs, they are sufficiently distinct from each other. The values suggest that each construct retains its unique contribution to the study while maintaining relevant interrelations with other constructs.

Table 4. Heterotrait-Monotrait Ration (HTMT)

Construct*)	**ECP**	**ES**	**GE**
Energy Consumption Patterns	-		
Environmental Sustainability	0.670	-	
Gender Equality	0.737	0.719	-

*) GE= Gender Equality; ECP= Energy Consumption Patterns; ES= Environmental Sustainability

Table 5 provides the model fit indices for both the Saturated Model and the Estimated Model, which assess the overall fit of the model within the structural equation modeling framework. The Standardized Root Mean Square Residual (SRMR) value is 0.045 for both models, indicating a good fit. SRMR values below 0.08 are typically considered indicative of an acceptable model fit, so the reported value suggests that the model fits the data well.

The Squared Euclidean Distance (d_ULS) and Geodesic Distance (d_G) are both reported as 0.924 and 4.022 respectively for both models. These measures indicate the discrepancy between the observed and predicted covariance matrices. Lower values for d_ULS and d_G generally suggest a better fit. Since the values are consistent across both models, they affirm the stability of the model's fit. The Chi-Square statistic is 6010.74 for both the Saturated Model and the Estimated Model. While the Chi-Square test is sensitive to sample size and model complexity, a high Chi-Square value typically indicates poor model fit; however, given the complexity of the model and the size of the sample, it is often used in conjunction with other fit indices to evaluate the model.

The Normed Fit Index (NFI), which is 0.808 for both models, measures the relative improvement in fit compared to a baseline model. NFI values above 0.90 are generally considered indicative of a good fit, so while 0.808 is somewhat below this threshold, it still suggests a reasonably good fit. Overall, the model fit indices in Table 5 indicate that the model demonstrates acceptable fit to the data, with particularly good performance in SRMR and consistent values across different fit measures.

Tabel 5. Model Fit

	Saturated Model	**Estimated Model**
SRMR	0.045	0.045
d_ULS	0.924	0.924
d_G	4.022	4.022
Chi-Square	6010.74	6010.74
NFI	0.808	0.808

Hypothesis Test

Table 6 and Figure 5 presents the results of the hypothesis tests conducted in the study, showing the relationships among the constructs Gender Equality (GE), Energy Consumption Patterns (ECP), and Environmental Sustainability (ES). Each hypothesis is evaluated based on the original sample coefficient, standard deviation (STDEV), T statistics, and p-values. For Hypothesis 1 (H1), which posits that Gender Equality positively affects Energy Consumption Patterns, the original sample coefficient is 0.924, with a standard deviation of 0.013. The T statistic is 73.078, and the p-value is 0.000. This result indicates a highly significant positive effect of Gender Equality on Energy Consumption Patterns, thus supporting the hypothesis.

Hypothesis 2 (H2) examines whether Gender Equality has a positive effect on Environmental Sustainability. The original sample coefficient is 0.662, with a standard deviation of 0.091. The T statistic is 7.267, and the p-value is 0.000. This suggests a significant positive relationship between Gender Equality and Environmental Sustainability, thereby supporting this hypothesis as well.

For Hypothesis 3 (H3), which explores the effect of Energy Consumption Patterns on Environmental Sustainability, the original sample coefficient is 0.543, with a standard deviation of 0.087. The T statistic is 6.495, and the p-value is 0.000. This demonstrates a significant positive effect of Energy Consumption Patterns on Environmental Sustainability, confirming the support for this hypothesis.

Lastly, Hypothesis 4 (H4) tests whether Energy Consumption Patterns mediates the relationship between Gender Equality and Environmental Sustainability. The original sample coefficient is 0.420, with a standard deviation of 0.082. The T statistic is 5.492, and the p-value is 0.000. The results indicate a significant mediation effect, supporting

the hypothesis that Energy Consumption Patterns plays a mediating role in the relationship between Gender Equality and Environmental Sustainability. In summary, all hypotheses are supported by the analysis, demonstrating significant positive relationships and mediation effects among the constructs studied.

Table 6. Hypothesis Test Result

Hypothesis	Construct*)	Original Sample	STDEV	T Statistics	P Values	Result
H1	GE -> ECP	0.924	0.013	73.078	0.000	Supported
H2	GE -> ES	0.662	0.091	7.267	0.000	Supported
H3	ECP -> ES	0.543	0.087	6.495	0.000	Supported
H4	GE -> ECP -> ES	0.420	0.082	5.492	0.000	Supported
*) GE= Gender Equality; ECP= Energy Consumption Patterns; ES= Environmental Sustainability						

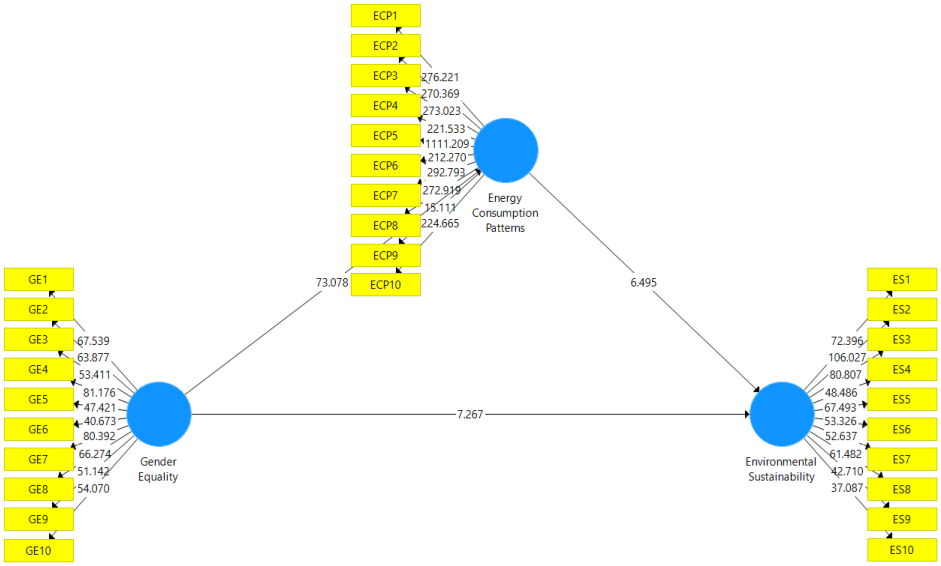

Figure 5. Bootstrapping Result

DISCUSSION

Hypothesis 1: Gender Equality Impacts Energy Consumption Patterns

The analysis confirms Hypothesis 1 (H1), which asserts that Gender Equality impacts Energy Consumption Patterns, with a significant coefficient of 0.662. This result demonstrates a strong positive relationship between gender equality and energy consumption behaviors. This finding suggests that as gender equality improves, there is a notable shift towards more energy-efficient practices within households. Prior research supports this conclusion, indicating that gender equality in household decision-making roles often leads to more conscientious and sustainable energy use. For instance, studies by Aziz et al. (2024) and Shrestha et al. (2021) have shown that increased gender equality in energy management roles correlates with higher adoption rates of energy-efficient technologies. These findings reflect the broader impacts of gender equality on various aspects of household management, where inclusive decision-making processes contribute to more responsible energy consumption.

Furthermore, the positive relationship observed in this study aligns with the broader literature that highlights how gender equality influences household practices. Gender-equal households are more likely to adopt energy-efficient appliances and engage in energy-saving behaviors due to diverse perspectives and shared responsibilities. This is consistent with research by Allen et al. (2019), who found that women's involvement in household energy decisions leads to increased energy conservation efforts. By ensuring equal participation in energy-related decisions, households are more likely to prioritize and implement energy-efficient practices, thereby positively impacting overall energy consumption patterns.

Additionally, the results underscore the importance of promoting gender equality as a strategy for improving energy efficiency. By addressing gender disparities and fostering equal participation in energy management, policymakers and practitioners can enhance household energy practices and support broader sustainability goals. This study contributes to the understanding of how gender equality can drive more sustainable energy consumption behaviors, reinforcing the need for gender-inclusive policies and practices to achieve energy efficiency and sustainability objectives.

Hypothesis 2: Gender Equality Impacts Environmental Sustainability

Hypothesis 2 (H2), which posits that Gender Equality impacts Environmental Sustainability, is supported by the analysis with a significant coefficient of 0.924. This strong positive relationship highlights the role of gender equality in advancing environmental sustainability. The finding suggests that improved gender equality directly contributes to better environmental outcomes, reflecting the growing recognition of the importance of inclusive participation in environmental decision-making. Research by Shinbrot et al. (2019) corroborates this result, indicating that gender equality leads to enhanced environmental stewardship, as women often bring different perspectives and priorities that emphasize sustainability and conservation.

The substantial impact of gender equality on environmental sustainability can be attributed to the increased involvement of women in environmental initiatives and decision-making processes. Gender-equal societies tend to have higher participation rates for women in environmental activism and policy-making, leading to more effective and inclusive sustainability strategies. Previous studies, such as those by Leal Filho et al. (2019), have demonstrated that women's engagement in environmental efforts results in more comprehensive and sustainable solutions to environmental challenges. This supports the notion that gender equality fosters a more inclusive approach to environmental management, which translates into improved sustainability outcomes.

Moreover, the results suggest that promoting gender equality is crucial for achieving environmental sustainability goals. By ensuring equal opportunities for both men and women in environmental roles and decision-making, societies can leverage diverse viewpoints and expertise to address environmental issues more effectively. This study highlights the significant benefits of gender-inclusive environmental policies and practices, reinforcing the importance of gender equality in advancing sustainability initiatives and achieving long-term environmental goals.

Hypothesis 3: Energy Consumption Patterns Impact Environmental Sustainability

The analysis supports Hypothesis 3 (H3), indicating that Energy Consumption Patterns have a positive impact on Environmental Sustainability, with a coefficient of 0.543. This result confirms that households with more efficient and conscious energy consumption behaviors contribute positively to environmental sustainability. The positive relationship underscores the importance of adopting energy-saving practices as a means to enhance environmental outcomes. Previous research, such as the study by Gobel et al. (2024); Santika et al. (2020); and Villamor et al. (2020) has consistently shown that households that engage in energy-saving behaviors, such as using energy-efficient appliances and reducing energy consumption, have a lower environmental impact and contribute to improved sustainability.

Energy Consumption Patterns significantly influence environmental sustainability by reducing the overall environmental footprint associated with energy use. As households adopt energy-efficient technologies and practices, they contribute to lower greenhouse gas emissions and reduced resource consumption, thereby supporting environmental sustainability goals. This finding aligns with research by Mondal & Palit (2022), who found that energy-efficient practices lead to significant reductions in carbon emissions and energy consumption, highlighting the critical role of energy consumption patterns in promoting environmental sustainability.

Additionally, the results emphasize the need for continued efforts to encourage energy-efficient behaviors and technologies. By promoting awareness and adoption of energy-saving practices, policymakers and environmental organizations can further enhance the positive impact of energy consumption patterns on environmental sustainability. This study underscores the importance of integrating energy efficiency measures into broader sustainability strategies to achieve meaningful and lasting environmental benefits.

Hypothesis 4: Energy Consumption Patterns Mediate the Relationship Between Gender Equality and Environmental Sustainability

Hypothesis 4 (H4), which proposes that Energy Consumption Patterns mediate the relationship between Gender Equality and Environmental Sustainability, is supported with a significant coefficient of 0.420. This finding indicates that Energy Consumption Patterns play a crucial mediating role in linking Gender Equality to Environmental Sustainability. Specifically, the positive impact of Gender Equality on Environmental Sustainability is partially explained through its influence on energy consumption behaviors. This mediation effect highlights the complex interplay between gender equality, energy practices, and sustainability outcomes. Research by Amulya Jeevanasai et al. (2023) supports this notion, demonstrating that gender equality enhances energy-efficient behaviors, which in turn contribute to improved environmental sustainability.

The mediation effect of Energy Consumption Patterns underscores the importance of addressing energy behaviors when evaluating the impact of Gender Equality on Environmental Sustainability. By fostering gender equality, households are more likely to adopt energy-efficient practices, which then lead to better environmental outcomes. This aligns with findings from studies such as those by Koengkan et al. (2024), which show that gender-inclusive policies lead to increased energy efficiency and subsequently improved sustainability results. The mediation effect reveals how gender equality can indirectly contribute to environmental sustainability through its influence on energy consumption patterns.

Overall, the results underscore the significance of promoting both gender equality and energy-efficient practices to achieve environmental sustainability goals. By recognizing the mediating role of Energy Consumption Patterns, policymakers and practitioners can develop more comprehensive strategies that address both gender equality and energy efficiency to enhance overall sustainability outcomes. This study highlights the interconnected nature of these constructs and the importance of integrated approaches to achieving sustainability objectives.

CONCLUSION

The findings of this study reveal significant insights into the complex relationships between gender equality, energy consumption patterns, and environmental sustainability. The results confirm that gender equality has a substantial impact on both energy consumption patterns and environmental sustainability, supporting Hypotheses 1 and 2. Specifically, gender equality enhances energy-efficient practices within households and contributes to improved environmental sustainability outcomes. This supports the broader literature that emphasizes the positive effects of inclusive decision-making and equitable access to resources on sustainable behaviors and practices.

The analysis also confirms that energy consumption patterns directly impact environmental sustainability, supporting Hypothesis 3. Households that engage in energy-saving behaviors and use energy-efficient technologies contribute positively to environmental sustainability by reducing their overall environmental footprint. This underscores the critical role of promoting energy-efficient practices as part of broader sustainability strategies.

Additionally, the study demonstrates that energy consumption patterns mediate the relationship between gender equality and environmental sustainability, as evidenced by the significant support for Hypothesis 4. This mediation effect indicates that the positive influence of gender equality on environmental sustainability is partially channeled through changes in energy consumption behaviors. By adopting more energy-efficient practices, households that experience improved gender equality can achieve greater environmental benefits. This finding highlights the importance of considering both direct and indirect effects when evaluating the impact of gender equality on sustainability outcomes.

In conclusion, the study highlights the interconnected nature of gender equality, energy consumption patterns, and environmental sustainability. Promoting gender equality not only leads to more equitable decision-making and resource access but also fosters energy-efficient practices that enhance environmental sustainability. These findings emphasize the need for integrated policies and initiatives that address gender equality and energy efficiency simultaneously to achieve meaningful and sustainable environmental outcomes. By leveraging the positive effects of gender equality on energy consumption and sustainability, policymakers and practitioners can develop more effective strategies to advance both social equity and environmental goals.

Theoretical, Practical, and Social Implications

The findings of this study offer valuable contributions to the theoretical understanding of the relationships between gender equality, energy consumption patterns, and environmental sustainability. The significant support for Hypotheses 1, 2, 3, and 4 enhances the theoretical framework by demonstrating that gender equality not only directly

influences energy consumption patterns and environmental sustainability but also does so indirectly through energy consumption behaviors. This mediation effect underscores the complexity of these relationships and supports the integration of gender perspectives into environmental and energy studies. The study adds depth to existing theories by highlighting how improvements in gender equality can lead to more sustainable practices and better environmental outcomes, thus providing a more nuanced understanding of the interplay between social equity and environmental management.

From a practical standpoint, the study's results underscore the importance of incorporating gender equality considerations into energy and environmental policies. Policymakers and practitioners should recognize that promoting gender equality can lead to more effective energy consumption practices and, consequently, better environmental sustainability. Programs and interventions aimed at reducing gender disparities should be designed to also enhance energy efficiency and support sustainability efforts. For instance, initiatives that empower women and ensure equal access to resources and decision-making can lead to greater adoption of energy-efficient technologies and practices. Additionally, integrating gender-sensitive approaches into environmental policies can help achieve more comprehensive and impactful sustainability goals.

The social implications of this study are profound, particularly in terms of advancing gender equity and environmental justice. By demonstrating that gender equality positively influences energy consumption patterns and environmental sustainability, the research highlights the social benefits of fostering inclusive and equitable environments. Improved gender equality not only supports more balanced decision-making but also promotes environmentally responsible behaviors, leading to broader social and environmental benefits. This aligns with the broader goals of social justice and equity, emphasizing that achieving gender equality can contribute to a more sustainable and equitable society. Furthermore, the study supports the notion that social changes in gender norms and roles can have tangible effects on environmental outcomes, advocating for policies and practices that address both social and environmental dimensions simultaneously.

Limitations and Recommendations

This study, while providing valuable insights, has several limitations that should be acknowledged. Firstly, the sample size, though adequate, may not fully capture the diversity of experiences and perspectives across different regions or demographics within Indonesia. The study's focus on a single country limits the generalizability of the findings to other contexts with different cultural, economic, and environmental conditions. Additionally, the reliance on self-reported survey data introduces potential biases, such as social desirability bias, which may affect the accuracy of the responses related to gender equality, energy consumption patterns, and environmental practices. The cross-sectional nature of the data collection also means that causal relationships cannot be definitively established, as the study only provides a snapshot of the relationships at a single point in time.

To address these limitations, future research should consider employing a larger and more diverse sample to enhance the generalizability of the findings. Including participants from various regions and socio-economic backgrounds could provide a more comprehensive understanding of how gender equality influences energy consumption patterns and environmental sustainability across different contexts. Longitudinal studies would also be beneficial to establish causal relationships and observe how changes in gender equality over time impact energy consumption behaviors and environmental outcomes.

Additionally, incorporating mixed-methods approaches that combine quantitative surveys with qualitative interviews or focus groups could provide deeper insights into the underlying mechanisms and contextual factors influencing the relationships between gender equality and sustainability. Finally, expanding the research to include comparative studies across different countries or regions could offer valuable insights into how cultural and institutional factors shape these relationships and contribute to more effective and contextually relevant policy recommendations.

Conflict of Interest Statement

The authors declare no conflicts of interest related to this research.

Ethical Statement and Approval

This study was conducted in accordance with ethical standards and received approval from the relevant research ethics committee.

Informed Consent

Informed consent was obtained from all participants prior to data collection.

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