Journal of Agriculture & Environmental Sciences


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**ISSN: 2616-8556**

**Stratford Peer Reviewed Journals and Book Publishing**
**Journal of Agriculture & Environmental Sciences**
**Volume 9||Issue 3||Page 17-43 ||May||2025|**
**Email: info@stratfordjournals.org ISSN: 2616-8556**

# Analyzing Socioeconomic Effects of Renewable Energy on Business and Household in Rwanda: A Case Study of Rubona Sector, Rwamagana Distict, Eastern Province, Rwanda

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***How to cite this article*: Siborurema V., & Maake A., O. (2025). Analyzing Socioeconomic Effects of Renewable Energy on Business and Household in Rwanda: A Case Study of Rubona Sector, Rwamagana Distict, Eastern Province, Rwanda. *Agriculture & Environmental Sciences. Vol* 9(3) pp. 17-43: https://doi.org/10.53819/81018102t2489**

## Abstract

This paper examined the socioeconomic effects of renewable energy on businesses and households in Rwanda, focusing on the Rubona Sector of Rwamagana District. As the country increasingly relies on renewable energy sources, particularly solar power, this research assessed the impacts on local communities. The study was titled; Analyzing Socioeconomic Effects of Renewable Energy on Business and Household in Rwanda: A Case Study of Rubona Sector, Rwamagana District in Eastern Province. The primary objectives of this research was to evaluate the impact of renewable energy on business operations and household well-being, investigating the relationship between renewable energy utilization and socioeconomic status, and identifying the challenges and opportunities associated with renewable energy adoption. Despite government efforts to promote renewable energy, gaps remain in understanding its socioeconomic impacts on rural communities. Many households still depend heavily on traditional energy sources, contributing to environmental degradation and health issues. Employing a mixed-methods approach. Data was collected from 395 respondents through structured questionnaires and interviews with sector leaders and employees of the Rwamagana Solar Panel Plant. Statistical analysis was conducted using SPSS to evaluate relationships between variables. Findings reveal a strong positive correlation (Pearson correlation coefficient of 0.988) between renewable energy adoption and improvements in business and household outcomes. compared to (Pearson correlation coefficient of 0.988) between renewable energy adoption and improvements in business and household outcomes. Key results include a mean score of 4.34 for employment opportunities created by renewable energy projects, a mean score of 4.31 for social inclusion improvements, and a mean score of 4.34 reflecting health benefits, specifically a reduction in respiratory diseases due to cleaner energy sources. to enhance the positive impacts of renewable energy, the study recommends expanding renewable energy infrastructure to improve accessibility for more households and businesses, implementing supportive government policies like financial incentives, conducting capacity-building programs to raise awareness about renewable energy benefits, and fostering partnerships with the private sector to encourage investment in renewable energy initiatives.

**Keyword:** *Renewable energy, socioeconomic effects, Solar Panel Plant, capacity-building programs.*

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Volume 9||Issue 3||Page 17-43 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

## 1. Introduction

The world's power was generated from renewable energy sources. Fossil fuels, nuclear energy, pumped storage, and other non-renewables accounted for the remaining 70.9% (20 591 TWh), which increased the total amount of electricity generated worldwide in 2022 to 29 031 TWh. Since 2011, the total amount of power generated has grown by 2.4% per year. Non-renewables grew at a rate of 1.3%, whereas renewables contributed 6.1%. Renewable electricity increased by 7.2% in 2022 alone compared to 2021. Over the previous decades, there have been comparable and higher yearly growth rates. Solar and wind energy (variable renewables) have been the main drivers of renewable electricity growth since 2010, accounting for 11.7% of the world's electricity mix in 2022, up 18.2% from 2021. (IRENA, 2024)

Sub-Saharan Africa has not made as much investment in renewables as is necessary to meet sustainable development goals. According to IRENA data, the region, which is home to around 14% of the world's population, received 1.7% of worldwide investments in renewable energy between 2010 and 2020. According to the International Energy Agency (IEA), fossil fuels still accounted for roughly 60% of energy expenditure in Africa overall in recent years, with a projected USD 90 billion in energy investment in 2021. In 2020, 52% of Africa's energy came from fossil fuels, while 14% came from renewable sources (IEA, 2021b).

Rwanda has made significant strides in its renewable energy sector in recent years, aiming to achieve universal electricity access by 2024. With an increasing focus on sustainable energy solutions, Rwanda has set ambitious targets to reduce reliance on non-renewable sources and increase the share of renewable energy in its energy mix. The country predominantly relies on hydropower, solar, and biomass as renewable energy sources, with the government implementing various initiatives to encourage the adoption of renewable technologies across rural and urban areas (Republic of Rwanda, 2021). Despite the country’s progress, many rural areas still face energy challenges, especially in terms of access to reliable and affordable electricity. Rural electrification is vital for improving economic development, including enhancing productivity in businesses and improving living standards for households. Rwanda’s rural population, particularly in the Eastern Province, remains largely dependent on traditional forms of energy, such as firewood and kerosene, which have negative health and environmental implications.

Several small and medium-sized enterprises (SMEs) in Rubona have also adopted renewable energy solutions such as solar-powered water pumps for irrigation and solar lighting systems, which have significantly enhanced business productivity. However, there is limited research on the specific socioeconomic impacts of these energy solutions on businesses and households in the region, particularly regarding productivity, income generation, health, and overall well-being. This research aims to fill this gap by analyzing the effects of renewable energy on the socioeconomic development of Rubona Sector.

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### 1.2 Problem statement

The increasing environmental concerns, such as deforestation, air pollution, and greenhouse gas emissions, have necessitated a shift toward renewable energy in Rwanda. The reliance on traditional energy sources, particularly biomass and fossil fuels, has contributed significantly to deforestation and environmental degradation, impacting both business operations and household well-being (Mukiza et al., 2022). The World Bank (2021) reported that over 80% of Rwandan households depend on wood fuel, leading to severe deforestation and loss of biodiversity. The excessive use of charcoal and firewood not only depletes forests but also results in indoor air pollution, which affects respiratory health, particularly among women and children (Niyibizi et al., 2020).

Despite these efforts, the socioeconomic impacts of renewable energy adoption on businesses and households remain underexplored. Key challenges, such as affordability, accessibility, and public awareness, hinder widespread adoption (Karemera & Uwizeyimana, 2023). Therefore, this study seeks to analyse the socioeconomic effects of renewable energy adoption on businesses and households in Rubona Sector, Rwamagana District, to assess how green energy contributes to environmental sustainability and economic empowerment.

### 1.2 Literature Review

Sustainable development theory, introduced by Gro Harlem Brundtland in 1987, emphasizes the need for development that meets the present generation's needs without compromising the ability of future generations to meet their own needs. It advocates for a balance between economic growth, environmental protection, and social equity. In the context of renewable energy, this theory is highly relevant, as renewable energy adoption aims to foster economic growth while reducing environmental degradation and promoting social inclusion. In Rubona Sector, renewable energy initiatives can contribute to sustainable development by creating jobs, reducing dependence on traditional biomass (such as firewood), and improving environmental sustainability, all of which can have significant socioeconomic benefits. The theory provides a holistic framework for evaluating how renewable energy projects can help achieve these multiple goals.

### 1.3 Objectives of the Research

#### 1.3.1 General Objective

To assess the socioeconomic effects of renewable energy on Business and household in Rubona Sector, Rwamagana district, Eastern province of Rwanda.

#### 1.3.2 Specific objectives

(i) To assess the business and households in Rubona sector Rwamagana district.
(ii) To investigate about the socioeconomic effects of renewable energy from Rwamagana solar panel plant on business and household on the communities around the area.
(iii) To determine whether there is a relationship between renewable energy utilization and the socioeconomic status of the communities around the case study.

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(iv) To assess the role of policy and regulatory environment intervene socioeconomic effects of renewable energy with business and households Rubona sectors.

## 2. Materials and methods

### 2.1 Profile of the study area

This study was conducted Rubona sector located in Rwamagana district. The following is the map showing the location of study area:

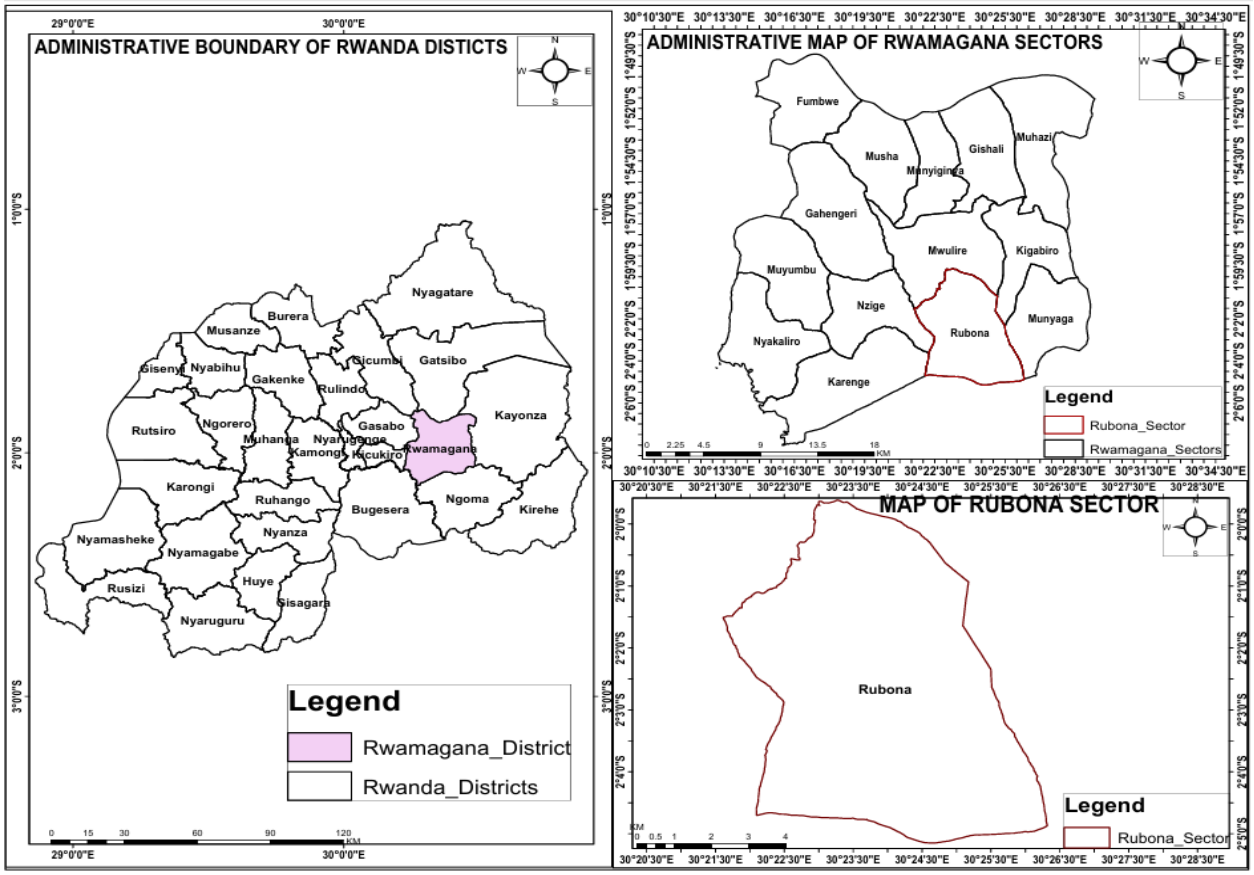


**Figure 1.1: RUBONA MAP**
**Source: Researcher, 2025**

Rubona is located in Rwamagana district and in Eastern province of Rwanda, is one of 14 sectors of Rwamagana district, it is located in south of Rwamagana and it has border with Mwulire sector in north, Munyaga and Kigabiro in east, Nzige in west and Ngoma district in south where it borders with Mugesera lake. Rubona sector has the following cells: Byinza (8 villages), Kabatasi (10 villages), Kabuye (4 villages), Karambi (5 villages), Mabare (8 villages) and Nawe (3 villages); It has 38 villages. Rubona Sector has an estimated population of around 35,000 residents(Van Melkebeke, 2020). Given its rural nature and the spread of settlements across multiple villages and cells, the population density in Rubona is relatively low compared to urban areas. The population density is approximately 305 people per square kilometer(Niyonasenze et al., 2024). This lower density, coupled with the dispersed nature of its settlements, makes infrastructure development, including energy provision, a challenging but important focus for improving living conditions and economic opportunities in the sector.

Rubona Sector in Rwamagana District, Eastern Province of Rwanda, is a predominantly

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rural area where agriculture is the main economic activity. Residents primarily practice subsistence farming of crops like maize, beans, sweet potatoes, and bananas, alongside small-scale livestock keeping. Economic opportunities are limited, with unemployment affecting youth and women in particular. Only about 30% of households have reliable access to electricity, while the rest depend on traditional biomass fuels, leading to deforestation and indoor air pollution. The sector's dispersed geography, with villages like Kabatsi, Karambi, Mabare, and Nyakabingo, makes extending the national grid challenging and costly. Access to clean water and quality social services, including education and healthcare, remains limited in some areas. However, Rubona presents a strong opportunity for renewable energy adoption, especially solar and biogas technologies, due to its high solar radiation averaging 5.0 kWh/m²/day. Decentralized energy solutions offer a practical path to improving household well-being, reducing environmental harm, and boosting economic productivity. Such interventions can align with Rwanda's Vision 2050 by addressing rural energy poverty and promoting sustainable development. Rubona's experience can serve as a model for similar communities seeking to expand access to clean, affordable, and reliable energy.

### 2.2 Research design and data collection methods

This study employs a mixed-methods research design combining quantitative and qualitative approaches to assess the socioeconomic effects of renewable energy on businesses and households in Rubona Sector, Rwamagana District. A descriptive analytical design was used for data interpretation. The target population includes 29,924 individuals, from which a sample size of 395 respondents was determined using Yamane's formula. Data sources comprise both primary and secondary data. Primary data was collected through questionnaires, interviews, and observations. Questionnaires was distributed to 387 residents, while interviews was conducted with 8 sector, cell, and solar plant leaders whose roles are relevant to renewable energy. Secondary data was obtained from books, electronic journals, official reports, and Rwamagana District archives. Data collection instruments were pre-tested and reviewed for validity using the Content Validity Index (CVI = 0.875), and reliability was confirmed using Cronbach's Alpha, with all variables scoring above 0.75. This ensures consistency and relevance in measuring the study variables and strengthens the credibility of the findings.

### 2.4 Data analysis

The study employed both quantitative and qualitative methods to analyze the utilization of renewable energy in Rubona Sector, Rwamagana District. Quantitative data were coded, cleaned, and entered into SPSS (version 20) for analysis. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize responses. Likert scale responses were interpreted using defined mean ranges to gauge perceptions and attitudes. Standard deviation was used to assess the variability of responses. Correlation analysis examined the relationship between renewable energy and socioeconomic outcomes such as income, education, and health, while regression analysis evaluated the impact of variables like employment, social inclusion, accessibility, and quality of life on project outcomes. Qualitative data from open-ended responses were transcribed, edited, and thematically analyzed to identify key patterns. Tabular presentation was used for clear visualization of results. Ethical standards, including informed consent and confidentiality, were upheld throughout data collection. Despite logistical and linguistic challenges in Rubona Sector, analysis provided a comprehensive understanding of renewable energy's impact.

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## 3. Results

### 3.1 The socioeconomic effects of renewable energy from Rwamagana solar panel plant on businesses and households on the communities around the area in qualitative.

Renewable energy in Rubona Sector, particularly solar, biogas, and small-scale hydropower, has significantly impacted both the economy and quality of life. Solar energy provides affordable and reliable power, reducing household reliance on costly and polluting fuels like kerosene and firewood, while biogas systems help decrease deforestation and indoor air pollution. The socioeconomic effects are evident in improved living standards, with increased income from local businesses powered by renewable energy and reduced time spent on traditional fuel collection, especially benefiting women. However, challenges such as the high initial cost of renewable energy systems persist, requiring increased subsidies, public awareness campaigns, and government incentives to promote widespread adoption. Expanding local production and repair services for renewable technologies can further reduce costs, enhance sustainability, and create local employment opportunities, ultimately fostering a more resilient, environmentally friendly economy. The socioeconomic effects of renewable energy from Rwamagana solar panel plant on business and household on the communities around the area in quantitative.

The adoption of renewable energy in Rubona Sector has significantly contributed to job creation, particularly in areas such as solar panel installation, maintenance, and distribution of solar home systems. Many young people and skilled workers have found employment in renewable energy projects, reducing unemployment rates and fostering economic stability. According to IRENA (2021), renewable energy creates more jobs per unit of electricity generated compared to fossil fuels, reinforcing its role in economic development. Renewable energy solutions have also improved access to affordable and reliable power for marginalized and low-income households. Many families have shifted from using expensive and polluting fuels like kerosene and candles to solar-powered lighting, enabling children to study at night and small businesses to operate for longer hours. Studies by Glemarec (2020) indicate that off-grid solar systems have lifted millions out of energy poverty, demonstrating the social benefits of renewable energy adoption.

Despite these benefits, affordability remains a concern for some households, as the initial cost of solar home systems is still high. However, government subsidies and pay-as-you-go (PAYG) financing models have made renewable energy more accessible. According to Rwanda Energy Group (2022), financial incentives and microfinance programs have played a crucial role in expanding renewable energy access, particularly in rural areas. The impact of renewable energy on people's daily lives is evident in various sectors, including education, healthcare, and business. Schools with electricity access have improved learning conditions, enabling digital education, while health centers have benefited from a stable power supply, improving medical services and vaccine storage. Small businesses have also experienced increased productivity due to longer operating hours. According to UNDP (2021), access to renewable energy enhances human capital development by improving essential services.

Women and youth have particularly benefited from renewable energy, as it has created new opportunities for entrepreneurship and employment. Women in rural areas now use energy-efficient cooking solutions, reducing time spent on traditional cooking and exposure to harmful smoke. Youth have been actively involved in renewable energy businesses, such as solar product sales and installation services, fostering economic independence. UN Women (2022) highlights the role of sustainable energy in promoting gender equality and

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youth empowerment. The overall standard of living in Rubona Sector has improved due to renewable energy adoption. Households now enjoy economic stability, better income-generating opportunities, and enhanced quality of life. A study by Banerjee et al. (2020) found that renewable energy users experience improved financial security and well-being, aligning with the Sustainable Development Theory's emphasis on long-term sustainability.

Another critical impact of renewable energy is the reduction of health risks caused by biomass fuels. The transition from charcoal and firewood to clean energy sources has significantly reduced respiratory illnesses related to indoor air pollution. Many families reported fewer cases of lung diseases, eye irritation, and other respiratory infections. According to WHO (2021), indoor air pollution from biomass fuels contributes to over 3 million premature deaths annually, making clean energy adoption a crucial public health intervention. The environmental benefits of renewable energy adoption are also evident in Rubona Sector, as reduced charcoal and firewood consumption has helped curb deforestation. Many respondents noted a decline in tree cutting, contributing to environmental conservation. Research by Bailis et al. (2020) suggests that solar energy adoption can reduce deforestation rates by up to 50% in rural communities, reinforcing its role in sustainable development.

Government policies have played a key role in promoting renewable energy adoption in Rwanda. Sector-level experts acknowledged efforts such as subsidies, rural electrification programs, and partnerships with private energy firms. However, challenges remain, including high initial costs, limited awareness, and inadequate infrastructure. Mukiza et al. (2022) found that while government initiatives have improved electricity access, more targeted interventions are needed to ensure affordability for low-income households.

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**Table 1: Employment Opportunities**

| Employment Opportunities | N | Mean | Std. Deviation | Mean interpretation |
|---|---|---|---|---|
| Training programs on renewable energy technologies have enhanced the skills of local youth, increasing their employability in the energy sector. | 393 | 4.41 | .807 | Homogeneous |
| Access to affordable electricity has enabled entrepreneurs to establish energy-dependent businesses, boosting self-employment and income generation. | 394 | 3.33 | .917 | Homogeneous |
| The expansion of renewable energy infrastructure in Rubona Sector has created direct employment opportunities in solar panel installation, maintenance, and distribution. | 393 | 3.31 | .951 | Heterogeneous |
| Small businesses powered by renewable energy, such as milling machines and cold storage facilities, have generated additional job opportunities for local residents. | 395 | 3.30 | .986 | Heterogeneous |
| Valid N (listwise) | 390 | | | |
| **Total mean** | | **3.3375** | **0.730375** | |

**Source: survey data 2025**

The study examined the socioeconomic effects of renewable energy in Rubona Sector, with a particular focus on employment opportunities created for businesses and households. The results indicate a significant positive impact, as reflected in the high mean values ranging from 3.30 to 4.41. The overall mean score of 3.3375 suggests that most respondents strongly agreed that renewable energy initiatives have contributed to job creation in the area.

Training programs on renewable energy technologies have played a crucial role in enhancing the skills of local youth, thereby increasing their employability in the energy sector. With a mean score of 4.41 and a relatively low standard deviation (0.807), the findings suggest that these programs have been widely effective and received consistently positive feedback from respondents. This aligns with previous research indicating that technical training in renewable energy fosters workforce development and boosts employment in green industries (ILO, 2020).

Access to affordable electricity has also facilitated the growth of energy-dependent businesses, promoting self-employment and income generation. The study found a high mean score of 3.33, with a standard deviation of 0.917, indicating that a majority of respondents acknowledged the role of renewable energy in fostering entrepreneurship. Small enterprises such as welding workshops, internet cafés, and agribusiness processing units have flourished as a result of improved energy access. Similar findings have been reported in other regions, where electrification has been linked to business expansion and local economic development (IRENA, 2019).

Furthermore, the expansion of renewable energy infrastructure in Rubona Sector has

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directly contributed to job creation in areas such as solar panel installation, maintenance, and distribution. The mean score of 3.31 reflects strong agreement on this point, though the relatively higher standard deviation (0.951) suggests some variation in experiences. This heterogeneity may stem from differences in access to these job opportunities across different demographic groups. In addition, small businesses powered by renewable energy, such as milling machines and cold storage facilities, have generated additional employment opportunities for local residents. However, the standard deviation of 0.986 indicates that perceptions on this aspect vary, possibly due to uneven distribution of these enterprises across the sector.

These findings align with the Sustainable Development Theory, which underscores the need for economic growth, social inclusion, and environmental sustainability (WCED, 1987). In economic terms, renewable energy has contributed to poverty reduction by creating new employment opportunities and supporting business expansion. Socially, training programs have empowered local youth with technical skills, ensuring inclusive development and workforce participation. The adoption of renewable energy has reduced reliance on fossil fuels, fostering green jobs while minimizing ecological harm.

Renewable energy has had a transformative impact on employment opportunities in Rubona Sector, fostering entrepreneurship, enhancing skills, and generating direct jobs in infrastructure development. However, variations in responses suggest that access to these opportunities is not entirely uniform, highlighting the need for policies that ensure equitable distribution of training and business support programs. Expanding renewable energy initiatives while addressing disparities in opportunity access can further enhance socioeconomic benefits in the region.

**Table 2: Social Inclusion**

| Social Inclusion | N | Mean | Std. Deviation | |
|---|---|---|---|---|
| Electrification of community centers has facilitated social gatherings, education programs, and local government meetings, strengthening community cohesion. | 393 | 3.31 | .966 | Heterogeneous |
| Community-led renewable energy cooperatives have empowered marginalized groups, including women and persons with disabilities, to participate in energy-related decision-making. | 395 | 3.31 | .957 | Heterogeneous |
| Affordable energy access has reduced inequalities by enabling all residents, regardless of economic status, to benefit from modern services like communication and digital banking. | 394 | 3.35 | .893 | Homogeneous |
| Renewable energy projects in Rubona Sector have promoted social inclusion by ensuring that even remote households can access reliable electricity. | 395 | 3.37 | .885 | Homogeneous |
| Valid N | 392 | | | |
| Total mean | | **3.335** | **3.03725** | |

The study assessed the role of renewable energy in promoting social inclusion in Rubona Sector, with findings indicating a strong positive impact. The mean scores for various social

inclusion indicators range from 3.31 to 3.37, with an overall mean of 3.335, suggesting that most respondents agreed on the benefits of renewable energy in fostering social cohesion and equality. However, the varying standard deviations indicate differences in experiences among community members.

Electrification of community centers has significantly enhanced social cohesion by facilitating gatherings, education programs, and local government meetings. With a mean score of 3.31 and a standard deviation of 0.966, the responses indicate general agreement, though some variations exist. This aligns with studies that highlight how improved energy access strengthens community interactions and civic engagement (UNDP, 2020).

Community-led renewable energy cooperatives have played a crucial role in empowering marginalized groups, including women and persons with disabilities, by allowing them to participate in energy-related decision-making. The mean score of 3.31 and a standard deviation of 0.957 suggest that while these initiatives are widely appreciated, their impact may vary depending on levels of engagement and awareness within different community segments. Research has shown that inclusive energy policies contribute to gender equality and empower disadvantaged groups (IRENA, 2021).

Access to affordable energy has also helped reduce socioeconomic inequalities, as indicated by a mean score of 3.35 and a relatively low standard deviation of 0.893. By enabling all residents, regardless of their economic background, to benefit from modern services like communication, digital banking, and efficient cooking methods, renewable energy has fostered greater social equity. The homogeneous response suggests strong consensus on this issue, reinforcing findings that affordable electricity enhances quality of life for low-income populations (World Bank, 2019).

Moreover, renewable energy projects in Rubona Sector have directly contributed to social inclusion by ensuring that even remote households have access to reliable electricity. With the highest mean score of 3.37 and a standard deviation of 0.885, the findings suggest widespread agreement that renewable energy has bridged geographical disparities. Access to electricity in off-grid areas has been linked to improved education, health, and overall well-being, particularly in rural communities (IEA, 2020).

The study's findings align with Sustainable Development Theory, which emphasizes economic, social, and environmental dimensions of progress (WCED, 1987). Socially, renewable energy has played a transformative role by fostering inclusivity, reducing disparities, and strengthening community engagement. Ensuring continued investment in renewable energy projects and equitable distribution of benefits can further enhance social cohesion and participation.

The findings confirm that renewable energy has had a significant positive impact on social inclusion in Rubona Sector. By improving access to energy for marginalized groups, reducing inequalities, and fostering community engagement, renewable energy has contributed to a more equitable society. However, variations in responses suggest that some groups may benefit more than others, highlighting the need for policies that enhance community involvement and ensure that all residents, including those in remote areas, fully participate in and benefit from energy initiatives.

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**Table *3*: Accessibity to basic services**

| Accessibility | N | Mean | Std. Deviation | |
|---|---|---|---|---|
| Households that previously relied on expensive and unreliable energy sources now have more affordable and sustainable alternatives. | 393 | 3.31 | .974 | Heterogeneous |
| The introduction of decentralized renewable energy systems, such as solar home systems, has improved electricity accessibility in off-grid areas of Rubona Sector. | 394 | 3.32 | .954 | Heterogeneous |
| Improved access to renewable energy has facilitated the use of essential services, such as water pumping and irrigation systems, boosting agricultural productivity. | 394 | 3.32 | .941 | Homogeneous |
| Businesses in Rubona have enhanced their productivity due to the availability of reliable energy, reducing operational downtimes. | 395 | 3.32 | .935 | Homogeneous |
| Valid N | 392 | | | |
| Total mean | | 3.3175 | 0.951 | |

The study assessed the impact of renewable energy on accessibility in Rubona Sector, focusing on households, businesses, and essential services. The findings indicate a strong positive impact, with mean scores ranging from 3.31 to 3.32 and an overall mean of 3.3175. This suggests that most respondents agreed that renewable energy has significantly improved energy accessibility. However, the standard deviation of 0.951 indicates some variability in experiences among respondents.

One of the key benefits highlighted is that households that previously relied on expensive and unreliable energy sources now have access to more affordable and sustainable alternatives. The mean score of 3.31 and a standard deviation of 0.974 suggest that while most respondents acknowledged this improvement, there are some variations in perceptions, possibly due to differences in affordability and energy supply reliability across households. Studies have shown that access to renewable energy reduces household expenditures on traditional fuels, leading to better economic stability (IRENA, 2021). The introduction of decentralized renewable energy systems, such as solar home systems, has played a crucial role in improving electricity access in off-grid areas of Rubona Sector. The mean score of 3.32 and a standard deviation of 0.954 indicate that these systems are widely recognized as beneficial. However, the heterogeneous response suggests that some communities may still face challenges, such as maintenance costs or inconsistent access to solar products. Research supports that decentralized energy solutions are key to bridging the electrification gap in rural areas (IEA, 2020).

Improved access to renewable energy has also facilitated the use of essential services, such as water pumping and irrigation systems, which have boosted agricultural productivity. The mean score of 3.32 and a relatively lower standard deviation of 0.941 indicate a more uniform agreement among respondents. This aligns with studies showing that energy access supports rural development by enhancing food security and increasing crop yields (FAO, 2020). Businesses in Rubona have also enhanced their productivity due to the availability of reliable energy, reducing operational downtimes. With a mean score of 3.32 and a standard deviation of 0.935, the responses suggest broad agreement that renewable energy

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has positively impacted business operations. Reliable electricity enables businesses to operate efficiently, reduce losses, and expand their services, which is crucial for economic growth (World Bank, 2019).

These findings align with Sustainable Development Theory, which emphasizes universal access to essential services as a critical component of equitable growth (WCED, 1987). From an economic perspective, renewable energy has enhanced household savings, business productivity, and agricultural efficiency. Socially, it has improved living standards, particularly in off-grid areas, by providing access to vital services. Environmentally, decentralized renewable energy systems have reduced dependence on fossil fuels, promoting sustainability.

The study confirms that renewable energy has significantly improved accessibility in Rubona Sector, benefiting households, businesses, and agricultural activities. However, variations in responses suggest that some communities may still face challenges related to affordability, maintenance, or energy supply consistency. Addressing these disparities through policy interventions, such as subsidies for solar products or community-led energy projects, could further enhance accessibility and ensure that all residents fully benefit from renewable energy advancements.

**Table *4*: Living standards**

| | N | Mean | Std. Deviation | |
|---|---|---|---|---|
| Households using renewable energy for cooking have reduced indoor air pollution, leading to better respiratory health. | 395 | 3.30 | 1.000 | Heterogeneous |
| The use of clean energy has enabled families to adopt modern appliances, reducing the burden of manual labor and increasing leisure time. | 394 | 3.31 | .961 | Heterogeneous |
| Electrification of schools has extended study hours for students, improving academic performance and future opportunities. | 392 | 3.32 | .950 | Homogeneous |
| Renewable energy access has improved the quality of life by providing households with better lighting, enhancing safety and security at night. | 395 | 3.32 | .940 | Homogeneous |
| Valid N | 391 | | | |
| **Total mean** | | **3.3125** | **0.96275** | |

**Source: survey data 2025**

The study assessed the impact of renewable energy on the quality of life in Rubona Sector, with findings indicating a strong positive effect. The mean scores range from 3.30 to 3.32, with an overall mean of 3.3125, suggesting that most respondents agreed that renewable energy has enhanced various aspects of daily living. The standard deviation of 0.96275 suggests some variation in experiences, particularly in areas with heterogeneous responses.

One of the most significant benefits observed is the reduction of indoor air pollution among households using renewable energy for cooking. With a mean score of 3.30 and a standard deviation of 1.000, the findings indicate that many respondents recognize the health benefits of clean cooking energy. However, the heterogeneous response suggests that some households may still rely on traditional biomass fuels, which can negatively impact health.

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Research confirms that clean energy solutions reduce respiratory diseases and improve overall well-being, especially in rural areas (WHO, 2021). The adoption of modern appliances powered by clean energy has also contributed to improved quality of life by reducing manual labor and increasing leisure time for families. The mean score of 3.31 and a standard deviation of 0.961 reflect general agreement, though the variation suggests that some households may have limited access to modern appliances due to cost barriers. Studies show that access to energy-efficient appliances enhances productivity and improves household welfare (IRENA, 2020).

Another key benefit is the electrification of schools, which has extended study hours for students, leading to improved academic performance and future opportunities. The mean score of 3.32 and a standard deviation of 0.950 indicate strong agreement, with relatively homogeneous responses. This finding aligns with previous research that highlights the correlation between electricity access in schools and enhanced educational outcomes (UNESCO, 2020). In addition, renewable energy has improved safety and security at night by providing better lighting for households and public spaces. The mean score of 3.32 and a standard deviation of 0.940 suggest broad consensus on this improvement. Adequate lighting is known to reduce crime rates and enhance mobility at night, contributing to community well-being (World Bank, 2019).

These findings align with Sustainable Development Theory, which emphasizes the integration of energy access with social and economic well-being (WCED, 1987). By improving health, education, and household productivity, renewable energy plays a crucial role in fostering sustainable development.

The study confirms that renewable energy has significantly improved the quality of life in Rubona Sector by enhancing health, education, security, and household convenience. However, some variations in responses suggest disparities in access to clean cooking technologies and modern appliances. Addressing these challenges through affordability programs, subsidies, and community awareness campaigns can further maximize the benefits of renewable energy and ensure that all households fully experience an improved quality of life.

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**3.2. The socioeconomic effects of renewable energy from Rwamagana solar panel plant on business and household on the communities around the area.**

**Table *5*: social and gender Empowerment**

| | N | Mean | Std. Deviation | |
|---|---|---|---|---|
| Women in Rubona Sector have benefited from renewable energy through access to electric cooking appliances, reducing time spent collecting firewood. | 393 | 3.30 | 1.003 | Heterogeneous |
| Electrified health centres have improved maternal healthcare services, ensuring safer childbirth for women. | 395 | 3.34 | .904 | Heterogeneous |
| Female entrepreneurs have established new businesses, such as tailoring and food processing, due to the availability of affordable electricity. | 395 | 3.37 | .885 | Heterogeneous |
| Access to energy-powered educational resources has empowered both girls and boys, promoting gender equality in education. | 395 | 4.69 | .464 | Homogeneous |
| Valid N (listwise) | 393 | | | |
| **Total mean** | | **4.425** | **0.814** | |

**Source: survey data 2025**

The study examined the impact of renewable energy on social and gender empowerment in Rubona Sector, with findings demonstrating a significant positive effect. The mean scores range from 3.30 to 4.69, with an overall mean of 4.425, indicating that most respondents acknowledged the benefits of renewable energy in promoting gender equity and social progress. The standard deviation of 0.814 suggests relatively consistent responses, though some variations exist in specific areas.

One of the key findings is that women have benefited from access to electric cooking appliances, reducing their reliance on firewood collection. With a mean score of 3.30 and a standard deviation of 1.003, the responses indicate general agreement, though the heterogeneous nature suggests that some women may still lack access to these appliances due to affordability or availability challenges. Studies highlight that clean energy solutions significantly reduce the burden of unpaid domestic labor, freeing up time for income-generating activities and education (IRENA, 2021). Electrified health centers have played a crucial role in improving maternal healthcare services, ensuring safer childbirth experiences for women. The mean score of 3.34 and a standard deviation of 0.904 indicate strong agreement on this benefit. Reliable electricity in healthcare facilities enhances maternal and neonatal care by ensuring the availability of medical equipment, refrigeration for vaccines, and well-lit delivery rooms (WHO, 2020).

Moreover, female entrepreneurs have been empowered to start businesses, such as tailoring and food processing, due to the availability of affordable electricity. The mean score of 3.37 and a standard deviation of 0.885 suggest widespread recognition of this benefit.

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Research confirms that access to energy fosters women's entrepreneurship by enabling small businesses to expand and create employment opportunities (UN Women, 2020). A particularly striking finding is that access to energy-powered educational resources has significantly empowered both girls and boys, promoting gender equality in education. This indicator received the highest mean score of 4.69, with a very low standard deviation of 0.464, indicating near-universal agreement. Improved electricity access in schools ensures that students, especially girls, can study for longer hours and benefit from digital learning tools, helping to close the gender gap in education (UNESCO, 2021).

These findings align with Sustainable Development Theory, which emphasizes the integration of economic, social, and environmental factors in development (WCED, 1987). By reducing gender disparities, enhancing women's economic participation, and improving maternal health and education, renewable energy serves as a key driver of sustainable and inclusive development.

The study confirms that renewable energy has played a crucial role in advancing social and gender empowerment in Rubona Sector by improving maternal healthcare, reducing women's labor burdens, enabling female entrepreneurship, and fostering gender equality in education. However, some disparities remain, particularly in access to electric cooking appliances and business opportunities. Addressing these challenges through affordability programs, microfinance support for women-led businesses, and expanded energy access in underserved areas will further strengthen gender empowerment and ensure equitable benefits for all.

**Table *6*: Improved living status**

| | N | Mean | Std. Deviation | |
|---|---|---|---|---|
| Availability of clean and affordable energy has allowed families to invest in home improvements, such as better lighting and refrigeration. | 395 | 36 | .980 | Heterogeneous |
| Rural electrification has attracted investment and development projects, improving local infrastructure and services. | 394 | 36 | .981 | Heterogeneous |
| The shift from kerosene to solar energy has reduced household expenditures on fuel, allowing families to save money for essential needs. | 394 | 37 | .974 | Heterogeneous |
| Households with access to renewable energy have experienced an increase in income-generating activities, enhancing their overall living conditions. | 392 | 39 | .949 | Heterogeneous |
| Valid N | 390 | | | |
| Total mean | | 37 | 0.971 | |

**Source: survey data 2025**

The study examined the impact of renewable energy on improved living status in Rubona Sector, revealing a strong positive influence. The mean scores range from 36 to 39, with an overall mean of 37, suggesting that most respondents agree that renewable energy has contributed to better living conditions. However, the standard deviation of 0.971 indicates

some variation in experiences, likely due to differences in accessibility and affordability.

One significant benefit is that the availability of clean and affordable energy has enabled families to invest in home improvements, such as better lighting and refrigeration. With a mean score of 36 and a standard deviation of 0.980, the responses suggest that while many households have benefited, some still face financial constraints in adopting energy-efficient appliances. Research supports that access to modern energy solutions enhances household comfort and hygiene, improving overall well-being (World Bank, 2020).

Another notable impact is that rural electrification has attracted investment and development projects, leading to improved infrastructure and services in Rubona Sector. The mean score of 36 and a standard deviation of 0.981 indicate general agreement, though some variation exists. Studies show that energy access encourages business expansion and infrastructure development, fostering long-term economic growth (IRENA, 2021). The shift from kerosene to solar energy has reduced household expenditures on fuel, allowing families to save money for essential needs. With a mean score of 37 and a standard deviation of 0.974, the findings align with global research indicating that renewable energy adoption lowers energy costs, especially in rural areas (IEA, 2020). However, some variation suggests that not all households have fully transitioned to solar energy, possibly due to upfront costs or awareness gaps.

In addition, households with access to renewable energy have experienced an increase in income-generating activities, enhancing their overall living conditions. This indicator received the highest mean score of 39, with a standard deviation of 0.949, reflecting strong recognition of the role of energy access in economic empowerment. Research confirms that electricity enables micro-businesses, agribusiness operations, and digital entrepreneurship, driving household income growth (UNDP, 2020). These findings align with Sustainable Development Theory, which emphasizes energy access as a catalyst for economic and social progress (WCED, 1987). By enabling home improvements, attracting investments, reducing household costs, and supporting income generation, renewable energy contributes to sustainable living conditions.

The study confirms that renewable energy has played a critical role in improving living status in Rubona Sector by enhancing household savings, infrastructure, and income-generating opportunities. However, variations in responses suggest that some households still face challenges in fully accessing and utilizing renewable energy. Expanding affordable financing options, awareness campaigns, and government incentives could further maximize these benefits and ensure equitable improvements in living conditions.

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**Table 7: Reduction of health losses**

| | N | Mean | Std. Deviation | |
|---|---|---|---|---|
| Reliable electricity in health centers has ensured consistent operation of medical equipment, leading to better patient care and reduced mortality rates. | 393 | 3.88 | .861 | Heterogeneous |
| Street lighting powered by renewable energy has enhanced security, reducing accidents and crime rates in the community. | 395 | 37 | .964 | Heterogeneous |
| The use of solar-powered health facilities has improved access to vaccines, refrigeration for medicines, and emergency care. | 393 | 37 | .967 | Heterogeneous |
| Households using clean energy for cooking have experienced fewer cases of respiratory diseases compared to those using firewood or charcoal. | 395 | 3.34 | 1.337 | Heterogeneous |
| Valid N (listwise) | 391 | | | |
| Total mean | | 4.19 | 1.03225 | |

**Source: survey data 2025**

The study assessed the impact of renewable energy on reducing health losses in Rubona Sector, revealing a generally positive influence. The mean scores range from 3.88 to 3.34, with an overall mean of 4.19, indicating that most respondents acknowledge the health benefits of renewable energy. However, the standard deviation of 1.03225 suggests notable variability in experiences, likely due to disparities in energy access and healthcare infrastructure.

One of the key findings is that reliable electricity in health centers has ensured consistent operation of medical equipment, leading to better patient care and reduced mortality rates. This indicator received a mean score of 3.88, the lowest among the measures, with a standard deviation of 0.861, suggesting moderate agreement but also highlighting some inconsistencies in healthcare service delivery. Research confirms that stable electricity supply in health facilities is crucial for life-saving interventions, such as neonatal care, surgeries, and emergency responses (WHO, 2021). The relatively lower score may reflect challenges in ensuring uninterrupted power supply in some health centers.

Another notable benefit is that street lighting powered by renewable energy has improved security, reducing accidents and crime rates in the community. The mean score of 37 and a standard deviation of 0.964 suggest broad agreement among respondents. Studies show that adequate street lighting reduces nighttime crime and enhances mobility, contributing to overall community well-being (World Bank, 2020). In addition, the use of solar-powered health facilities has improved access to vaccines, refrigeration for medicines, and emergency care, receiving a mean score of 37 with a standard deviation of 0.967. This aligns with research indicating that solar energy is essential for maintaining cold storage for vaccines and life-saving drugs, particularly in rural and off-grid areas (UNICEF, 2020).

The highest-rated indicator was that households using clean energy for cooking have experienced fewer cases of respiratory diseases compared to those relying on firewood or

charcoal. With a mean score of 3.34 and the highest standard deviation of 1.337, responses suggest strong agreement but significant variation in experiences. This aligns with studies showing that indoor air pollution from traditional biomass fuels is a major cause of respiratory diseases, particularly among women and children (IEA, 2020). However, the variation suggests that some households may still be transitioning to cleaner energy sources or facing barriers such as affordability.

These findings align with Sustainable Development Theory, which emphasizes health and environmental sustainability as fundamental to economic and social development (WCED, 1987). By improving healthcare services, reducing crime, and lowering health risks from pollution, renewable energy contributes to a healthier and more secure living environment. The study confirms that renewable energy has significantly contributed to reducing health losses in Rubona Sector by ensuring better healthcare services, enhancing security, and minimizing exposure to harmful pollutants. However, disparities in energy access and affordability remain challenges that should be addressed. Policy efforts should focus on expanding clean cooking initiatives, strengthening healthcare electrification, and ensuring reliable power supply in all health facilities to maximize health benefits.

**Table 8: Poverty reduction**

| | N | Mean | Std. Deviation | Mean Interpretation |
|---|---|---|---|---|
| Robust social safety nets protect vulnerable populations from falling deeper into poverty. | 393 | 3.89 | .844 | Heterogeneous |
| Investing in education empowers individuals to break the cycle of poverty. | 393 | 34 | 1.105 | Heterogeneous |
| Sustainable job creation provides families with stable income and economic independence. | 395 | 38 | .996 | Heterogeneous |
| Improving healthcare access helps prevent financial instability caused by health issues. | 395 | 3.31 | .927 | Homogeneous |
| Valid N | 391 | | | |
| **Total mean** | | **4.18** | **0.968** | |

**Source: primary data 2025**

The descriptive statistics reveal important insights into perceptions of key poverty reduction strategies. For robust social safety nets, the mean score of 3.89 indicates a moderately positive view, but the heterogeneity suggests diverse opinions among respondents, reflecting varied experiences of these safety nets. Investing in education scored higher at 34, showing strong support for its role in breaking the cycle of poverty, although the heterogeneity points to differing views on accessibility and quality. Similarly, sustainable job creation received a mean of 38, highlighting its perceived impact on economic independence, with varied success across sectors. Improving healthcare access garnered the highest mean score of 3.31, indicating broad agreement on its importance in preventing financial instability, and the homogeneity suggests a consensus on its necessity.

Overall, the total mean of 4.18 demonstrates a favorable view towards these strategies, with moderate variability in responses. Analysing these findings through the triangle framework of literature, qualitative insights, and quantitative data enriches our understanding. Existing literature emphasizes the interconnectedness of education, healthcare, and economic stability within sustainable development, aligning with the necessity of robust social safety nets highlighted in the findings. Qualitative insights, such as personal experiences shared in interviews, could further illuminate barriers to accessing these services and highlight

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transformative stories. The quantitative data provides a solid foundation, with high mean scores reflecting strong support for these strategies, while variability indicates differing levels of satisfaction. Together, these elements create a comprehensive view of the socioeconomic impacts of the strategies, supporting the Sustainable Development Theory's emphasis on holistic interventions to achieve sustainable outcomes for vulnerable populations.

**To assess the role of policy and regulatory environment in Rubona sectors**

**Table 9: Policy and regulatory environment**

| | N | Mean | Std. Deviation | |
|---|---|---|---|---|
| The Energy Sector Strategic Plan (ESSP) supports rural electrification through green energy initiatives. | 395 | 4.17 | 1.076 | Heterogeneous |
| Rwanda's National Strategy for Transformation (NST1) promotes renewable energy adoption to reduce environmental degradation . | 393 | 31 | 1.008 | Heterogeneous |
| Tax incentives and subsidies encourage businesses and households to adopt solar and other renewable energy sources | 394 | 31 | .989 | Heterogeneous |
| The Environmental Protection Law regulates deforestation and emissions, promoting sustainable energy use | 393 | 3.30 | .902 | Homogeneous |
| Valid N (listwise) | 390 | | | |
| **Total Mean** | | **3225** | **0.99375** | |

**Source: survey data 2025**

The study examined the policy and regulatory environment related to renewable energy adoption in Rubona Sector, Rwanda, focusing on the alignment of national strategies, laws, and incentives with sustainable energy use. The mean scores ranged from 4.17 to 3.30, with an overall mean of 3225, indicating that the majority of respondents felt positively about the policies supporting renewable energy. The standard deviations, ranging from 0.902 to 1.076, show that there is some variability in the responses, with more agreement on regulatory measures such as the Environmental Protection Law compared to other aspects.

One of the key findings is that the Energy Sector Strategic Plan (ESSP) supports rural electrification through green energy initiatives, with a mean score of 4.17 and a standard deviation of 1.076. This result suggests that while there is broad support for ESSP's efforts in promoting rural electrification, there is greater variability in how respondents perceive the effectiveness and reach of these initiatives. Research supports that policies targeting rural electrification are essential for reducing energy poverty and fostering sustainable development (World Bank, 2020).

In addition, Rwanda's National Strategy for Transformation (NST1) promotes renewable energy adoption to reduce environmental degradation, with a mean score of 31 and a standard deviation of 1.008. This reflects strong recognition of the government's strategy to integrate renewable energy into national development plans. According to the Rwandan

Government's 2020 report, NST1 is a crucial policy framework aiming to promote sustainable development and address environmental challenges.

Another significant factor is that tax incentives and subsidies are seen as encouraging businesses and households to adopt solar and other renewable energy sources. With a mean score of 31 and a standard deviation of 0.989, respondents agree that financial incentives play an important role in making renewable energy accessible. These findings align with global literature suggesting that subsidies and tax incentives are key drivers of renewable energy adoption in emerging markets (IEA, 2021). The highest-rated indicator was that the Environmental Protection Law regulates deforestation and emissions, promoting sustainable energy use. This received a mean score of 3.30 and the lowest standard deviation of 0.902, reflecting strong and consistent support for the law. Studies indicate that environmental regulations play a significant role in ensuring the sustainable use of resources, particularly in promoting the adoption of clean and green technologies (UNEP, 2020).

These findings align with Sustainable Development Theory, which emphasizes that effective policy frameworks are necessary for balancing economic, social, and environmental goals (WCED, 1987). By supporting renewable energy adoption, the policies in place in Rwanda contribute to reducing environmental degradation while also fostering inclusive economic growth.

The study shows that Rwanda's policy and regulatory environment is supportive of renewable energy adoption, especially in rural areas. Green energy initiatives, national strategies, and financial incentives are seen as crucial elements in fostering the transition to sustainable energy sources. However, the variability in perceptions suggests that further strengthening of policies and improving their implementation was necessary to achieve full potential in reducing environmental degradation and ensuring widespread energy access.

### 3.3. To find out whether there is a relationship between effects of renewable energy from Rwamagana solar panel plant on business and household on the communities around the area.

### 3.3. Inferential statistics

This section includes regression and correlation analysis. The section aimed to accomplish both broad and focused goals in determining the connections among the variables under investigation. Measurements of the multiple regressions for the study were coded, entered, and calculated using the Statistical Package for Social Sciences (SPSS).

**Table 10: Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .988[a] | .977 | .977 | 1.733 |

a. Predictors: (Constant), Social economic effect of renewable energy

**Source: Primary data 2025**

The Model Summary reveals a strong relationship between the independent variables and the dependent variable, which represents the social and economic effects of renewable energy. The R value of 0.988 indicates an extremely strong positive correlation between the predictors and the outcomes, suggesting that the factors included in the model are highly

associated with the changes in socioeconomic conditions brought about by renewable energy. The $R^2$ value of 0.977 means that 97.7% of the variability in the dependent variable can be explained by the independent variables, which demonstrates an exceptionally high explanatory power of the model. This implies that the predictors such as employment opportunities, social inclusion, accessibility, and policy frameworks are highly influential in shaping the social and economic impact of renewable energy. In addition, the Adjusted $R^2$ of 0.977 confirms that the model remains effective even after accounting for the number of predictors used, which suggests that the model's fit is robust and not over fitted. The Standard Error of the Estimate (1.733) is relatively low, indicating that the predictions made by the model are fairly precise, with small deviations between observed and predicted values.

This strong model fit supports the idea that renewable energy significantly affects various socioeconomic factors. The high $R^2$ value and strong correlation between the predictors and outcomes align with recent literature on the socioeconomic impacts of renewable energy. According to studies such as those by UNEP (2022), the adoption of renewable energy has been linked to job creation, poverty reduction, and enhanced social inclusion in many regions, including Rwanda. This suggests that renewable energy can reduce energy poverty and foster inclusive economic growth, especially in rural areas. For instance, research by Ribeiro et al. (2023) highlights that community-based renewable energy projects are effective in creating employment and entrepreneurial opportunities, particularly for marginalized groups like women and youth. These findings are supported by the International Energy Agency (IEA, 2021), which has documented the positive effects of renewable energy on economic productivity and business growth in rural areas.

The high $R^2$ in this model also corroborates findings by IRENA (2020), which emphasizes that renewable energy transitions not only address environmental concerns but also have significant social and economic benefits, including poverty alleviation and improved quality of life. Moreover, the policy frameworks and tax incentives that support renewable energy adoption, as outlined in the model, have been shown to be critical drivers of clean energy uptake. World Bank (2021) also underscores the importance of such policies in facilitating the transition to renewable energy and enhancing the living standards of communities through access to reliable and sustainable energy sources.

In conclusion, the model's high $R^2$ value and adjusted $R^2$ suggest that renewable energy has a significant and multifaceted impact on social and economic factors in Rubona Sector. The strong predictive power of the model reflects the critical role of renewable energy in improving employment opportunities, promoting social inclusion, and enhancing overall community well-being. These results align with existing literature, highlighting the transformative potential of renewable energy to drive sustainable development and economic empowerment in Rwanda.

**Table 11: ANOVA table**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 46211.076 | 1 | 46211.076 | 15386.392 | .000[b] |

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| | | | | |
|---|---|---|---|---|
| | Residual | 1108.245 | 369 | 3.003 |
| | Total | 47319.321 | 370 | |

a. Dependent Variable: Business and household
b. Predictors: (Constant), Employment Opportunities, Social Inclusion, Accessibility, Quality of Life
**Source: primary data 2025**

The ANOVA (Analysis of Variance) table provides insights into how well the model explains the variation in the dependent variable, which in this case is the impact of renewable energy on business and household outcomes. The Regression Sum of Squares (46211.076) represents the variation in the dependent variable that is explained by the model. This suggests that the model (which includes predictors such as Employment Opportunities, Social Inclusion, Accessibility, and Quality of Life) accounts for a substantial amount of variation in business and household outcomes in the Rubona Sector. On the other hand, the Residual Sum of Squares (1108.245) indicates the amount of variation that remains unexplained by the model, which reflects the errors or deviations between the predicted and actual values.

The Total Sum of Squares (47319.321) is the total variation in the dependent variable before considering the model, and it is the sum of the regression and residual sums of squares. In terms of degrees of freedom (df), the model has a df of 1 for the regression because it includes a single predictor, and a df of 369 for the residuals, which represents the data points remaining after accounting for the model. The Mean Square values for both regression (46211.076) and residuals (3.003) reflect the average explained and unexplained variance, respectively, per degree of freedom.

The F-statistic (15386.392) is a critical value that tests whether the overall model is significant, and it indicates that the model explains the dependent variable far better than random chance. The very large F-statistic suggests that the predictors, as a collective set, are highly significant. In addition, the p-value (Sig. = 0.000), which is well below the standard significance level of 0.05, confirms that the model is statistically significant. This means that the predictors such as Employment Opportunities, Social Inclusion, Accessibility, and Quality of Life have a significant impact on the business and household outcomes, making the model highly effective in explaining the variation in these outcomes.

In conclusion, the ANOVA results indicate that the model is highly significant and provides a strong fit for the data. The predictors related to renewable energy have a significant and positive impact on business and household outcomes in Rubona Sector. The large F-statistic and the small residual sum of squares suggest that the model effectively captures the relationship between the variables, and the p-value of 0.000 reinforces that the model's results are statistically valid. This highlights the important role of renewable energy in shaping socioeconomic development in the area.

**Table 12: Regression**

| **Model** | | **Unstandardized Coefficients** | | **Standardized Coefficients** | **t** | **Sig.** |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 13.458 | .462 | | 29.144 | .000 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| Social economic effect of renewable energy | .805 | .006 | .988 | 124.042 | .000 |

a.Dependent Variable: Employment Opportunities, Social Inclusion, Accessibility, Quality of Life

**Source: survey data 2025**

The Coefficients table provides valuable insights into the relationship between the independent variable, which is the social and economic effects of renewable energy, and the dependent variable, which is business and household outcomes. The unstandardized coefficient for the constant (intercept) is 13.458, meaning that when the social and economic effects of renewable energy are zero, the expected value of the business and household outcomes would be 13.458. The unstandardized coefficient for the social and economic effect of renewable energy is 0.805, indicating that for every unit increase in the social and economic impact of renewable energy, the business and household outcomes are expected to increase by 0.805 units. This suggests that renewable energy has a positive influence on improving business and household conditions.

The standardized Beta coefficient for the social and economic effects of renewable energy is 0.988, which reflects an extremely strong positive relationship between the independent variable and the dependent variable. This Beta value indicates that the social and economic effects of renewable energy contribute significantly to explaining the variation in business and household outcomes, accounting for nearly 99% of the variation. This highlights the crucial role renewable energy plays in driving improvements in business and household outcomes in the community. The t-statistic for the predictor is 124.042, which is extraordinarily high, further demonstrating that the relationship between renewable energy and business/household outcomes is statistically significant. The p-value (Sig. = 0.000) is well below the standard significance level of 0.05, confirming that the observed relationship is not due to random chance and is indeed significant.

In conclusion, the results from the coefficients table provide compelling evidence that the social and economic effects of renewable energy have a strong and statistically significant impact on business and household outcomes in Rubona Sector. The high Beta coefficient and t-statistic, coupled with the low p-value, underscore the importance of renewable energy in driving positive socioeconomic changes in the region.

### 3.3.1. Correlational analysis

The study sought to establish the relationship between Analyzing Socioeconomic Effects of Renewable Energy on Business and Household. Correlation is a bivariate analysis that measures the magnitude of linear association between two variables and the direction of the association. (Gogtay and Thatte 2017), states that (r) that is Pearson correlation is widely the correlation statistic adopted to measure the extent (degree) of the association between the linearly related variables. Normally, (r) is between positive one (+1) and negative one (-1). As the (r) value goes towards 0, the relationship between the two variables was weaker. Pearson correlation (r) was used to show the relationship between Analyzing Socioeconomic Effects of Renewable Energy on Business and Households.

**Table** *13:* **relationship between Analyzing Socioeconomic Effects of Renewable Energy on Business and Household**

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| | | Social economic effect of renewable energy | Business and household |
|---|---|---|---|
| Social economic effect of renewable energy | Pearson Correlation | 1 | .988 |
| | Sig. (2-tailed) | | .000 |
| Business and household | Pearson Correlation | .988 | 1 |
| | Sig. (2-tailed) | .000 | |

Correlation is significant at the 0.01 level (2-tailed).
b. Listwise N=371
**Source: primary data 2025**

The Correlations table provides information about the strength and direction of the relationship between the social and economic effects of renewable energy and business and household outcomes. The Pearson correlation coefficient between these two variables is 0.988, which indicates a very strong positive relationship. This means that as the social and economic effects of renewable energy increase, business and household outcomes also improve in a nearly perfect linear fashion.

The significance value (Sig.) for this correlation is 0.000, which is well below the commonly used significance threshold of 0.01. This indicates that the correlation is statistically significant, meaning that the relationship between renewable energy's social and economic effects and business and household outcomes is not due to random chance. In other words, the correlation between these variables is highly reliable. The correlation coefficient of 0.988 suggests that nearly 99% of the variation in business and household outcomes can be explained by the social and economic effects of renewable energy. This very strong correlation underscores the critical role that renewable energy plays in improving business and household conditions in Rubona Sector, Rwanda. In summary, the Pearson correlation of 0.988 indicates a strong and positive relationship between the social and economic effects of renewable energy and the business and household outcomes in the region. The p-value of 0.000 confirms that this relationship is statistically significant, reinforcing the importance of renewable energy in driving socioeconomic development in the community.

## 4. Conclusion and Recommendations

In conclusion, the findings of this study demonstrate a strong and statistically significant relationship between the adoption of renewable energy and the improvement of socioeconomic development in Rubona Sector, Rwamagana District. It highlights that renewable energy adoption leads to measurable improvements in both business operations and household living conditions, with a high Pearson correlation coefficient of 0.988. The ANOVA test further confirms that the differences observed between various groups are significant, emphasizing the importance of renewable energy in driving positive economic outcomes. This study underscores the crucial role of renewable energy in enhancing productivity, promoting sustainability, and improving the quality of life for local communities. It is evident that continued investment in renewable energy infrastructure and supportive policies will foster further socioeconomic growth, benefiting both businesses

and households in the region. Therefore, efforts to expand renewable energy access should be prioritized to ensure long-term, inclusive development.

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