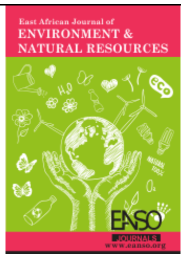

East African Journal of Environment and Natural Resources
eajenr.eanso.org
Volume 8, Issue 1, 2025
Print ISSN: 2707-4234 | Online ISSN: 2707-4242
Title DOI: https://doi.org/10.37284/2707-4242

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Impact of Solar Energy Usage on Socio-Economic Development in Ngoma District

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Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

Date Published:

11 May 2025

Keywords:

Electronic Devices, Heating Water, Socio-Economic Development, Solar Energy Usage.

ABSTRACT

The study evaluated the impact of solar energy usage on socio-economic development in Ngoma District. The specific objectives were to assess the effectiveness of solar energy usage in Ngoma District, the socio-economic development indicators in Ngoma District, and the relationship between solar energy usage and socio-economic development in Ngoma District. The target population was 271 households that used solar energy in Ngoma District, while the sample size was 162 respondents. The questionnaire, interview guide, and Documentary technique were used to obtain the necessary information for the study. Descriptive statistics method, correlation coefficient matrix and multiple linear regression analysis methods were used in this study. Findings indicated that with a Pearson's correlation coefficient (R) of 0.989, showing a strong linear relationship between predictors such as generating electricity, heating water, and socio-economic development, and an R-square value of 0.978, suggesting that approximately 97.8% of the variability in socio-economic development can be explained by these predictors, the model demonstrates robust explanatory power. Furthermore, the adjusted R-squared value of 0.978 remains consistent, suggesting stability in explanatory capability even with additional predictors. The low standard error of the estimate (2.60592) and the Durbin-Watson statistic (1.017) close to 2 indicate minimal residual autocorrelation, validating the model's effectiveness in capturing socio-economic dynamics. The analysis of variance underscores the significance of the model, with predictors collectively exerting a significant effect on socio-economic development, as evidenced by a large F-statistic (1168.641) and a very low p-value (Sig. = .000). The substantial sum of squares for regression (47616.150) further emphasizes the explained variability in socio-economic development by the predictors. Recommendations stemming from these findings advocate for targeted interventions such as investment in renewable energy infrastructure, improvement of basic services, and community empowerment to foster sustainable development. Moreover, suggestions for further research encourage longitudinal studies, complementing quantitative analyses with qualitative methods, and undertaking comparative analyses across diverse regions to deepen understanding and inform evidence-based policies for addressing energy poverty and fostering inclusive growth in rural communities. This study contributes to understanding the role of solar energy in rural socio-economic development, providing insights for policymakers, stakeholders, and researchers to promote sustainable development initiatives.

APA CITATION

Manirakiza, S. & Pancrass, N. (2025). Impact of Solar Energy Usage on Socio-Economic Development in Ngoma District. *East African Journal of Environment and Natural Resources*, *8*(1), 389-411. https://doi.org/10.37284/eajenr.8.1.2982.

CHICAGO CITATION

Manirakiza, Sylvin and Ndokoye Pancrass. 2025. "Impact of Solar Energy Usage on Socio-Economic Development in Ngoma District". *East African Journal of Environment and Natural Resources* 8 (1), 389-411. https://doi.org/10.37284/eajenr.8.1.2982

HARVARD CITATION

Manirakiza, S. & Pancrass, N. (2025) "Impact of Solar Energy Usage on Socio-Economic Development in Ngoma District", *East African Journal of Environment and Natural Resources*, 8 (1), pp. 389-411. doi: 10.37284/eajenr.8.1.2982.

IEEE CITATION

S., Manirakiza & N., Pancrass "Impact of Solar Energy Usage on Socio-Economic Development in Ngoma District", *EAJENR*, vol. 8, no. 1, pp. 389-411, May. 2025. doi: 10.37284/eajenr.8.1.2982

MLA CITATION

Manirakiza, Sylvin & Ndokoye Pancrass. "Impact of Solar Energy Usage on Socio-Economic Development in Ngoma District". *East African Journal of Environment and Natural Resources*, Vol. 8, no. 1, May 2025, pp. 389-411, doi:10.37284/eajenr.8.1.2982

INTRODUCTION

In the East African Community (EAC), renewable energy can address energy access, poverty, and underdevelopment challenges (Bhattacharyya & Timilsina, 2010). Rwanda, an EAC member, exemplifies positive transformation, emphasising renewable energy adoption for rural development (Kamugisha & Svensson, 2017). Technologies like solar photovoltaics and hydropower are gaining traction, promising socio-economic development (Kabera et al., 2017). This study focuses on Rwanda's comprehensive assessment of renewable energy's impact on rural socio-economic development, examining indicators like income, education, healthcare, and environmental sustainability (Kabera et al., 2017). Through data analysis, surveys, and case studies, it aims to uncover challenges and opportunities, contributing to the global discourse on sustainable energy adoption and rural development (Ministry of Infrastructure, Rwanda, 2019). Ultimately, the research emphasises renewable energy's pivotal role in enhancing the well-being of rural communities, serving as a foundation for future policies and interventions (Ministry of Infrastructure, Rwanda, 2019).

Problem Statement

Rwanda, like many developing nations, faces a critical challenge in fostering socio-economic development in its rural areas. One potential solution is the adoption of renewable energy sources, such as solar energy, to meet the energy needs of these underserved regions (Ngabonziza, Mukama, & Byaruhanga, 2018). The existing disparities in energy access between urban and rural areas in Ngoma District, and the impact the daily lives and economic opportunities of rural residents; to what extent has solar energy been adopted in Ngoma District, and what are the primary reasons for its adoption or non-adoption among rural households and businesses; what socio-economic development indicators (e.g., income, education, healthcare, employment, quality of life) are used to assess the impact of solar energy adoption in Ngoma District; and what are the main challenges and barriers faced by rural communities, local governments, and renewable energy providers in implementing and maintaining solar energy solutions in Ngoma District; what are the environmental impacts (positive or negative) of solar energy adoption in Ngoma District, and how do they intersect with socio-economic development

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

goals (World Bank Group, 2019). To address these challenges and gaps, it is essential to conduct a comprehensive study that investigates the impact of solar energy adoption in Ngoma District, focusing on its socio-economic implications. This study examines factors such as energy access, economic development, environmental benefits, policy effectiveness, and improvements in the overall well-being of the rural population. The findings provide valuable insights for policymakers, energy practitioners, and development organisations seeking to promote sustainable socio-economic development through renewable energy interventions in rural Rwanda.

Objective of the Study

The study assessed the impact of solar energy usage on socio-economic development in Ngoma District.

The study was guided by the specific objectives below:

- Assess the effectiveness of solar energy usage in Ngoma District.
- Evaluate the socio-economic development indicators in Ngoma District.

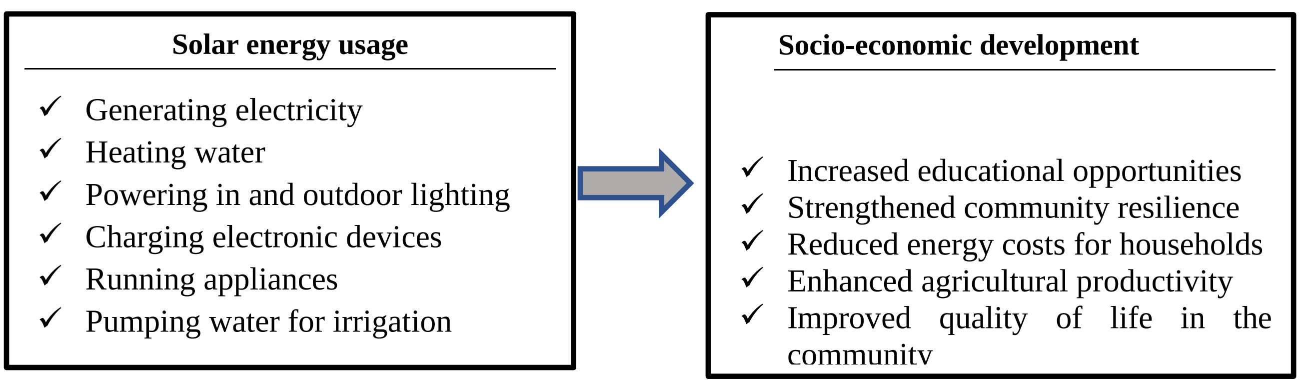
Determine the relationship between solar energy usage and socio-economic development in Ngoma District.

CONCEPTUAL FRAMEWORK

Overall, a conceptual framework plays a crucial role in knowledge development, problem-solving, and understanding complex phenomena by providing a structured and organised framework for thought and analysis. This is represented in the following schematic form, as developed in Figure 1.

Figure 1: Conceptual Framework

Independent Variable **Dependent Variable**



Source: *Researcher conceptualisation (2024)*

THEORETICAL FRAMEWORK

The impact of the use of renewable energy on the socio-economic development of rural areas has been the subject of extensive research and analysis. Various theories and models have been developed to understand and explain this impact. Here is a review of some key theories and their deep details with relevant references:

Energy Transition Theory

Energy transition theory is a concept that addresses the shift from traditional, non-renewable energy sources (such as fossil fuels) to more sustainable and environmentally friendly energy sources (such as renewable energy). This transition is driven by various factors, including environmental concerns, energy security, and economic considerations. This theory posits that the transition from fossil fuels to renewable energy sources can lead to socio-economic development by creating new jobs,

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

reducing energy costs, and improving environmental sustainability. Scholars like Sovacool (2016) explored the energy transition theory in the context of rural development. They emphasise the role of renewable energy in rural job creation and the potential for decentralised energy systems to empower rural communities. Energy transition theory highlights the importance of moving away from fossil fuels to reduce greenhouse gas emissions and combat climate change. This is a critical strength given the pressing need to mitigate the adverse impacts of global warming. Transitioning to renewable energy sources can enhance energy security by reducing reliance on finite fossil fuel reserves and mitigating geopolitical conflicts associated with resource extraction. It underscores the potential for job creation and economic growth in the renewable energy sector. Many countries have seen economic benefits from investing in clean energy technologies. Energy transition theory encourages innovation in energy technologies, leading to advancements in solar, wind, and energy storage, which can have far-reaching impacts beyond the energy sector (Kim & Lee, 2019).

Capability Approach

The Capability Approach was developed by the Indian economist and philosopher Amartya Sen. He first articulated the approach in the 1980s and 1990s through various publications, most notably in his book "Development as Freedom," which was published in 1999. The Capability Approach is a framework for evaluating well-being and development that focuses on people's capabilities and freedoms to lead the kind of lives they value, rather than just measuring their material well-being or income. It has had a significant influence on the fields of economics, ethics, and development studies. This approach, developed by Amartya Sen, focuses on enhancing individuals' capabilities and freedoms. Renewable energy enhances capabilities by providing access to electricity and improving living standards in rural areas. Renewable energy projects can empower rural communities by providing access to electricity for lighting, education, healthcare, and income-generating activities. Sen's capability approach provides a framework to assess the impact of these enhancements. Like any theoretical framework, the Capability Approach has both strengths and weaknesses (Bhattacharyya and Timilsina, 2010).

The capability approach can be challenging to implement in practice because it requires assessing a wide range of capabilities and freedoms. Measuring capabilities accurately can be difficult, and it often involves subjective judgments. The approach relies on social choice and deliberation to determine which capabilities are important and how resources should be allocated. This can lead to disagreements and conflicts about what constitutes a good life and whose capabilities should be prioritised. Critics argue that the Capability Approach does not provide clear guidance on how to allocate resources among competing priorities. In practice, it can be challenging to make trade-offs between different capabilities.

The capability approach recognises the intrinsic value of environmental sustainability. Renewable energy sources like solar, wind, and hydropower contribute to reducing environmental degradation, which is critical for ensuring that future generations have the freedom to lead fulfilling lives. The Capability Approach encourages a multidimensional assessment of development. When examining the impact of renewable energy projects, it encourages researchers and policymakers to consider a wide range of indicators beyond just economic metrics, including health outcomes, educational attainment, gender equality, and social inclusion. In summary, the capability approach offers a valuable perspective on well-being and social justice, emphasising the importance of individual capabilities and freedoms. However, its complexity, subjectivity, and lack of specific policy guidance can be viewed as limitations. It is important to consider these strengths and weaknesses when applying the

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Capability Approach to real-world situations and policy development.

Resource Curse Theory

The Resource Curse Theory, also known as the "paradox of plenty," was developed by various scholars and researchers over time, and it does not have a single originator. This theory explores the idea that countries rich in natural resources, particularly non-renewable resources like oil, gas, and minerals, often experience economic and political challenges that can hinder their development rather than fostering it (Biswas and Shaw, 2019).

The resource curse theory is an economic and political theory that suggests countries rich in natural resources, particularly non-renewable resources like oil, minerals, and natural gas, often experience negative economic and social consequences despite their apparent wealth. While this theory has gained prominence and has been widely discussed, it has both strengths and weaknesses. Strengths of the resource curse theory are based on how there is a significant body of empirical evidence that supports the existence of the resource curse. Many resource-rich countries, particularly in Africa and the Middle East, have experienced economic instability, corruption, conflict, and poor governance. The theory identifies plausible causal mechanisms that link resource abundance to negative outcomes.

Weaknesses of the resource curse theory are related to how not all resource-rich countries experience the same negative outcomes. Some resource-rich nations have managed their resources effectively and experienced positive economic and social development. The theory does not account for this heterogeneity adequately. The theory often oversimplifies complex economic and political dynamics in resource-rich countries. It may not capture the full range of factors influencing a nation's development. The resource curse theory is not always a reliable predictor of a country's future economic and political trajectory. Some resource-poor countries may also face governance challenges, and some resource-rich nations may perform well economically. The theory tends to focus on economic and political factors while neglecting cultural, historical, and social factors that can also influence a country's development trajectory. Implementing policy recommendations based on the resource curse theory can be challenging.

LITERATURE REVIEW

Renewable Energy

Renewable energy, particularly solar energy, has become a crucial part of the global effort to reduce greenhouse gas emissions and combat climate change. Solar energy systems harness the power of the sun's rays to generate electricity or heat, providing a clean and sustainable source of energy. There are two types of solar energy systems, including Photovoltaic (PV) Solar Systems convert sunlight directly into electricity using solar panels made of semiconductor materials like silicon. When sunlight strikes these panels, it creates an electrical current, which can be used to power homes, businesses, or even feed electricity back into the grid. The solar thermal systems use sunlight to generate heat, which can be used for various purposes, including space heating, hot water production, and industrial processes. There are two main types of solar thermal systems: flat-plate collectors and concentrating collectors (Barnes *et al.*, 2004). Renewable energy systems are essential components of the transition towards sustainable energy sources. Shukla *et al.* (2019) define renewable energy systems as technologies and infrastructure that harness energy from naturally occurring and replenishable sources. These systems, such as solar, wind, hydro, and biomass energy, play a crucial role in reducing greenhouse gas emissions, mitigating climate change, and promoting energy sustainability.

Solar Energy Usage

Solar energy usage involves harnessing solar radiation as a renewable energy source to generate

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electricity or provide heat for various purposes. According to REN21 (2021), solar energy usage encompasses deploying solar panels or solar thermal systems to convert sunlight into usable energy for residential, commercial, or industrial applications. Solar energy offers a clean, abundant, and environmentally friendly alternative to conventional fossil fuels.

Generating Electricity : Generating electricity involves converting various energy sources, including solar energy, into electrical power. In the context of solar energy usage, generating electricity specifically refers to the process of converting sunlight into electrical energy through photovoltaic (PV) cells or solar panels (IEA, 2020). Solar photovoltaic systems enable the direct conversion of sunlight into electricity, providing a sustainable and renewable energy source for powering homes, businesses, and utilities.

Heating Water: Heating water with solar energy involves using solar thermal energy to raise the temperature of water for domestic, commercial, or industrial purposes. Solar water heating systems typically consist of solar collectors that absorb sunlight and transfer heat to a fluid, which is then circulated to heat water stored in a tank (IRENA, 2019).

Powering Indoor and Outdoor Lighting: Powering indoor and outdoor lighting with solar energy entails using solar-powered lighting systems to illuminate spaces, streets, or landscapes. These lighting systems incorporate solar panels to capture sunlight during the day, storing energy in batteries for use during nighttime or low-light conditions (SEIA, 2020). Solar-powered lighting offers an off-grid lighting solution that enhances safety, security, and energy efficiency in various applications.

Charging Electronic Devices: Charging electronic devices using solar energy involves utilising solar-powered chargers or photovoltaic panels to replenish the batteries of gadgets such as smartphones, tablets, or laptops. Solar chargers convert sunlight into electrical energy, enabling the charging of devices in off-grid or remote locations (NREL, 2020). Solar-powered charging solutions provide a portable and sustainable alternative to grid-based electricity for powering electronic devices.

Running Appliances: Running appliances with solar energy entails powering household or commercial appliances using electricity generated from solar panels. Solar-powered appliances, such as refrigerators, air conditioners, or washing machines, contribute to energy efficiency and sustainability by reducing reliance on grid electricity or fossil fuels (EIA, 2021). Solar appliances offer a clean and reliable energy solution for meeting everyday energy needs while minimising environmental impact.

Pumping Water for Irrigation: Pumping water for irrigation involves using solar-powered pumps or systems to extract and distribute water for agricultural irrigation purposes. Solar pumps harness solar energy to drive water pumps, providing a sustainable and environmentally friendly solution for irrigation in remote or off-grid areas (FAO, 2018). Solar irrigation systems offer farmers a reliable and cost-effective means of water supply, improving crop yields and livelihoods.

Socio-Economic Development

Socio-economic development refers to the process by which a society or community improves the economic, social, and cultural well-being of its members. It is a multifaceted concept that encompasses a wide range of factors and outcomes, and it is often used to assess and measure the progress and quality of life within a society. It seems like you're interested in various aspects related to income generation, savings, employment opportunities, access to basic services, enhanced livelihoods, and improved education and healthcare. These topics are crucial for the well-being and development of individuals and communities (Samuel O. Babalola et al., 2022). Socio-economic development encompasses multifaceted efforts to improve the well-being and prosperity of

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individuals, communities, or nations. Key aspects of socio-economic development include education, resilience, energy affordability, agricultural productivity, and overall quality of life.

Increased Educational Opportunities: Increased educational opportunities refer to initiatives aimed at expanding access to education and skill development programs. The World Bank (2018) emphasises the importance of improving school enrollment rates, literacy levels, and vocational training to foster human capital development and socio-economic empowerment. Access to quality education is crucial for enhancing workforce skills, promoting economic growth, and reducing poverty.

Strengthened Community Resilience: Strengthened community resilience involves building the capacity of communities to withstand and recover from various challenges or shocks. The UNDRR (2015) highlights the importance of social cohesion, adaptive capacity, and participatory decision-making in enhancing resilience to environmental, economic, or social risks. Resilient communities are better equipped to adapt to changing circumstances, mitigate disasters, and sustain long-term development.

Reduced Energy Costs for Households: Reduced energy costs for households are essential for ensuring energy affordability and economic stability. The IEA (2019) emphasises the significance of implementing energy efficiency measures, promoting renewable energy adoption, and providing financial assistance to lower-income households. Affordable energy services help alleviate energy poverty, improve living standards, and enhance household welfare.

Enhanced Agricultural Productivity: Enhanced agricultural productivity is vital for ensuring food security, income generation, and rural development. The FAO (2020) advocates for adopting sustainable farming practices, modern technologies, and value-chain development to increase crop yields, improve market access, and enhance livelihoods. Productive and resilient agriculture contributes to poverty reduction, economic growth, and environmental sustainability.

Improved Quality of Life in the Community: Improved quality of life encompasses various aspects of well-being, including health, housing, infrastructure, and social cohesion. The WHO (2019) emphasises the importance of addressing basic needs such as clean water, sanitation, healthcare, and education to enhance overall happiness and satisfaction. Quality of life indicators reflect the holistic impact of socio-economic development efforts on individual and community welfare.

RESEARCH METHODOLOGY

Research Design

The researcher follows a descriptive design/quantitative, and correlative research designs. Descriptive survey design demonstrated the frequencies, percentages, mean and standard deviation for data collected from the selected respondents. The correlative research design deeply analyzes the relationship between Solar Energy usage represented by generating electricity; heating water; powering in and outdoor lighting; charging electronic devices; running appliances; and pumping water for irrigation on the socio-economic development in Ngoma District represented by the increased educational opportunities; strengthened community resilience; reduced energy costs for households; enhanced agricultural productivity; and improved quality of life in the community in Rwanda.

Study Population

The study population is ideally homogeneous, meaning that the members share similar characteristics relevant to the research topic. For instance, in this case, the households are all using solar energy. The target population consists of all households in Ngoma District using solar energy, not just the 271 households includes 265 families or individuals (beneficiaries) residing in the Ngoma

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

District especially Gashanda; Mugesera; Zaza; Sake; Rurenge; & Kazo sectors who utilize solar energy, and also 6 leaders in charge of infrastructure development for these selected sectors. The researcher examined various factors such as socio-economic status, energy consumption patterns, satisfaction with solar energy systems, and challenges faced in adopting solar energy. The leaders offered perspectives on the efficacy of solar energy initiatives, community needs, and potential areas for improvement.

Sample Size and Sampling Techniques

The selection of an appropriate sample size and sampling techniques is paramount in ensuring the reliability and validity of research findings. In this study, we present a structured overview of the target population, sample sizes allocated to each category within the population, and the sampling procedures employed. The provided table serves as a clear and organised reference point, facilitating a comprehensive understanding of the sampling framework utilised. The sample size calculation utilised the formula proposed by Taro Yamane in 1986, considering a total population of 271 households in Ngoma District and a margin of error of 0.05 with a confidence level of 95%. Applying the formula, the calculated sample size was 162 respondents, ensuring an adequate representation of the target population while minimising sampling error.

$$n = \frac{N}{1 + N * (e^2)}$$

n = sample size **N =** Total population: 271

e= margin error: 0.05

$n = \frac{271}{1+(271*0.05^2)}$ =162 Respondents

In this study, the sample size of 162 respondents, including the household beneficiaries of solar energy in Gashanda, Mugesera, Zaza, Sake, Rurenge, & Kazo sectors of Ngoma District and the leader in charge of infrastructure development from each sector selected above. A stratified sampling technique was used to select 162 respondents from households across different sectors, ensuring representative participation. The study also utilised the purposive sampling technique to select 6 respondents from Gashanda, Mugesera, Zaza, Sake, Rurenge, and Kazo sectors.

Data Collection Techniques

Data collection for this study involved both primary and secondary sources, employing questionnaires and document review as the methods. These techniques were carefully chosen to ensure comprehensive data gathering and analysis. The combination of questionnaire administration and document review served as robust data collection techniques, enabling the study to gather rich, diverse, and well-rounded data necessary for addressing the research objectives effectively. To collect data for this study, primary and secondary data were needed. This means questionnaires and document reviews were much needed. Questionnaires were administered to gather firsthand information from respondents using solar energy in Ngoma District.

Documentary Review

In conjunction with primary data collection, a thorough review of relevant documents was conducted. This involved scrutinising existing literature, reports, policy documents, and other relevant sources to gain a deeper understanding of the research area. Document review provided valuable contextual information, historical perspectives, and theoretical frameworks that complemented the primary data collected through questionnaires. By synthesising information from both primary and secondary sources, a comprehensive understanding of the research topic was achieved, enriching the analysis and interpretation of findings.

Data Processing and Analysis

Initially, the collected data underwent editing, coding, and the creation of statistical tables using

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

various analytical techniques. This process aimed to prepare the data for further analysis by organising it into meaningful categories through editing, coding, recording, classifying, and tabulation. The method of data analysis in this study involved several steps to organise and interpret the information gathered from respondents who utilised Solar Energy. To conduct the analysis, the researchers utilised SPSS 23.0, a computer software specifically designed for data analysis. SPSS facilitated the examination and interpretation of the collected data, allowing for the application of quantitative or descriptive statistical methods. These methods enabled the researcher to analyse the responses obtained from the questionnaires in a systematic and structured manner.

By employing quantitative analysis, the study aimed to uncover patterns, trends, and relationships within the data, providing valuable insights into the use of Solar Energy among the respondents.

Pearson Correlation coefficient was used as positive or direct; however, when they move in the opposite direction, the correlation is negative or inverse. The value ranges from -1 (perfectly negative correlation), through 0 (no correlation), to +1 (perfectly positive correlation), and it indicates how closely two variables co-vary. This is demonstrated by the discovery of the correlation coefficient, which deals with the gathering and analysis of quantitative data and the application of probability theory. Multiple linear Regression analysis models were adopted to show relationships using econometric models.

The socio-economic benefits of adopting solar energy systems have garnered considerable attention due to their potential to address energy access challenges, improve living standards, and stimulate economic growth in communities. In Ngoma District, recent efforts have been directed towards implementing solar energy solutions to mitigate energy scarcity and enhance various aspects of socio-economic development. To assess the effectiveness of these initiatives, an inferential statistical analysis was conducted to analyse primary data collected on the perceived socio-economic benefits of utilising solar energy systems in the district. In this analysis, various socio-economic indicators were evaluated, including access to clean and reliable electricity, improvements in living standards, economic opportunities, healthcare services, educational opportunities, job creation, community resilience, energy cost reduction, agricultural productivity, and overall quality of life.

RESULTS AND DISCUSSIONS

The chapter contains the results from the survey conducted on the impact of solar energy usage on the socio-economic development in Ngoma District. They were presented in accordance with the research objectives comprised the effectiveness of solar energy usage in Ngoma District; the socio-economic development indicators in Ngoma District; and the relationship between solar energy usage and socio-economic development in Ngoma District. Data were collected from 162 respondents from households that used Solar energy at Gashanda, Mugesera, Zaza, Sake, Rurenge, and Kazo sectors of Ngoma District. During data collection, the respondents were given three weeks of responding, and the data collected results indicated the participation rate of 100.0% of respondents to the questionnaires; and this allowed the researcher to continue the study with data cleaning with editing, coding, recording and making statistical tables/figures in the tabulation stage. Data were analysed quantitatively using the computer software SPSS IBM 23.0 version.

Socio-Demographic Characteristics of Respondents

The socio-demographic characteristics of respondents refer to the collective information about individuals participating in the research. These characteristics provide an understanding of the social and demographic composition of the group under research. The findings suggested the

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

information about the age, marital status and education level of respondents.

Table 1: Distribution of Respondents by Age

Age category of respondents		Frequency	Percent
Valid	Less than 30 years	11	6.8
	31-40years	72	44.4
	41-50years	47	29.0
	51-60years	21	13.0
	61 years and Above	11	6.8
	Total	**162**	**100.0**

Source: *Primary data (2024)*

The distribution of respondents by age in Table 1 provides insights into potential trends in solar energy usage and its socio-economic impact across different age groups in the Gashanda, Mugesera, Zaza, Sake, Rurenge, and Kazo sectors of Ngoma District. The findings revealed that less than 30 years is the youngest age group constitutes only 6.8% of the total respondents. Engaging with this demographic is crucial as they represent the future workforce and decision-makers who will shape energy policies and practices in the long term. The age group of 31-40 years comprises the largest proportion of respondents, accounting for 44.4% of the total. This demographic likely represents individuals in their prime working years, with significant influence over household and community decisions. Their relatively high representation suggests a key target audience for solar energy initiatives aimed at promoting socio-economic development. Strategies focus on leveraging this group's potential to drive adoption through incentives, financing options, and capacity-building programs. The 41-50 years age group constitutes 29.0% of the respondents, indicating a substantial representation of individuals in the middle-aged bracket. Similar to the 31-40 years age group, this demographic likely holds decision-making power within households and businesses. Engaging with this segment through targeted outreach efforts yields significant dividends in terms of solar energy adoption and its associated socio-economic impacts. The older age groups (51-60 years and 61 years and above) together constitute 19.8% of the respondents. While their representation is comparatively lower, their inclusion is still essential for understanding the diverse perspectives on solar energy adoption and its implications for socio-economic development.

Table 2: Distribution of Respondents by Marital Status

Marital Status		Frequency	Percent
Valid	Single	15	9.3
	Married	112	69.1
	Divorced	4	2.5
	Widow (er)	31	19.1
	Total	**162**	**100**

Source: *Primary data (2024)*

The distribution of respondents by marital status in Table 2 provides insights into potential correlations between marital status, solar energy usage, and socio-economic development in the Gashanda, Mugesera, Zaza, Sake, Rurenge, and Kazo sectors of Ngoma District. The category of single respondents represents 9.3% of the total. Single individuals have different energy consumption patterns compared to married or widowed individuals, as they typically reside in smaller

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

households or have different priorities when it comes to resource allocation. The majority of respondents (69.1%) are married individuals. Married couples often have higher energy demands due to larger households and additional responsibilities, such as childcare and household maintenance. Promoting solar energy adoption among married couples has significant socio-economic benefits, including reduced energy costs, increased resilience to power outages, and improved environmental outcomes. Divorced individuals and widows/widowers represent smaller percentages of respondents (2.5% and 19.1%, respectively). These groups face unique challenges and opportunities regarding solar energy adoption. For divorced individuals, initiatives focus on providing support and resources for transitioning to sustainable energy solutions in newly established households. Widows and widowers benefit from programs that empower them to become energy-independent and enhance their economic resilience through solar entrepreneurship or community solar projects.

Table 3: Educational Background of Respondents

Educational background		**Frequency**	**Percent**
Valid	Illiterate/No education	10	6.2
	Primary level	92	56.8
	Secondary level	41	25.3
	Bachelor’s Degree	19	11.7
	Total	162	100.0

Source: *Primary data (2024)*

The findings from Table 3, which presents the distribution of respondents by educational background in the survey on the impact of solar energy usage on socio-economic development in Ngoma District. The results indicated that 6.2% of the respondents reported being illiterate or having no formal education. This indicates a small but existing portion of the population that may face challenges in accessing and understanding certain information or participating in activities that require basic literacy skills. The majority of respondents (56.8%) have completed primary education. This suggests a relatively high level of basic education attainment among the surveyed population, which is encouraging as primary education is often considered essential for acquiring foundational skills and knowledge. Approximately a quarter of the respondents (25.3%) have completed secondary education. This indicates a significant portion of the population with further educational attainment beyond the primary level, which may contribute to higher literacy rates, broader knowledge base, and potentially increased awareness of socio-economic issues. 11.7% of the respondents reported having a Bachelor's degree. While this percentage is relatively low compared to the other educational categories, it still represents a notable portion of the population with higher education qualifications. Individuals with Bachelor's degrees may bring specialised skills, expertise, and perspectives to various endeavours, including socioeconomic development initiatives.

Findings on the Effectiveness of Solar Energy Usage in Ngoma District

In understanding the complex background of solar energy adoption in Ngoma District, the examination of various factors becomes instrumental. This section inspects the key determinants influencing the adoption and usage of solar energy systems, offering a nuanced representation of the socio-economic fabric within the community. The factors, ranging from the economic considerations, such as the cost of solar systems and availability of financial incentives, to the societal and cultural dimensions,

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

including socio-cultural factors and community support, contribute to the intricate decision-making process surrounding solar technology. Additionally, elements like awareness and knowledge of solar technology, government policies and regulations, reliability of solar energy, geographic location, and the availability of maintenance and repair services add layers to the narrative. The approaching exploration delves into each factor individually, unravelling the unique role it plays in shaping the landscape of solar energy adoption in Ngoma District.

Table 4: Perception of Respondents on the Factors Influencing the Solar Energy Usage at Ngoma District; N= 162

Factors influencing the Solar Energy Usage	Mean	Std. Deviation	Kurtosis
The cost of solar systems hinges on the affordability of solar installations.	4.37	0.8332	0.897
The availability of financial incentives ensures accessible to rebates and subsidies.	4.438	0.74718	-0.149
Access to financing options depends on the availability of loans or leasing alternatives.	4.364	0.8969	1.661
Awareness and knowledge of solar technology correlate with understanding the benefits of solar technology.	4.457	0.83479	2.613
Government policies and regulations necessitate compliance with solar energy regulations.	4.383	0.87856	2.801
The reliability of solar energy is contingent on the consistency of solar power generation.	4.432	0.87673	2.96
Geographic location and solar potential determine the suitability of a location for solar energy production.	4.352	0.84495	0.924
Community support and involvement entail engagement and backing from the local community.	4.451	0.76453	1.574
The availability of maintenance services is crucial for the accessible and reliable upkeep of solar systems.	4.395	0.91474	2.782
Socio-cultural factors and perceptions significantly influence societal beliefs on solar adoption.	4.432	0.96444	3.321
Overall Average	**4.407**	**0.855605**	**1.9384**

Source: *Primary data (2024)*

Table 4 presents the perceptions of respondents regarding factors influencing solar energy usage in Ngoma District. The table provides statistical measures such as mean, standard deviation, skewness, and kurtosis for each statement. Findings revealed that the mean scores range from 4.352 to 4.457, indicating that respondents generally perceive these factors positively, with a higher mean indicating stronger agreement with the statements. Looking at the standard deviation, it ranges from 0.74718 to 0.96444, suggesting that perceptions among respondents are relatively consistent for most factors such as cost of solar systems; availability of financial incentives; access to financing options; awareness and knowledge of solar tech; government policies and regulations; reliability of solar energy; geographic location and solar potential; community support and involvement; availability of maintenance services; socio-cultural factors and perceptions. Kurtosis values range from -0.149 to 3.321, indicating varying degrees of peakedness or horizontalness in the distribution of responses. Higher kurtosis values suggest more extreme responses, while lower values suggest a compliment distribution. Overall, the respondents show positive perceptions towards all factors influencing solar energy usage in Ngoma District, with the average mean score being 4.407 out of 5.

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

Table 5: Findings on Effectiveness of Solar Energy Usage in Ngoma District, N=162

Effectiveness of Solar Energy Usage	Mean	Std. Deviation	Kurtosis
Reduced reliance on fossil fuels;	4.358	0.88196	1.431
Lower electricity costs for households;	4.5123	0.71573	-0.151
Mitigation of environmental impact;	4.4815	0.83571	3.412
Increased access to electricity in remote areas;	4.4753	0.92717	3.559
Creation of local job opportunities;	4.1605	0.95822	-0.511
Enhanced energy security and independence;	4.4506	0.78061	0.149
Improved reliability of power supply;	4.3827	0.85709	0.931
Diversification of energy sources;	4.4568	0.72316	-0.479
Promotion of sustainable development;	4.4074	0.90242	2.921
Empowerment of local communities.	4.4198	0.9505	2.82
Overall Average	**4.41049**	**0.853257**	**1.4082**

Source: *Primary data (2024)*

The findings in Table 5 indicated the perceptions of respondents on the effectiveness of solar energy usage in Ngoma District. The results revealed that the mean represents the average score given by respondents for each statement regarding the effectiveness of solar energy usage, showing a higher mean, which indicates stronger agreement or perception of effectiveness, while a lower mean suggests less agreement or effectiveness. In this context, the means range from 4.1605 to 4.5123, indicating generally positive perceptions across all statements. The standard deviation measures the dispersion or variability of responses around the mean. A higher standard deviation suggests greater variability in responses, indicating diverse opinions among respondents. Conversely, a lower standard deviation indicates more consistency in responses. In this case, the standard deviations range from 0.71573 to 0.95822, suggesting relatively consistent perceptions among respondents for most statements. Kurtosis measures the peakedness or flatness of the distribution of responses compared to a normal distribution. A positive kurtosis value indicates a peaked distribution with more extreme responses, while a negative kurtosis value suggests a flatter distribution with less extreme responses. In this context, kurtosis values range from -0.511 to 3.559, indicating varying degrees of peakedness or flatness in the distribution of responses. Higher kurtosis values suggest more extreme responses, while lower values suggest a flatter distribution.

The overall average mean score across all statements is 4.41049 out of 5, indicating a generally positive perception of solar energy's effectiveness among respondents. This suggests a high level of agreement regarding the beneficial impact of solar energy usage across different aspects, such as reducing reliance on fossil fuels, mitigating environmental impact, and promoting sustainable development. The standard deviation of 0.853257 indicates a relatively low level of variability in respondents' perceptions across the different dimensions of solar energy effectiveness. This suggests a consistent pattern of agreement among respondents, with little divergence in opinions regarding the benefits of solar energy usage. The kurtosis value of 1.4082 suggests a moderate degree of peakedness in the distribution of responses, indicating that while the majority of respondents perceive solar energy usage as effective, there are some respondents who may have more extreme opinions on either end of the spectrum.

Findings on the Socio-Economic Development indicators for the beneficiaries in Ngoma District

The analysis of socio-economic development indicators in Ngoma District delves into a myriad of transformative outcomes arising from the adoption of solar energy systems. From the fundamental improvement in access to electricity and enhanced lighting in households to the profound impacts on

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

education, income generation, and healthcare services, this section unravels the holistic tapestry of benefits. The transition to solar energy contributes not only to the reduction of indoor air pollution but also fosters advancements in communication, connectivity, and agricultural productivity. Furthermore, the study explores the socio-economic implications of solar energy adoption, including job creation in the burgeoning solar energy sector and a notable decrease in dependence on traditional energy sources in Ngoma District.

Table 6: Perceptions of Respondents on the Socio-Economic Development Indicators for the Beneficiaries in Ngoma District; N=162

Socio-Economic Development indicators for the beneficiaries	Mean	Std. Deviation	Kurtosis
Increased access to electricity;	4.407	0.80028	-0.195
Improved lighting in households;	4.457	0.79672	1.563
Enhanced educational opportunities;	4.451	0.82697	3.033
Increased income generation.	4.506	0.82843	3.145
Improved healthcare services.	4.321	0.96944	1.517
Reduced indoor air pollution.	4.531	0.78156	2.368
Enhanced communication and connectivity.	4.463	0.78129	2.229
Increased agricultural productivity.	4.469	0.92025	3.664
Job creation in the solar energy sector.	4.377	1.0216	3.039
Reduced dependence on traditional energy sources.	4.438	0.93211	3.152
Overall Average	**4.442**	**0.865865**	**2.3515**

Source: *Primary data (2024)*

Table 6 provides insights into the perceptions of respondents regarding various socio-economic development indicators for beneficiaries in Ngoma District, particularly concerning the impact of solar energy usage. Findings revealed that the mean represents the average score given by respondents for each socio-economic development indicator. Higher mean values indicate a more positive perception of the effectiveness of solar energy in contributing to that particular indicator. In this context, all means are relatively high, ranging from 4.321 to 4.531, indicating a generally positive perception across all indicators. The standard deviation measures the dispersion or variability of responses around the mean. Higher standard deviation values indicate greater variability in responses, suggesting more diverse opinions among respondents. Conversely, lower standard deviation values indicate more consistency in responses. In this case, standard deviation values are relatively low, ranging from 0.71573 to 1.0216, indicating relatively consistent perceptions among respondents for most indicators. Skewness measures the symmetry of the distribution of responses. A positive skewness indicates that the distribution is skewed towards higher values, while a negative skewness suggests that the distribution is skewed towards lower values. A positive kurtosis value indicates a peaked distribution with more extreme responses, while a negative kurtosis value suggests a flatter distribution with less extreme responses. The kurtosis values range from -0.511 to 3.664, indicating varying degrees of peakedness or flatness in the distribution of responses. Higher kurtosis values suggest more extreme responses, while lower values suggest a flatter distribution. The Socio-Economic Development indicators across all respondents is 4.442. This indicates a generally positive perception among respondents regarding these indicators. The standard deviation of 0.865865 suggests that the responses are relatively consistent around the mean score. This means that there's not a significant amount of variation in the responses, indicating a certain level of agreement among respondents. The kurtosis value of 2.3515 indicates that the distribution of responses is

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

leptokurtic, meaning it is relatively peaked compared to a normal distribution.

Findings on the Relationship between Solar Energy Usage and Socio-Economic Development

The relationship is determined by the perceptions of respondents on the Socio-Economic benefits of using Solar Energy systems in Ngoma District and also on the statistical test of inferential statistics analysis results, as shown below.

Socio-Economic Benefits of Using Solar Energy Systems in Ngoma District

The findings from the study provide valuable insights into the socio-economic benefits derived from the adoption of solar energy systems in Ngoma District. Table 4.7 presents an overview of various statements reflecting these benefits, ranging from increased access to clean and reliable electricity to enhanced agricultural productivity and improved quality of life in the community. The table outlines statistical measures such as mean, standard deviation, skewness, and kurtosis, offering a comprehensive understanding of respondents' perceptions towards each statement. Notably, the overall average perception stands at 4.411, indicating a generally positive sentiment towards the socio-economic benefits associated with solar energy usage in the district.

Table 7: Socio-Economic Benefits of Using Solar Energy Systems in Ngoma District, N=162

Statements	Mean	Std. Deviation	Kurtosis
Solar Energy usage increased access to clean and reliable electricity.	4.401	0.79173	-0.169
Solar Energy usage improved living standards in households.	4.457	0.7649	1.609
Solar Energy usage enhanced economic opportunities.	4.414	0.89613	3.1
Solar Energy usage facilitates for better healthcare services;	4.438	0.84104	1.47
Solar Energy usage increased educational opportunities.	4.42	0.83946	1.375
Jobs are created through Solar Energy usage.	4.444	0.82658	2.993
Solar Energy usage strengthened community resilience.	4.235	0.95581	-0.379
Solar Energy usage reduced energy costs for households.	4.451	0.78852	1.638
Solar Energy usage enhanced agricultural productivity.	4.37	0.945	3.282
Solar Energy usage helps to improve the quality of life in the community.	4.482	0.87208	3.458
Overall Average	**4.411**	**0.852125**	**1.8377**

Source: *Primary data (2024)*

Table 7 presents an analysis of the socio-economic benefits derived from the utilisation of solar energy systems in Ngoma District. These findings are crucial for understanding the effectiveness and significance of solar energy as a sustainable energy solution in promoting socio-economic development and enhancing the well-being of individuals and communities in Ngoma District. The results indicated that the mean scores range from 4.235 to 4.482. The benefits associated with solar energy usage are consistently perceived positively, with mean scores consistently above 4. The findings show the standard deviations range from 0.7649 to 0.95581. The range of standard deviations reflects the variability in responses across different statements. While some benefits have relatively low variability in responses (e.g., improved living standards), others show slightly higher variability (e.g., enhanced agricultural productivity). The kurtosis values range from -0.379 to 3.458. The range of kurtosis values reflects the shape of the distribution of responses. While some benefits exhibit relatively flat distributions with lighter tails (e.g., strengthened community resilience), others have distributions with heavier tails and sharper peaks, indicating the presence of extreme positive

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responses (e.g., enhanced economic opportunities). The overall average for the socio-economic benefits of using solar energy systems in Ngoma District, based on Table 4.7, is 4.411. This indicates a generally positive perception of the benefits of solar energy usage across various aspects, including increased access to clean and reliable electricity, improved living standards, enhanced economic opportunities, better healthcare services, increased educational opportunities, job creation, strengthened community resilience, reduced energy costs for households, enhanced agricultural productivity, and improved quality of life in the community. The standard deviation of 0.852125 suggests that there is some variability in perceptions across respondents, but overall, the average score is relatively high. The kurtosis of 1.8377 suggests that the distribution is moderately leptokurtic, indicating that there are some outliers with very high or very low scores, but the majority of responses cluster around the mean. The range of findings suggests that while there is consistency in the positive perception of the socio-economic benefits associated with solar energy usage, there are variations in the level of variability and distributional characteristics of responses across different benefits. These variations provide insights into the nuanced perceptions of respondents regarding the specific impacts of solar energy adoption on various aspects of life and livelihoods within Ngoma District.

Correlation Coefficient Analysis

Correlation coefficient analysis is a statistical By calculating the correlation coefficient, researchers can assess the degree to which changes in one variable are associated with changes in another. This analysis is essential in various fields, including psychology, economics, biology, and social sciences, as it provides insights into patterns of association and helps researchers understand the interplay between different factors. The correlation coefficient ranges from -1 to +1, where a value closer to +1 indicates a strong positive correlation, a value closer to -1 indicates a strong negative correlation, and a value near 0 suggests little to no correlation.

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Table 8 : Correlation Coefficient Matrix Analysis

		Generating electricity	Heating water	Powering in and outdoor lighting	Charging electronic devices	Running appliances	Pumping water for irrigation	Solar energy usage	Socio-economic development
Generating electricity	Pearson Correlation	1							
	Sig. (2-tailed)								
	N	162							
Heating water	Pearson Correlation	.233**	1						
	Sig. (2-tailed)	.003							
	N	162	162						
Powering in and outdoor lighting	Pearson Correlation	.124	.532**	1					
	Sig. (2-tailed)	.115	.000						
	N	162	162	162					
Charging electronic devices	Pearson Correlation	.404**	.279**	.220**	1				
	Sig. (2-tailed)	.000	.000	.005					
	N	162	162	162	162				
Running appliances	Pearson Correlation	.271**	.305**	.244**	.320**	1			
	Sig. (2-tailed)	.000	.000	.002	.000				
	N	162	162	162	162	162			
Pumping water for irrigation	Pearson Correlation	.443**	.357**	.376**	.282**	.221**	1		
	Sig. (2-tailed)	.000	.000	.000	.000	.005			
	N	162	162	162	162	162	162		
Solar energy usage	Pearson Correlation	.624**	.679**	.647**	.591**	.552**	.773**	1	

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

		Generating electricity	Heating water	Powering in and outdoor lighting	Charging electronic devices	Running appliances	Pumping water for irrigation	Solar energy usage	Socio-economic development
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		
	N	162	162	162	162	162	162	162	
Socio-economic development	Pearson Correlation	**.606****	**.662****	**.653****	**.584****	**.548****	**.767****	**.989****	**1**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	
	N	162	162	162	162	162	162	162	162

***. Correlation is significant at the 0.01 level (2-tailed).*

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

Based on Table 8, which presents correlation coefficient analysis results, we observe the following correlations between various factors: Generating electricity; Strong positive correlation with socio-economic development (Pearson's r = 0.606, p < 0.01). Positive correlation with other factors such as heating water, powering indoor and outdoor lighting, charging electronic devices, running appliances, and pumping water for irrigation. Heating water; Strong positive correlation with socio-economic development (Pearson's r = 0.662, p < 0.01). Positive correlation with other factors such as generating electricity, powering indoor and outdoor lighting, charging electronic devices, running appliances, and pumping water for irrigation. Powering indoor and outdoor lighting, Strong positive correlation with socio-economic development (Pearson's r = 0.653, p < 0.01). Positive correlation with other factors such as generating electricity, heating water, charging electronic devices, running appliances, and pumping water for irrigation. Charging electronic devices, Strong positive correlation with socio-economic development (Pearson's r = 0.584, p < 0.01). Positive correlation with other factors such as generating electricity, heating water, powering indoor and outdoor lighting, running appliances, and pumping water for irrigation. Running appliances, Strong positive correlation with socio-economic development (Pearson's r = 0.548, p < 0.01). Positive correlation with other factors such as generating electricity, heating water, powering indoor and outdoor lighting, charging electronic devices, and pumping water for irrigation. Pumping water for irrigation, strong positive correlation with socio-economic development (Pearson's r = 0.767, p < 0.01). Positive correlation with other factors such as generating electricity, heating water, powering indoor and outdoor lighting, charging electronic devices, and running appliances. Solar energy usage has, extremely strong positive correlation with socio-economic development (Pearson's r = 0.989, p < 0.01). Positive correlation with all other factors mentioned in the table. Socio-economic development: Strong positive correlation with all other factors, with extremely high correlation with solar energy usage (Pearson's r = 1, p < 0.01.

Multiple Linear Regression Analysis

Multiple linear regression analysis is a powerful statistical method used to examine the relationship between a dependent variable and two or more independent variables. Unlike simple linear regression, which involves only one independent variable, multiple linear regression allows us to assess how a dependent variable changes when multiple predictors are considered simultaneously.

Table 9: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.989[a]	.978	.978	2.60592	1.017

a. Predictors: (Constant), Generating electricity; Heating water; Powering outdoor lighting; Charging electronic devices; Running appliances; Pumping water for irrigation; Powering remote communication systems

b. Dependent Variable: Socio-economic development

The findings from Table 9 of the Model Summary stated that the value of R, which is 0.989, represents the correlation between the observed and predicted values of the dependent variable (socio-economic development) based on the independent variables included in the model. A high R value close to 1 indicates a strong linear relationship between the predictors and the dependent variable. The R-squared value, which is 0.978, indicates the proportion of variance in the dependent variable (socio-economic development) that is explained by the independent variables included in the model. In this case, approximately 97.8% of the variability in socio-economic development can be accounted for

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

by the predictors in the model. The adjusted R-squared value, also 0.978, provides a more conservative estimate of the proportion of variance explained by the predictors, adjusting for the number of predictors and sample size. It is essentially the same as the R-squared in this model, indicating that the inclusion of additional predictors does not significantly change the explanatory power of the model. The standard error of the estimate, which is 2.60592, represents the average deviation of the observed values from the predicted values of the dependent variable. Smaller values of the standard error indicate a better fit of the model to the data. The Durbin-Watson statistic, with a value of 1.017, is a test for the presence of autocorrelation in the residuals of the regression model. The Durbin-Watson statistic ranges from 0 to 4, with values close to 2 indicating no significant autocorrelation. In this case, the value of 1.017 suggests that there is little to no autocorrelation present in the residuals.

Table 11: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	47616.150	6	7936.025	1168.641	.000[b]
1	Residual	1052.577	155	6.791		
	Total	48668.727	161			

a. Dependent Variable: Socio-economic development

b. Predictors: (Constant), *Generating electricity; Heating water; Powering in and outdoor lighting; Charging electronic devices; Running appliances; Pumping water for irrigation; Powering remote communication systems*

This table presents the results of an Analysis of Variance (ANOVA) for a regression model predicting socio-economic development based on various predictors. The model is statistically significant ($p < 0.05$), as indicated by the very low p-value (Sig. = .000). This suggests that the predictors included in the model collectively have a significant effect on socio-economic development. The F-statistic is 1168.641, which is very large, indicating that there is a significant difference between the model and the null hypothesis (i.e., the model with no predictors). This further supports the significance of the model. The regression model accounts for a substantial amount of variability in the dependent variable (Socio-economic development), as indicated by the large sum of squares for regression (47616.150) and the corresponding mean square (7936.025). The degrees of freedom (df) for the regression model is 6, indicating that there are 6 predictors being examined. The sum of squares for the residual (1052.577) represents the unexplained variability in socio-economic development after accounting for the predictors in the model. The degrees of freedom for the residual are 155, suggesting the number of observations minus the number of predictors in the model. The total sum of squares (48668.727) represents the total variability in socio-economic development in the dataset. The predictors included in the model are listed as: Generating electricity; Heating water; Powering in and outdoor lighting; Charging electronic devices; Running appliances; Pumping water for irrigation, Powering remote communication systems. These predictors collectively contribute to explaining socio-economic development. In summary, the ANOVA results indicate that the regression model, which includes various predictors related to energy usage, is highly significant in predicting socio-economic development.

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

Table 11: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	4.525	3.305		1.369	.173
Generating electricity	.925	.062	.211	14.887	.000
Heating water	.890	.063	.207	14.160	.000
Powering in and outdoor lighting	1.071	.057	.273	18.759	.000
1 Charging electronic devices Running appliances	1.004	.067	.204	15.066	.000
Pumping water for irrigation	1.003	.063	.209	16.051	.000
Powering remote communication systems	.999	.036	.394	27.629	.000

a. Dependent Variable: Socio-economic development

Table 11 presents regression coefficients for various factors and their impact on socioeconomic development. Findings indicated that Generating electricity, for each additional unit of electricity generated, socioeconomic development increases by approximately 0.925 units. This suggests that improving electricity generation capacity can positively impact socioeconomic development by providing essential energy resources for various activities such as industry, education, and healthcare. Heating water, increasing the capacity to heat water by one unit, is associated with a socioeconomic development increase of approximately 0.890 units. Access to hot water is crucial for sanitation, hygiene, and comfort, which can indirectly contribute to socioeconomic development by improving public health and living standards. Powering in and outdoor lighting, each additional unit of power for lighting is associated with a socioeconomic development increase of around 1.071 units. Adequate lighting infrastructure enhances safety, extends productive hours, and facilitates various activities, thus fostering socioeconomic development. Charging electronic devices and running appliances: Increasing the capacity for charging electronic devices and running appliances by one unit leads to a socioeconomic development increase of approximately 1.004 units. Access to electricity for powering appliances and electronic devices supports economic activities, education, and communication, thereby contributing to socioeconomic development. Pumping water for irrigation, increasing the capacity for pumping water for irrigation by one unit, is associated with a socioeconomic development increase of approximately 1.003 units. Improved irrigation infrastructure enables efficient agricultural practices, increases crop yields, and enhances food security, positively impacting socioeconomic development. Powering remote communication systems, each additional unit of power allocated to remote communication systems is associated with a significant increase in socioeconomic development, approximately 0.999 units.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study confirms that solar energy usage significantly contributes to socioeconomic development in Ngoma District, with respondents expressing a highly positive perception of its benefits. Key advantages include reduced reliance on fossil fuels, economic gains, environmental sustainability, and societal improvements. Statistical analysis reveals strong agreement among respondents, with minimal variability in opinions. Correlation analysis further

Article DOI: https://doi.org/10.37284/eajenr.8.1.2982

indicates a strong link between solar energy and socioeconomic progress, with solar usage showing an exceptionally high correlation. The regression model explains 97.8% of the variability in socioeconomic development, validating the impact of energy-related factors. These findings emphasise the crucial role of solar energy in enhancing livelihoods and promoting sustainable development in rural areas.

Recommendations

Based on the findings above, it is recommended to focus on policies and interventions aimed at enhancing energy access and utilisation in rural communities.

- Investment in Renewable Energy Infrastructure: Given the strong correlation between generating electricity from renewable sources and socio-economic development, there should be increased investment in renewable energy infrastructure, particularly solar energy systems, in rural areas. This will not only provide reliable electricity but also contribute to economic growth and environmental sustainability.
- Improvement of Basic Services: prioritise initiatives aimed at providing essential services such as heating water, powering outdoor lighting, and running appliances. Access to these services improves living standards, health outcomes, and overall well-being in rural communities.
- Enhanced Communication Infrastructure: Recognising the significant impact of powering remote communication systems on socio-economic development, efforts should be made to improve communication infrastructure in rural areas. This includes expanding access to the internet and mobile networks, which can facilitate education, healthcare, and economic opportunities.

Suggestions for Further Researchers

As research on the relationship between solar energy access and socio-economic development in rural areas continues to evolve, further investigations are warranted to deepen our understanding of the complex dynamics at play. Building upon the findings of this study, future researchers are encouraged to explore additional avenues for advancing knowledge and informing policy interventions. Here are three suggestions for further research:

- Enhancing Agricultural Productivity through Solar Energy Solutions in Rwanda: A Case Study of Ngoma District
- Promoting Access to Quality Education and Healthcare through Solar Energy;

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