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(REVIEW ARTICLE)

Analysis of the spatial variations in the adoption of solar energy technologies among households in rural and urban areas of Konoin sub-County, Kenya

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Abstract

Globally, the overall demand and cost of energy and particularly, for fossil fuels is on the rise due to increasing population and overall development process. The increasing use of fossil fuels has significant ramifications to the environment, such as increase in carbon emissions. There is need, therefore, to adopt the use of green energy technologies like solar energy so as to minimize the negative effects of fossil fuels on the environment. Despite these, there is paucity of information on factors influencing the spatial variations in the adoption of solar energy technologies among households in the study area, which this study sought to investigate. The study was informed by the Diffusion of Innovation theory and Technology Adoption Model. A a descriptive survey research design was employed. A stratified random sample of 387 households was surveyed and data collected analyzed using descriptive statistics and multiple linear regression. The findings reveal significant spatial variations in solar energy adoption rates. Proximity to renewable energy sources and fluctuations in energy costs positively influenced adoption levels. Also, social factors, including: household size; and community support had a positive influence in adoption of solar energy. Further, economic considerations, such as perceived installation costs and anticipated long-term savings, played a significant role in influencing adoption levels. Moreover, geographic variables, particularly access to areas with abundant sunshine, significantly influenced adoption levels.

Keywords: Adoption; Solar energy; Bomet; Spatial Variation

1. Introduction

The energy landscape on a worldwide scale is seeing a substantial transformation in the 21st century. The need for energy is growing fast as a result of population growth and economic advancement, with fossil fuels often serving as the primary source of this expanding requirement (International Energy Agency, 2023). However, relying on fossil fuels results in a substantial ecological impact. The uncontrolled burning of fossil fuels releases harmful greenhouse gases into the atmosphere, significantly contributing to climate change, a phenomenon with significant consequences to the planet (Shahzad, 2015).

Kenya is well-acquainted with these difficulties. The nation grapples with meeting its energy demands and often relies heavily on imported fossil fuels. This dependence not only exacerbates environmental problems but also places a significant economic burden on the country (Koch & Koch, 2019). Solar energy emerges as a beacon of optimism in the face of these challenges. This sustainable resource offers a feasible alternative that has the capacity to significantly reduce reliance on fossil fuels and their associated environmental and economic drawbacks (Kumar et al., 2021). The imperative to transition to renewable energy sources is amplified by the escalating threat of deforestation and environmental degradation in Kenya. The nation's reliance on traditional biomass fuels such as firewood and charcoal for cooking and heating has resulted in significant degradation of its previously abundant forests (Wamukunda, 2014). Solar energy offers a viable solution to the ecological challenge by allowing households to meet their energy needs without causing harm to the environment (Ocelli et al., 2013).

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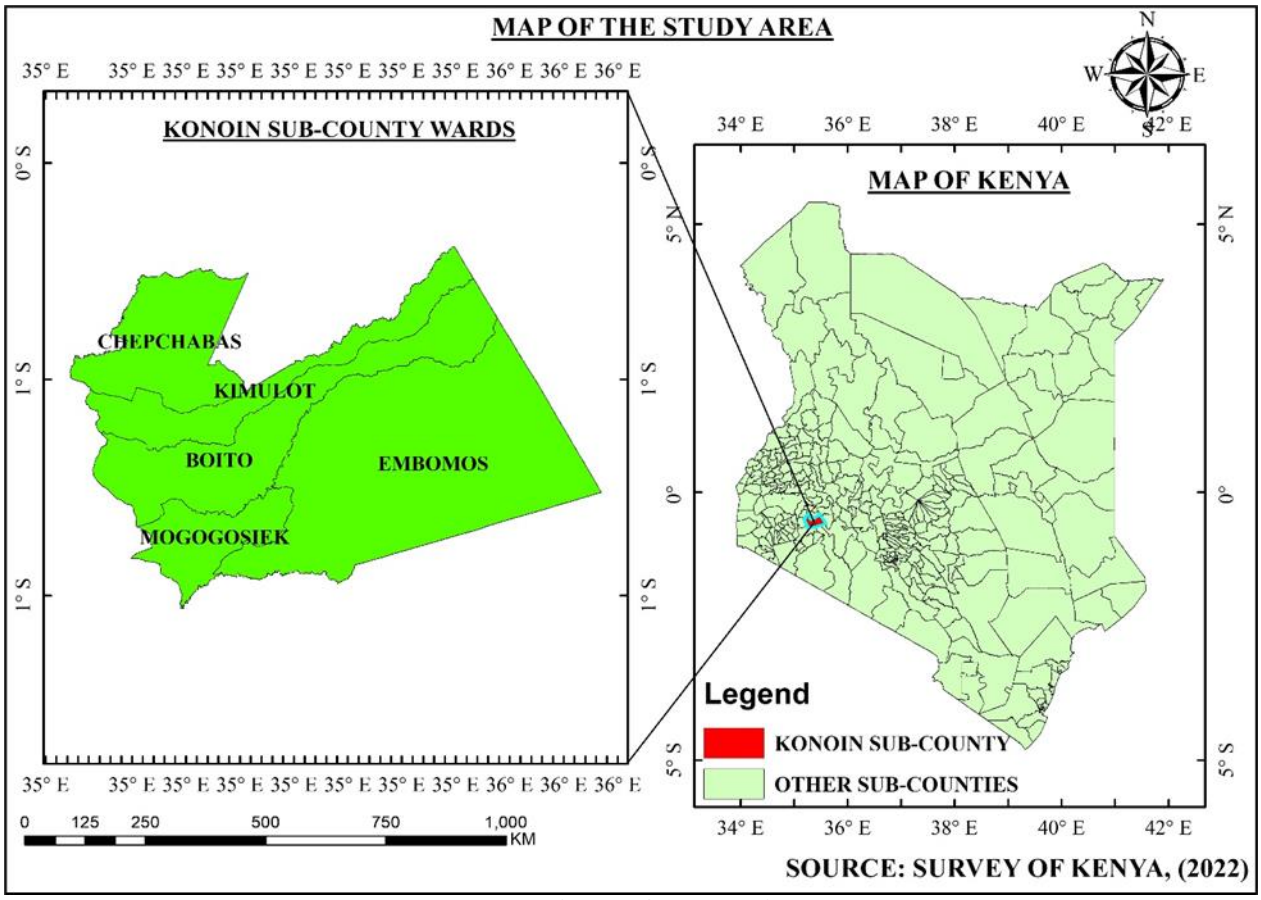
Thus, understanding the factors that influence the adoption of solar energy technologies among households is crucial for promoting a more sustainable energy future. This study investigated the temporal and spatial usage of solar energy technologies among households in Konoin sub-County. By analyzing these variations, the study aimed to identify the key factors that influence adoption patterns and levels. Konoin sub-County in Bomet County, Kenya, presents an ideal area to study to investigate factors that influence adoption of solar energy technologies. The sub-County encompasses a variety of landscapes, such as fertile agricultural plains and rugged highlands. The diversity in geography is manifested in the manner in which energy is obtained. Several locations have convenient access to the national power grid, while other localities, particularly those that are remote and sparsely populated, face significant challenges in terms of accessibility (KNBS, 2019). The gap in the availability of traditional energy sources underscores the potential of solar energy to alleviate this imbalance and provide a reliable and environmentally acceptable power source for these remote regions.

This study builds upon the existing research on the factors that influence the acceptance of renewable energy sources. The Diffusion of Innovation theory and Technology Adoption Model provide valuable insights into the decision-making process of individuals when adopting new technologies (Rogers, 2003; Moore, 1991). This study acknowledges the need of considering geographical and temporal variations in the patterns of adoption of solar energy technologies.

2. Methodology

2.1. Study Area

The research area is situated in Konoin sub-County, which is located in Bomet County, Kenya. Konoin sub-County has five Wards: Kimulot, Mogogosiek, Boito, Chepchabas, and Embomos, with Embomos being the most extensive among them (KIHBS, 2019). The specific coordinates of the geographical place are 35° 16' east longitude and 0° 36' south latitude. Additionally, the elevation of the area is 1909 meters above sea level (Survey of Kenya, 2022) .



Source: (Survey of Kenya, 2022).

Figure 1 The Location of Study Area

The varied topography of Konoin sub-County, which includes hills, plains, and huge agricultural areas, significantly influences the social, economic, and environmental conditions of the study area (CIDP, 2022). The rolling hills create a picturesque background and may impact the ease of reaching and distributing resources in the area. Plains can indicate regions that are well-suited for certain land uses, such as the construction of infrastructure or the practice of agriculture. The focus on agricultural regions highlights the significance of the local economy, which could have an effect on the livelihoods and attitudes of local people towards green energy technologies. Moreover, comprehending the geographical and administrative attributes of Konoin sub-County improves the contextual lucidity of the investigation on the adoption of green energy technologies. This offers a nuanced viewpoint on the interaction between the local geography, administrative frameworks, and the community's likelihood of embracing sustainable energy solutions,(CIDP,2022).

The study was conducted in this sub-county due to the presence of signs of homes and the county government making efforts to provide education and install solar panels at a reduced price, as stated in the CIDP report of 2022. In addition, the sub-County benefits from its near vicinity to multinational tea firms, which actively contribute to the education of neighboring communities on the sustainable utilization of solar energy. These companies implement corporate social responsibility (CSR) initiatives to promote the adoption of solar energy within their estates, (CIDP, 2022).

2.2. Research Design

This study utilized a descriptive survey design, employing a questionnaire as the primary data collection instrument (Burkholder et al., 2019). A descriptive survey design is a research methodology that seeks to gather extensive and precise information about the attributes of a population or phenomena (Creswell, 2014). Data was collected in a methodical manner to create a comprehensive overview of the current condition of the subject under investigation, providing valuable understanding of its characteristics and qualities (Creswell, 2014).

Additionally, a descriptive survey approach used in an energy study aims to elucidate current energy consumption patterns, assess awareness and attitudes towards various energy sources, and identify specific energy needs and preferences within a community. This methodology offers crucial fundamental data for making educated decisions, formulating policies, and conducting targeted actions in the energy industry.

2.3. Target Population

Konoin sub-County comprises a total of 38,220 homes. The target population of the study consisted of 38,178 households spread across the five wards. Households play a pivotal role in energy studies due to their significant impact on overall consumption patterns. An analysis of energy consumption in residential homes revealed important insights into human behavior, preferences, and choices that directly influence energy needs. Understanding this notion is essential for tailoring effective strategies aimed at enhancing energy efficiency and sustainability. Researchers can assess the direct impact of energy-related behavior at an individual level and also recognize the broader implications of energy consumption throughout the entire community by specifically studying homes. Consequently, the assessment of residential properties plays a pivotal role in developing comprehensive strategies to address energy challenges and foster a more sustainable and resilient energy landscape.

Key informants played a vital role in providing strategic approaches for green energy in the research area. The group comprised five ward members, one from each ward, along with a representation from each of the ministries of water, sanitation, environment, natural resources, climate change, commerce, energy, industry, and tourism. The addition of these representatives increased the total count to seven.

The study also encompassed institutional residences as a specific demographic to collect vital data. The study examined 35 institutions, which were classified as follows: 15 elementary schools, 10 high schools, 5 colleges, and 5 tea processing plants.

2.4. Sampling Technique

The sample methodology employed in this study was specifically designed to effectively account for the extensive geographical distribution of residential properties. A systematic and meticulous approach was employed to reach out to every family in each ward, ensuring a comprehensive representation. A systematic methodology was employed to choose households for the questionnaire survey in these locations. This methodology involved the amalgamation of basic random sampling and selective sampling to guarantee meticulous selection.

2.5. Sampling Size

This study utilized a conventional method for determining sample size, as established by Krejcie and Morgan (1970). This model is suitable in situations where there is a substantial population, ensuring that the produced figure accurately reflects the entire population of households. The formula is provided below.

$$n = \frac{x^2 Npq}{d^2(N-1) + x^2 pq}$$

Where:
n =Required sample size.
x^2 =The table value of Chi-Square value for one degree of freedom at the desired confidence level (x^2 =3.841 at confidence level).
N =The target population.
p= The population proportion (Assumed to be 0.50 since this would provide the maximum sample size)
d = Degree of accuracy reflected by the amount of error that can be tolerated.

Subjecting the formula to the target population of 38178, yields a sample size of 380

2.6. Research Instruments

This study utilized a questionnaire, consisting of both open-ended and closed-ended questions (Mugenda & Mugenda, 2012). Questionnaires allowed the researcher to gather information in a standardized and consistent manner (Mugenda & Mugenda, 2012). Each participant received the same set of questions, ensuring consistency in responses. This uniformity is essential for facilitating comparative analysis and enabling the production of reliable conclusions (Mugenda & Mugenda, 2012). The structured format of a questionnaire also simplifies data processing (Mugenda & Mugenda, 2012). Responses can be easily quantified, categorized, and subjected to statistical analysis, allowing for the identification of patterns, trends, or connections within the data (Mugenda & Mugenda, 2012).

In addition, the utilization of a questionnaire is frequently more time-efficient compared to other methods, since participants can complete it at their convenience, and data collection can be carried out from a significant number of respondents simultaneously. The scalability of this technique is particularly advantageous when dealing with a wide range of situations, since it allows for a comprehensive analysis of multiple aspects within a reasonable timeframe.

Sreejesh et al. (2013) describes closed-ended questions as those that provide respondents with a predetermined set of response options, while open-ended questions allow participants to freely react in their own words without any limitations on predefined responses.

2.7. Data Analysis

The data was analyzed using descriptive and inferential statistics, with the use of the Statistical Package for Social Scientists (SPSS). Descriptive statistics were essential for summarizing and organizing the data, so facilitating the construction of meaningful conclusions. The analyzed data successfully achieved the goal of researching the research questions.

3. Results and Discussions

This section presents the research findings largely based on primary data collected form households.

3.1. Spatial Variations in the Adoption of Solar Energy Technologies Among Households

Table 1 presents a collection of questions asked to the heads of households regarding the changes in the use of solar energy technologies over time and across different locations.

Table 1 Descriptive Statistics Table Showing Spatial Variations in Adoption of Solar Energy Technologies Among Households

Descriptive Statistics					
	N	**Min**	**Max**	**Mean**	**Std. Deviation**
Indicate your current residential home setting	317	1.00	1.00	1.0000	0.00000
Proximity to Hydropower	317	1.00	2.00	1.2744	0.44694
Proximity to Wind plant	317	2.00	2.00	2.0000	0.00000
Proximity to Biogas	317	1.00	2.00	1.8391	0.36800
Proximity to Solar energy	317	1.00	2.00	1.5647	0.49658
Have you noticed any changes in your energy bills since installing solar energy technologies?	317	1.00	2.00	1.5994	0.49080
Valid N (listwise)	317				

Source: Survey data (2023)

From the table it is evident that all the 317 respondents originated from a rural and urban environment. The respondents, on average, reported a proximity score of 1.27 for hydropower when asked about their proximity to green energy sources. This suggests that they are very close to hydropower sources, with a small amount of variation (0.45) in proximity. Further, respondents unanimously reported a proximity score of 2.00 for wind plants, indicating an agreement that they are not in close proximity to such facilities. The respondents' rating for their proximity to biogas was 1.84, indicating that they were rather close, with a moderate level of fluctuation, denoted by a value of 0.37. Regarding solar energy, the average proximity score was 1.56, suggesting that respondents are moderately near solar energy sources, with a considerable level of variation (Standard deviation of 0.5).

The respondents were subsequently queried regarding any alterations in their energy costs subsequent to the installation of solar energy technologies. On average, they rated this question with a score of 1.60, indicating that individuals have observed changes in their energy bills following the implementation of solar energy solutions. Notably, a standard deviation of 0.49 indicates that there is a significant variation in the observed changes among the respondents.

Further, the study sought to find out the source of energy used by households. The results of descriptive analysis are shown in Table 2.

Table 2 indicates a complete overview of energy use in several households within a dataset consisting of 317 hoseholds. Upon analyzing the electricity usage, particularly for cooking and lighting, it is evident that there is a consistent consumption rate of 2.00 units. This lack of variability is supported by the standard deviation value of 0.00000. A consistent trend is noticed in the power usage of household appliances, with a steady consumption level of 1.00 unit. Nevertheless, the electricity used for space heating shows a range of variability, spanning from 1.00 to 2.00 units. The average consumption is 1.8233 units, with a standard deviation of 0.38198.

When the usage of alternative energy sources is considered, it is evident that the amount of charcoal consumed for heating and space heating remains constant at 2.00 units. However, the amount of charcoal used for space heating varies, ranging from 1.00 to 2.00 units. The average usage for charcoal space heating is 1.2114, with a standard deviation of 0.40892. The use of biogas for cooking exhibits a consistent consumption rate of 2.00 units, which aligns with the steady pattern observed in electricity consumption categories. The utilization of fuel wood for cooking, lighting, and space heating shows no variation, with a consistent consumption of 2.00 units and standard deviations of 0.00000.

Table 2 Source of Energy used at the Household Level

Descriptive Statistics					
	N	**Min**	**Max**	**Mean**	**Std. Deviation**
Electricity for cooking	317	2.00	2.00	2.0000	0.00000
Electricity for lighting	317	2.00	2.00	2.0000	0.00000
Electricity for space heating	317	1.00	2.00	1.8233	0.38198
Electricity for home appliances	317	1.00	1.00	1.0000	0.00000
Charcoal for heating	317	2.00	2.00	2.0000	0.00000
Charcoal for space heating	317	1.00	2.00	1.2114	0.40892
Biogas for cooking	317	2.00	2.00	2.0000	0.00000
Fuel wood for cooking	317	2.00	2.00	2.0000	0.00000
Fuel wood for lighting	317	2.00	2.00	2.0000	0.00000
Fuel wood for space heating	317	1.00	2.00	1.3533	0.47875
Solar for lighting	317	2.00	2.00	2.0000	0.00000
Solar for Home appliances	317	1.00	2.00	1.4227	0.49477
Valid N (listwise)	317				

Source: Survey data (2023)

The consumption of fuel wood for space heating varies between 1.00 and 2.00 units. The average consumption is 1.3533 units, with a standard deviation of 0.47875 units. The solar energy consumption for lighting and residential appliances remains constant at 2.00 units, with no observed variability, as seen by the standard deviation of 0.00000. Nevertheless, the usage of solar energy for household devices shows a range of fluctuation between 1.00 and 2.00 units, with an average consumption of 1.4227 and a standard deviation of 0.49477.

4. Conclusion

The investigation of the uptake of solar energy in Konoin sub-County, Kenya, uncovers an intriguing interaction between geography and other variables. Although being close to renewable energy sources, such as biogas and hydropower, has a good impact on household adoption, the trend is not necessarily determined by simple geography. There is no denying the financial benefit: homes that see large reductions in their energy costs after switching to solar power are more inclined to adopt it. It is important to note that institutions' motivations for going solar and the difficulties they encounter are highly associated, pointing to a connection between having defined objectives and conquering barriers. This was confirmed by key informants, who identified adoption initiatives, affordability, cultural factors, and community involvement as important motivators. This emphasizes the value of a comprehensive strategy that takes into account the social, cultural, and economic backdrop in addition to the technology itself. Going forward, comprehensive research can evaluate the long-term environmental and economic effects of widespread solar adoption while sorting through the driving forces and obstacles involved. Furthermore, evaluating the success of various policy interventions will direct future subsequent initiatives on solar energy technologies. Through the execution of these suggestions and the cultivation of a cooperative environment, interested parties can enable Konoin to welcome a sustainable energy future, clearing the path for a more pristine and optimistic future.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have disclosed no conflicts of interest with the research findings.

References

[1] Burkholder, J. M., Gravatt, B. B., & Morgan, M. A. (2019). Descriptive research. In J. M. Burkholder, B. B. Gravatt, & M. A. Morgan (Eds.), Designing your mixed methods research study (2nd ed., pp. 123-140). SAGE Publications, Inc.

[2] Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approach. Sage publications.

[3] Fricker, T. J. (2019). Sampling in quantitative research. Sage Publications, Inc.

[4] International Energy Agency (IEA). (2023). World Energy Outlook 2023.

[5] Kenya National Bureau of Statistics (KNBS). (2019). Kenya Population and Housing Census. Kenya National Bureau of Statistics.

[6] Kericho County Integrated Development Plan (CIDP). (2022). Kericho County Integrated Development Plan 2023-2027. Kericho County Government.

[7] Kericho Institute of Health Biotechnology and Social Studies (KIHBS). (2019). Kericho County Statistical Abstract 2019. Kericho County Government.

[8] Koch, A., & Koch, V. (2019). The economic impact of energy dependence: A case study of Kenya. Journal of African Economies, 28(4), 872-893.

[9] Krejcie, R. V., & Morgan, D. W. (1970). Sampling techniques. Journal of Research on Educational Psychology, 60(3), 607-610.

[10] Kumar, S., Singh, M., & Zhao, P. (2021). A review of clean energy sources and their applications. Renewable and Sustainable Energy Reviews, 140, 110783.

[11] Moore, G. A. (1991). Crossing the chasm: Marketing and selling high-tech products to mainstream customers. Harper Perennial.

[12] Mugenda, O. M., & Mugenda, A. G. (2012). Research methods: Quantitative and qualitative approaches. Acts Press.

[13] Ocelli, L., Wekesa, M., & Nyukuri, L. (2013). Can renewable energy address energy security challenges in Kenya? Energy Policy, 61, 101-109.

[14] Rogers, E. M. (2003). Diffusion of innovations. Fifth Edition. Free Press.

[15] Shahzad, S. M. N. (2015). The impact of greenhouse gas emissions on climate change: A review of scientific evidences. Journal of Environmental Science and Technology, 9(1), 206-220.

[16] Sreejesh, S., Kumar, B. V., & Asokan, V. U. (2013). Open ended vs. closed ended questions: A comparative study. International Journal of Engineering Research and Technology, 2(7), 1089-1092.

[17] Wamukunda, G. (2014). The impact of charcoal production and consumption on forest resources in Kenya. Environment and Development Economics, 19(3), 337-355.