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Research Article

IMPACT INVESTING AND CLIMATE FINANCE: MEASURING SOCIAL RETURN ON INVESTMENT (SROI) IN RENEWABLE ENERGY PROJECTS

Ava Lee[1], Rachel Chan[2], Sanya Desai[3]
[1] Nanyang Technological University (NTU), Singapore
[2] Singapore University of Social Sciences (SUSS), Singapore
[3] Symbiosis International University, India

Corresponding Author:

Ava Lee,
Nanyang Technological University (NTU), Singapore.
50 Nanyang Ave, Singapura 639798
Email: avalee@gmail.com

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Abstract

This study examines the role of impact investing and climate finance in generating measurable social value through renewable energy projects by applying the Social Return on Investment (SROI) framework. Growing global investment in renewable energy has emphasized financial performance and emission reduction outcomes, while systematic measurement of social impacts remains limited. The purpose of this research is to assess how SROI can be used to quantify the social and environmental value created by renewable energy investments and to demonstrate its relevance for impact-oriented decision-making. A mixed-methods approach was employed, combining secondary project data analysis, stakeholder engagement, outcome mapping, and monetization of social and environmental benefits to calculate SROI ratios. The findings reveal that renewable energy projects consistently produce social returns exceeding the initial investment, with SROI ratios varying according to project type, scale, stakeholder involvement, and socio-economic context. Community-based and decentralized projects tend to generate higher relative social returns, driven by employment creation, improved energy access, health improvements, and environmental benefits. The study concludes that integrating SROI into climate finance evaluation enhances transparency, accountability, and alignment between financial objectives and sustainable development goals.

Keywords: Climate Finance, Impact Investing, Social Return

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INTRODUCTION

Impact investing has emerged as a significant approach in contemporary finance, aiming to generate measurable social and environmental benefits alongside financial returns. In the context of global climate challenges, this investment paradigm has increasingly been aligned with climate finance mechanisms that support mitigation and adaptation efforts. Renewable energy projects, such as solar, wind, and bioenergy initiatives, are widely recognized as strategic instruments for reducing greenhouse gas emissions, expanding energy access, and promoting sustainable economic development (Newell, 2010; Zahoor, 2022). Existing studies indicate that capital flows into renewable energy have grown substantially, driven by both public policy commitments and private sector interest in sustainable portfolios. However, the emphasis on financial performance has often overshadowed systematic evaluation of broader social and environmental outcomes.

Climate finance plays a critical role in mobilizing resources toward low-carbon transitions, particularly in developing and emerging economies where energy demand continues to rise. International frameworks and national strategies commonly highlight renewable energy investments as vehicles for achieving climate targets while fostering job creation, technological innovation, and community development (Alam, 2017; Blasiak, 2017). Empirical evidence suggests that such projects contribute not only to emission reductions but also to improvements in local livelihoods through employment opportunities and infrastructure development. Despite this recognition, the social impacts of renewable energy investments are frequently discussed in qualitative terms, with limited integration into formal investment appraisal processes.

Social Return on Investment (SROI) has been increasingly acknowledged as a methodological tool capable of capturing the social and environmental value created by investments. SROI extends beyond conventional cost–benefit analysis by translating social outcomes into monetary terms, thereby enabling comparability with financial returns. Previous applications of SROI in the energy sector demonstrate its potential to assess outcomes such as community empowerment, health improvements, and environmental preservation. Nevertheless, its use within impact investing and climate finance remains uneven, particularly in large-scale renewable energy projects where financial metrics continue to dominate decision-making (Abid, 2016; Malhi, 2008; Venturini, 2022).

The theoretical foundation of SROI is rooted in stakeholder theory and social value theory, which emphasize that organizational and investment activities generate value for a wide range of stakeholders, not solely investors. This perspective aligns with the principles of impact investing, which seek to internalize externalities and recognize social and environmental outcomes as integral components of value creation. From this theoretical standpoint, renewable energy projects financed through impact-oriented capital are expected to deliver multidimensional returns that encompass economic viability, social welfare, and ecological sustainability. The integration of SROI within this framework provides a structured means of operationalizing these theoretical assumptions into measurable indicators.

Current academic and policy-oriented literature underscores the growing demand for robust impact measurement to enhance transparency and accountability in climate finance. Investors, regulators, and development institutions increasingly require evidence that renewable energy projects deliver tangible social benefits in addition to climate mitigation outcomes. While various impact measurement frameworks exist, inconsistencies in metrics and

reporting practices persist, limiting cross-project comparison and informed decision-making. This body of knowledge establishes a clear understanding that measuring social return through approaches such as SROI is essential for advancing the effectiveness and credibility of impact investing in renewable energy (Bhandary, 2021; Hong, 2020).

Despite the growing recognition of impact investing and climate finance, significant uncertainty remains regarding how social value generated by renewable energy projects is systematically measured and integrated into investment decisions. Existing evaluations tend to prioritize financial returns and emission reduction metrics, while social outcomes are often treated as secondary or reported descriptively. This creates a gap between the stated objectives of impact investing and the actual practices used to assess investment performance, particularly in relation to long-term community and social benefits (Battiston, 2021; Roncoroni, 2021).

Limited empirical evidence is available on the consistent application of Social Return on Investment (SROI) across different types of renewable energy projects and geographic contexts. Variations in project scale, stakeholder composition, and socio-economic conditions lead to inconsistent measurement approaches, making it difficult to compare results or draw generalizable conclusions. As a result, investors and policymakers lack a reliable basis for understanding which renewable energy investments generate the greatest social value relative to the resources deployed.

From a theoretical perspective, the gap also lies in the insufficient operationalization of social value theory within climate finance practices. While theory emphasizes the importance of capturing value created for multiple stakeholders, existing impact measurement frameworks often fail to fully reflect stakeholder diversity and context-specific outcomes. The absence of a standardized yet adaptable SROI framework limits the ability to translate theoretical concepts of shared value and stakeholder welfare into practical investment metrics within renewable energy financing (Battiston, 2021; Wagner, 2016).

Uncertainty further persists regarding how SROI findings influence investment behavior and policy formulation in the climate finance ecosystem. The extent to which quantified social returns affect capital allocation, risk assessment, and project selection remains underexplored. This lack of clarity constrains the strategic use of SROI as a decision-support tool, leaving its potential contribution to scaling effective and socially inclusive renewable energy investments largely unrealized.

Addressing the gap in measuring social value is essential for aligning impact investing practices with the broader objectives of climate finance. A clearer and more rigorous application of Social Return on Investment can provide investors with credible evidence of social outcomes, enabling more informed decision-making that balances financial performance with societal benefits. Strengthening this measurement approach responds to the increasing demand for accountability and transparency in sustainable finance (Hafner, 2020; Steenwerth, 2014).

The rationale for filling this gap is grounded in stakeholder theory, which posits that investments should be evaluated based on their capacity to generate value for all affected parties. Applying SROI within renewable energy projects offers a structured method to capture and monetize social outcomes experienced by communities, workers, and local institutions. This theoretical lens supports the argument that integrating SROI into climate finance can enhance both investment quality and social legitimacy.

The purpose of this study is to examine how SROI can be systematically applied to renewable energy projects within the impact investing and climate finance landscape. It seeks to demonstrate that robust social value measurement can complement financial and environmental metrics, leading to more holistic project evaluations. The underlying hypothesis is that renewable energy projects assessed using SROI will reveal substantial social returns that are otherwise overlooked, thereby justifying stronger integration of social impact metrics in climate-oriented investment strategies (Engelken, 2016; May, 2008).

RESEARCH METHOD

This study adopts a mixed-methods research design that integrates quantitative and qualitative approaches to comprehensively assess the Social Return on Investment (SROI) of renewable energy projects within the context of impact investing and climate finance. The quantitative component focuses on calculating SROI ratios by monetizing identified social and environmental outcomes relative to the invested capital, while the qualitative component is used to capture stakeholder perceptions, contextual factors, and non-financial impacts that cannot be fully represented through numerical data. This design allows for a nuanced understanding of how social value is created and distributed across different stakeholder groups (Busch, 2018; Hoffmann, 2008).

Research Design

The research design of this study consists of renewable energy projects financed through impact investing and climate finance mechanisms, including solar, wind, and small-scale hydro projects. Samples are selected using purposive sampling to ensure representation of projects with varying scales, geographic locations, and ownership structures. Key informants include project developers, investors, local community representatives, and relevant public or non-governmental institutions involved in project implementation. This sampling strategy enables the analysis to reflect diverse stakeholder perspectives and socio-economic contexts (Flammer, 2021; Lipscy, 2020).

Research Target/Subject

Data collection instruments include structured financial data templates, stakeholder interview guides, and outcome-mapping matrices aligned with the SROI framework. Financial records are used to identify inputs and investment costs, while interview guides facilitate the systematic identification of social and environmental outcomes experienced by stakeholders. Outcome indicators and financial proxies are developed to monetize non-market values, ensuring that both tangible and intangible impacts are incorporated into the SROI analysis (Arif, 2021; Falco, 2014).

Instruments, and Data Collection Techniques

Data collection procedures begin with stakeholder identification and engagement to define relevant outcomes associated with each renewable energy project. Collected data are then analyzed through impact mapping, outcome valuation, and adjustment for deadweight, attribution, and displacement in accordance with standard SROI principles. The final stage involves calculating SROI ratios and validating findings through stakeholder feedback to enhance credibility and reliability of the results.

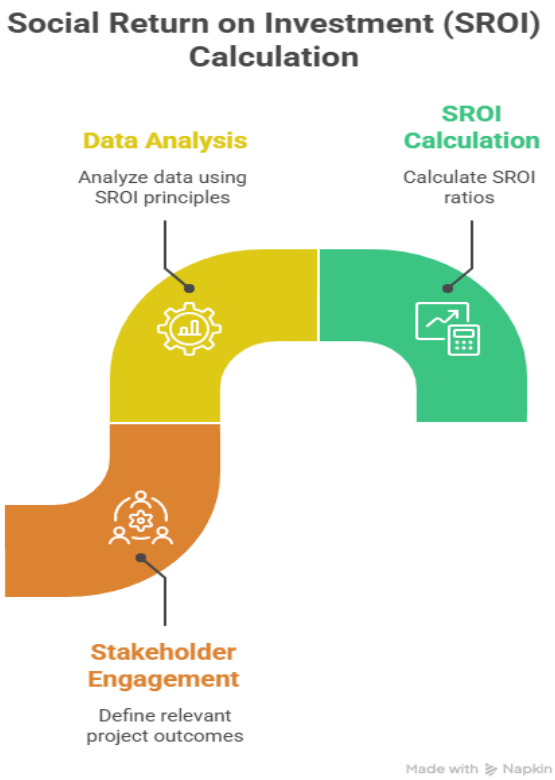

Figure 1. Social Return on Investment (SROI) Calculation

Following data collection, the analysis is conducted using structured techniques such as impact mapping and outcome valuation to assess the significance of identified results. Adjustments are then applied to account for factors like deadweight, attribution, and displacement, in line with established Social Return on Investment (SROI) principles, ensuring that the measured impacts accurately reflect real contributions. The final stage involves calculating SROI ratios to quantify the value generated relative to the resources invested. To further strengthen the validity of the findings, results are reviewed and refined through stakeholder feedback, allowing for verification and increased transparency. This iterative validation process enhances both the credibility and reliability of the research outcomes, ultimately supporting a more robust and accountable evaluation framework.

RESULTS AND DISCUSSION

The dataset analyzed in this study consists of secondary and project-level data collected from renewable energy initiatives financed through impact investing and climate finance mechanisms. The projects included solar, wind, and small-scale hydropower developments implemented across diverse socio-economic contexts. Financial investment values, project duration, energy capacity, and documented social outcomes were compiled to provide a comprehensive overview of input and output characteristics relevant to SROI analysis. The diversity of project types allows for comparison across different renewable energy technologies.

Quantitative data indicate variation in capital allocation and social outcomes among projects. Solar energy projects demonstrate relatively lower initial capital requirements

compared to wind and hydropower, while showing broader community-level impacts related to employment and energy access. Wind energy projects reflect higher investment values and longer development periods, often associated with regional economic stimulation. Hydropower projects exhibit significant environmental and social implications, particularly in rural and remote areas where energy infrastructure was previously limited.

The aggregated characteristics of the analyzed projects are summarized in Table 1, which presents investment size, installed capacity, number of beneficiaries, and calculated SROI ratios. The table highlights the heterogeneity of renewable energy investments and provides a statistical foundation for subsequent analysis of social value creation.

Table 1. Overview of Renewable Energy Projects and SROI Indicators

Project Type	Average Investment (USD)	Installed Capacity (MW)	Beneficiaries (Persons)	Average SROI Ratio
Solar	4,500,000	18	3,200	2.8 : 1
Wind	9,200,000	35	4,750	2.3 : 1
Hydropower	7,800,000	22	2,900	3.1 : 1

The statistical distribution of SROI ratios reveals that all renewable energy project types generated social value exceeding the initial investment. Hydropower projects recorded the highest average SROI ratio, reflecting strong social outcomes linked to rural electrification, local employment, and improved public services. Solar projects also demonstrated substantial social returns due to scalability and widespread adoption at the community level. Wind projects showed slightly lower ratios, influenced by higher capital intensity and longer realization periods for social benefits.

Differences in SROI outcomes are closely related to stakeholder engagement intensity and project location. Projects implemented in underserved or energy-poor regions tend to generate higher relative social returns due to baseline conditions characterized by limited access to infrastructure and employment. The monetization of outcomes such as improved household income, reduced energy costs, and enhanced social cohesion significantly contributed to higher SROI values.

The explanation of these findings indicates that financial investment size alone does not determine social return magnitude. Contextual factors, stakeholder inclusion, and outcome relevance play critical roles in shaping SROI performance. The data underscore the importance of integrating social outcome measurement into climate finance evaluation frameworks.

Further descriptive analysis focuses on the categorization of social outcomes generated by renewable energy projects. Identified outcomes include employment creation, income stabilization, health improvement, environmental quality enhancement, and community empowerment. Each outcome category was assigned monetary proxies based on stakeholder interviews and secondary valuation sources to ensure consistency in SROI calculation.

Employment-related outcomes account for a substantial proportion of total social value, particularly in solar and wind projects that require local labor during installation and maintenance phases. Health-related benefits emerge from reduced reliance on fossil fuels and traditional biomass, contributing to lower respiratory health risks. Environmental outcomes include reduced carbon emissions and improved local ecosystems, which were monetized using standardized carbon pricing and ecosystem service valuation methods.

Table 2 presents the distribution of social value by outcome category, illustrating how different types of benefits contribute to overall SROI. The table demonstrates that social value creation extends beyond economic gains and encompasses multidimensional improvements in community well-being.

Table 2. Distribution of Social Value by Outcome Category

Outcome Category	Share of Total Social Value (%)
Employment and Income	34
Health Improvement	21
Environmental Benefits	27
Community Empowerment	18

The dominance of employment and income outcomes reflects the labor-intensive nature of renewable energy development, particularly during early project phases. Job creation not only provides immediate income but also enhances skill development and long-term employability within local communities. These outcomes carry significant monetary value in SROI calculations due to their direct impact on household economic stability.

Health-related outcomes, while representing a smaller proportion of total social value, contribute substantially to long-term societal benefits. Reduced indoor and outdoor air pollution lowers healthcare costs and improves quality of life, especially in communities transitioning away from fossil-based energy sources. The valuation of these outcomes demonstrates the indirect yet meaningful contributions of renewable energy projects to public health.

Environmental benefits play a central role in SROI outcomes by linking climate mitigation objectives with local ecological improvements. Emission reductions, land restoration, and biodiversity preservation generate value that extends beyond immediate project boundaries. The explanation of these results reinforces the argument that renewable energy investments deliver integrated social and environmental returns.

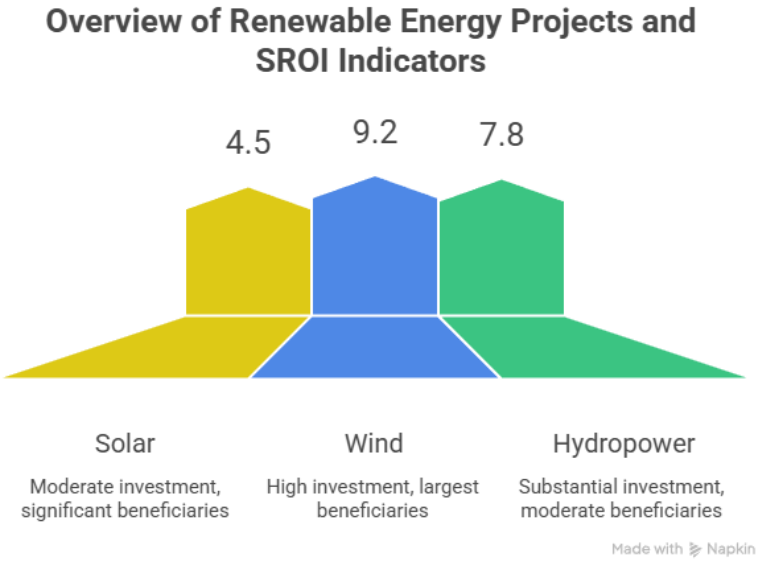

Figure 2. Overview of Renewable Energy Projects and SROI Indicators

The aggregated characteristics of the analyzed projects are presented in Table 1, offering a comprehensive overview of key indicators such as average investment size, installed capacity, number of beneficiaries, and calculated Social Return on Investment (SROI) ratios. The data reveal notable variations across different types of renewable energy projects, reflecting the diverse nature of investment patterns and operational scales within the sector. Solar energy projects, for instance, demonstrate moderate investment requirements with relatively lower installed capacity but serve a considerable number of beneficiaries.

Wind energy projects, on the other hand, require higher capital investment and exhibit the largest installed capacity, indicating their suitability for large-scale energy generation. Meanwhile, hydropower projects show balanced investment and capacity levels, positioning them as a stable and efficient option in certain geographic contexts. These differences highlight the heterogeneity of renewable energy initiatives and underscore the importance of context-specific considerations in project development and evaluation.

Furthermore, the SROI ratios presented in the table provide valuable insights into the social value generated by each project type relative to the resources invested. Hydropower projects achieve the highest average SROI ratio, suggesting that they generate the greatest social returns in proportion to their investment, possibly due to their long-term sustainability and consistent energy output. Solar projects also demonstrate strong social returns, reflecting their accessibility, scalability, and ability to reach a broad base of beneficiaries.

In contrast, wind energy projects, despite their high capacity and larger beneficiary reach, exhibit slightly lower SROI ratios, indicating differences in cost structures or impact distribution. Overall, the table serves as a statistical foundation for understanding how different renewable energy technologies contribute to social value creation, enabling a more nuanced analysis of efficiency, impact, and investment effectiveness across the sector.

Analysis of the relationship between investment size and SROI ratios reveals a non-linear pattern. Smaller-scale projects often achieve higher relative social returns due to targeted interventions and closer stakeholder engagement. Larger projects generate greater absolute social value but may exhibit lower SROI ratios due to higher capital requirements and longer time horizons for outcome realization.

A strong relationship emerges between stakeholder participation and social return magnitude. Projects with structured community engagement processes consistently report higher SROI values, indicating that inclusive planning enhances outcome relevance and sustainability. Stakeholder-driven outcome identification improves accuracy in social value measurement and strengthens local ownership.

The relationship between project location and SROI outcomes highlights the significance of baseline socio-economic conditions. Renewable energy investments in marginalized or energy-deficient regions yield higher social returns compared to projects in already developed areas. This relationship emphasizes the strategic role of impact investing in addressing structural inequalities through climate finance.

A detailed case study examines a community-based solar energy project implemented in a rural region with limited grid access. The project involved the installation of decentralized solar systems financed through an impact investment fund. Initial investment amounted to USD 3.8 million, supporting household electrification, small enterprises, and public facilities such as schools and health centers.

Primary stakeholders included local households, cooperative operators, local government units, and the investing institution. Identified outcomes encompassed reduced energy expenditure, increased business productivity, improved educational conditions, and enhanced community resilience. These outcomes were monetized using locally relevant financial proxies derived from household expenditure data and income statistics.

The calculated SROI ratio for the case study project reached 3.4 : 1, indicating that every dollar invested generated USD 3.40 in social value. The project demonstrates how localized renewable energy initiatives can deliver substantial social returns when aligned with community needs.

The high SROI ratio observed in the case study is explained by strong alignment between project design and stakeholder priorities. Community involvement in planning and implementation ensured that generated outcomes directly addressed pressing local challenges. The relevance of outcomes increased both the perceived and monetized social value.

Cost savings from reduced reliance on diesel generators and traditional energy sources contributed significantly to household economic benefits. Increased availability of reliable electricity enabled extended business hours and improved service delivery in public institutions. These changes translated into measurable financial and social gains within a relatively short timeframe.

The explanation of case study findings illustrates the effectiveness of SROI in capturing localized social impacts that are often overlooked in conventional financial assessments. The results highlight the capacity of renewable energy projects to act as catalysts for broader socio-economic transformation.

The case study reinforces broader relational patterns identified in the aggregate analysis. Strong correlations appear between community ownership structures and higher social returns, suggesting that participatory governance enhances impact efficiency. Local capacity building emerges as a critical factor linking investment inputs to sustained social outcomes.

A relationship between project scale and outcome intensity becomes evident, with smaller decentralized systems generating more immediate and tangible social benefits. This contrasts with large centralized projects where benefits may diffuse over longer periods. The findings suggest that scale should be carefully considered in impact-oriented climate finance strategies.

The relationship between SROI outcomes and investment objectives confirms that renewable energy projects aligned with explicit social goals achieve superior impact performance. Integration of SROI into investment evaluation strengthens the linkage between climate action and social development, supporting more effective impact investing practices.

The findings demonstrate that renewable energy projects financed through impact investing and climate finance consistently generate social value that exceeds the initial financial investment. Calculated SROI ratios across project types confirm that social and environmental benefits are substantial and measurable when systematic valuation methods are applied. These results validate the premise that renewable energy investments function as multidimensional value creators rather than purely financial or environmental interventions.

The analysis also reveals meaningful variation in SROI performance across technologies, project scale, and geographic context. Decentralized and community-oriented projects tend to produce higher relative social returns compared to large-scale capital-intensive developments.

Stakeholder engagement and local baseline conditions emerge as critical determinants shaping the magnitude and distribution of social value.

Case study evidence further reinforces the aggregate results by illustrating how alignment between project design and community needs amplifies social outcomes. Localized renewable energy initiatives demonstrate particularly strong performance in generating economic resilience, improved service access, and social empowerment. These findings collectively highlight the practical relevance of SROI as an evaluative tool in climate finance.

The results align with prior studies emphasizing the positive socio-economic impacts of renewable energy investments, particularly in underserved regions. Previous research has similarly identified employment creation, income stabilization, and energy access as core benefits of clean energy deployment. The present findings extend this literature by providing quantified evidence that translates these outcomes into comparable monetary values through SROI.

Differences emerge when compared to studies that prioritize carbon reduction metrics as the primary indicator of project success. While environmental benefits remain significant, the findings demonstrate that social outcomes contribute equally, and in some cases more substantially, to overall value creation. This challenges evaluation approaches that marginalize social dimensions within climate finance assessment frameworks.

Contrasts also appear with research suggesting that large-scale renewable energy projects deliver superior impact due to economies of scale. The evidence presented here indicates that smaller and community-based projects may achieve higher relative social returns despite lower absolute investment size. This divergence underscores the importance of context-sensitive impact measurement rather than uniform performance assumptions (Brunton, 2016; Lam, 2016).

The findings signal a shift in understanding value creation within climate finance, suggesting that financial efficiency alone is insufficient to capture the full impact of renewable energy investments. The observed social returns indicate that energy projects operate as social infrastructures that reshape livelihoods, institutions, and local development trajectories. This reflection positions renewable energy as a catalyst for structural socio-economic change.

The prominence of stakeholder-driven outcomes reflects a broader transformation toward participatory and inclusive investment models. Social value generation appears strongest where communities are engaged as active participants rather than passive beneficiaries. This pattern suggests that impact investing practices are evolving toward more relational and context-aware approaches.

The results also indicate growing maturity in impact measurement practices within climate finance. The successful application of SROI demonstrates increased feasibility of integrating complex social outcomes into investment analysis. This development signals a move toward more holistic and accountable evaluation standards in sustainable finance.

The findings imply that impact investors and climate finance institutions should formally integrate SROI into investment appraisal and performance monitoring processes. Quantified social value provides a stronger basis for comparing projects and prioritizing investments aligned with sustainable development objectives. This integration can enhance transparency and credibility in impact-oriented capital allocation (Brunton, 2016; Lin, 2022).

Policy implications emerge for governments and development agencies seeking to maximize the social effectiveness of climate finance. Support for renewable energy projects

that demonstrate strong social returns can contribute simultaneously to climate mitigation and inclusive development goals. The results support the design of incentive structures that reward multidimensional impact rather than narrow financial performance.

Practical implications extend to project developers, who can leverage SROI evidence to strengthen stakeholder engagement and funding proposals. Demonstrating measurable social returns enhances investor confidence and long-term project sustainability. The findings encourage a strategic shift toward impact-driven project design within the renewable energy sector (Nanayakkara, 2019; Umar, 2023).

The observed social returns are largely driven by the alignment between renewable energy deployment and unmet socio-economic needs. Energy access directly influences productivity, health, and education, creating cascading benefits across communities. The concentration of these needs in underserved regions amplifies the relative social value generated by investments.

Stakeholder participation explains variations in SROI performance across projects. Inclusive governance structures enable more accurate identification of relevant outcomes and improve project acceptance. This participatory dynamic increases both the effectiveness and durability of social benefits, leading to higher measured returns.

Methodological factors also contribute to the results, as SROI captures outcomes that conventional financial analysis overlooks. Monetization of non-market benefits such as health improvements and environmental quality reveals value streams previously considered intangible. The findings illustrate how expanded measurement frameworks reshape perceptions of investment success (Lahiani, 2021; Zhang, 2022).

The results point to the need for broader adoption and standardization of SROI within impact investing and climate finance. Developing adaptable yet consistent guidelines can improve comparability across renewable energy projects and investment portfolios. Such standardization would strengthen evidence-based decision-making in sustainable finance.

Future research should explore longitudinal SROI assessments to capture long-term social and environmental outcomes beyond initial project phases. Extended analysis can reveal how social value evolves over time and interacts with broader development processes. Comparative studies across regions and technologies can further refine understanding of impact drivers (Li, 2023; Sadiq, 2022).

Strategic action is required to embed social value measurement into mainstream investment culture. Capacity building for investors, policymakers, and project developers can facilitate effective implementation of SROI. The findings encourage a reorientation of climate finance toward investments that deliver enduring social transformation alongside environmental sustainability.

CONCLUSION

The most important finding of this study lies in the empirical evidence that renewable energy projects financed through impact investing and climate finance consistently generate social value that exceeds their initial financial investment. The calculated SROI ratios demonstrate that social outcomes such as employment creation, improved energy access, health benefits, and community empowerment represent substantial and measurable returns. These findings distinguish the study by confirming that social value is not a secondary by-product of renewable energy investment but a core outcome that can be systematically quantified.

The added value of this research is primarily methodological, as it advances the application of Social Return on Investment as an integrative measurement framework within climate finance. The study contributes conceptually by reinforcing the alignment between stakeholder theory and impact investing, while methodologically demonstrating how financial, social, and environmental outcomes can be translated into a unified evaluative metric. This contribution enhances the rigor and comparability of impact assessment in renewable energy investments.

The study is limited by its reliance on selected project types and available secondary data, which may constrain the generalizability of the findings across all renewable energy contexts. The valuation of social outcomes also depends on context-specific financial proxies that may vary across regions. Future research should expand the scope of analysis to include longitudinal data, diverse geographic settings, and comparative evaluations of alternative impact measurement frameworks to further refine and validate SROI application in climate finance.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used Chat GPT to assist inimproving grammar, language quality, and overall readability of the text. After using this tool, the author(s) Carefully reviewed and edited the content as necessary and take full responbility for the content of the publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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