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RISK TRANSFER STRATEGIES ON PERFORMANCE OF GEOTHERMAL ENERGY PROJECTS IN KENYA

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ABSTRACT

Geothermal energy plays a central role in Kenya's plan to achieve 100% renewable electricity by 2030, yet geothermal projects continue to face challenges such as cost overruns, delays, and low output reliability. Risk transfer, which involves shifting the burden of project risks to external parties such as insurers, contractors, and financial institutions, is one of the strategies used to manage these challenges, but its effect on project performance in Kenya has not been sufficiently studied. This study examined the effect of risk transfer strategies on the performance of geothermal energy projects in Kenya. The study was anchored on Transaction Cost Theory and adopted a quantitative correlational research design. The unit of analysis was geothermal energy projects in Kenya, while the unit of observation was 360 individuals involved in these projects, including project managers, engineers, risk managers, and contractors, drawn from eight geothermal power plants. A sample of 189 respondents was determined using the Yamane formula. Primary data were collected using a structured questionnaire, achieving an 82% response rate after 155 questionnaires were properly filled and returned. Data were analyzed using descriptive statistics (means and standard deviations) and inferential statistics (Pearson correlation and simple linear regression). The findings revealed that risk transfer strategies were poorly implemented among Kenyan geothermal projects, with insurance adoption being the most commonly used mechanism, while communication of risk-sharing measures was the most deficient. The correlation analysis showed a strong, positive and statistically significant relationship between risk transfer strategies and performance of geothermal energy projects ($r = 0.838$, $p < 0.01$). The regression results confirmed that risk transfer strategies had a positive and significant effect on performance. The study concluded that risk transfer strategies have a positive and significant effect on the performance of geothermal energy projects in Kenya, even though their current level of implementation remains low. Recommendations include developing a national geothermal insurance framework, enforcing mandatory risk-sharing clauses in contracts, and establishing structured contract review mechanisms.

KEYWORDS*:* *Risk Transfer, Insurance, Risk-Sharing, Project Performance, Geothermal Energy.*

INTRODUCTION

1.1 Background of the Study

The demand for clean and reliable energy has pushed countries to invest heavily in renewable sources, with geothermal energy emerging as one of the most stable and reliable options due to its low carbon footprint and constant availability regardless of weather conditions (IPCC, 2022). Countries such as the United States, Indonesia, and the Philippines lead the world in geothermal capacity, and international reports show that global installed geothermal capacity has been steadily rising as governments and private investors seek to diversify their energy mix (IRENA, 2021). However, geothermal projects worldwide are capital-intensive and carry significant uncertainty, particularly during exploration and drilling, which exposes investors and developers to considerable financial and operational risk (OECD, 2022). To manage this uncertainty, project developers across the world increasingly rely on risk transfer mechanisms such as insurance policies, Power Purchase Agreements (PPAs), Public-Private Partnerships (PPPs), and Engineering, Procurement and Construction (EPC) contracts to shift potential losses to parties better placed to absorb them (Hansen *et al*., 2021).

Within Africa, the geothermal sector is concentrated mainly along the East African Rift Valley, which stretches through countries such as Kenya, Ethiopia, Tanzania, and Uganda, and is estimated to hold a geothermal potential of over 20,000 MW (African Development Bank, 2021). Despite this potential, African countries have struggled to fully exploit geothermal resources due to limited access to affordable financing, weak insurance markets, and underdeveloped contractual frameworks for managing project risk. Regional reports indicate that many geothermal projects in the region experience delays and cost overruns similar to those seen in other large infrastructure projects across the continent, largely because risk transfer mechanisms remain informal or poorly structured compared to more mature energy markets (African Development Bank, 2021).

In Kenya, geothermal energy has become the backbone of the country's renewable energy strategy, contributing 47% of the national electricity mix with an installed capacity of 988.7 MW as of 2023 (Kenya National Bureau of Statistics, 2023). This places Kenya among the top geothermal producers in Africa, alongside its Vision 2030 target of achieving 100% renewable electricity. However, the country's estimated geothermal potential of 7,000 to 10,000 MW across 14 identified sites remains largely underdeveloped, and existing projects continue to experience significant challenges (Geothermal Development Company, 2023). Geothermal projects in Kenya take an average of seven years to complete, compared to four years for hydropower projects, mainly due to high drilling costs of about $5.5 million per well and geological uncertainties (Kamau & Kimani, 2023). These projects also record lower output reliability, with an average uptime of 85% compared to 95% recorded at Lake Turkana wind projects, largely due to equipment failures and resource variability (Mwangi, 2022).

Geothermal sites such as Olkaria, Menengai, Eburru, Suswa, Baringo-Silali, Akiira, Longonot, and Arus-Bogoria illustrate the practical challenges facing Kenya's geothermal sector. Community land disputes have affected approximately 30% of these sites, stalling projects such as Suswa for up to 15 months, while inconsistent contracting practices and limited insurance coverage have left many of these projects exposed to financial and operational shocks (African Development Bank, 2024). Risk transfer, as a strategy for managing this uncertainty, involves shifting the responsibility for potential risks to external parties such as insurance companies, contractors, and financial institutions through mechanisms including insurance policies, PPAs, PPPs, and EPC contracts (IRENA, 2021). By transferring risks to parties better placed to manage them, project developers are able to protect their investments, stabilize revenue streams, and reduce the financial burden of unexpected events (OECD, 2022). Despite the increasing adoption of risk transfer strategies in renewable energy projects, this study sought to examine the relationship between risk transfer strategies and the performance of geothermal energy projects in Kenya.

1.2 Statement of the Problem

Despite Kenya's significant geothermal potential of 7,000–10,000 MW, geothermal energy contributed only 988.7 MW to the national grid in 2023 due to persistent financial and operational challenges (Kenya National Bureau of Statistics, 2023; Geothermal Development Company, 2023). High drilling costs, equipment failures, contractual disputes, and community compensation claims continue to cause project delays, cost overruns, and reduced output reliability. Risk transfer strategies, including insurance, contractual risk-sharing agreements, warranties, outsourcing, and public-private partnerships, have been adopted to shift these risks and improve project performance. However, geothermal projects continue to experience substantial financial losses and implementation delays, raising concerns about the effectiveness of these strategies. Previous studies by Bassey *et al*. (2024), Njuguna (2019), and Apondi and Senelwa (2020) found that risk transfer improves project outcomes in renewable energy, construction, and healthcare sectors. Nevertheless, these studies did not specifically examine geothermal energy projects in Kenya, creating geographical and contextual gaps. This study therefore sought to examine the effect between risk transfer strategies and the performance of geothermal energy projects in Kenya.

LITERATURE REVIEW

2.1 Theoretical Framework

This study was anchored on Transaction Cost Theory, which was developed by Ronald Coase (1937) in his work "The Nature of the Firm" and later extended by Williamson (1981, 2019). The theory explains that firms and organizations engage in exchanges with external parties in order to reduce the costs associated with managing uncertainty, including search costs, bargaining costs, and monitoring costs. According to the theory, organizations transfer risk to external partners such as contractors or insurance companies through contracts, thereby shifting the burden of potential negative outcomes away from themselves and reducing the internal costs of managing that uncertainty (Williamson, 2020).

Applying Transaction Cost Theory to this study, geothermal energy projects in Kenya face significant transaction costs arising from uncertainties in financing, construction, operations, and regulation. The theory suggests that transferring these risks through contracts, insurance policies, and joint ventures can improve project outcomes by reducing the costs associated with managing unforeseen events (Rossi & Costa, 2021). This theoretical framework guided the study in examining how mechanisms such as insurance adoption, risk-sharing agreements, outsourcing, and contractual reviews relate to the performance of geothermal energy projects in Kenya.

2.2 Empirical Review

Several studies have examined the relationship between risk transfer and project performance in different contexts. Bassey, Aigbovbiosa, and Agupugo (2024) found that financial derivatives, Power Purchase Agreements, and insurance products significantly enhance the viability of geothermal energy projects by reducing price volatility and ensuring revenue stability, although they noted that comprehensive insurance coverage for specialized geothermal risks is often unavailable or too costly in developing economies. Hansen *et al*. (2021) established that Engineering, Procurement and Construction contracts allow project developers to transfer construction-related risks to specialized firms, helping projects to be completed within budget and timeline constraints.

Within the Kenyan context, Njuguna (2019) examined risk transfer strategies among geothermal energy projects in Nairobi City County and found that risk transfer had the greatest effect on project performance compared to other risk management practices studied. Apondi and Senelwa (2020) also found that project risk transfer practices positively influenced the sustainability of infrastructure projects, supporting the view that shifting risk to external parties protects project outcomes. While these studies confirm the general importance of risk transfer, most have focused on financial or infrastructure projects outside the geothermal sector, or have examined risk transfer alongside several other variables without isolating its specific contribution to geothermal project performance in Kenya.

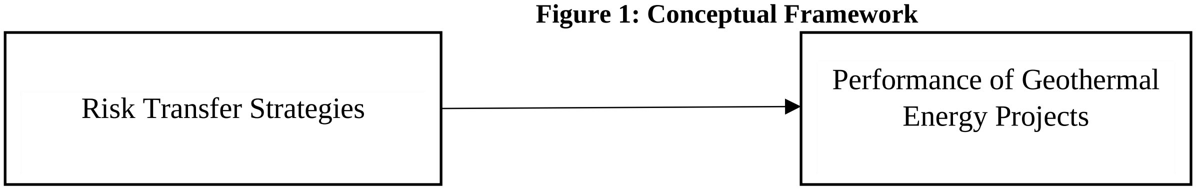
2.3 Research Gap

Although the reviewed literature confirms that risk transfer strategies are important for project performance, most studies have either been conducted outside Kenya's geothermal sector or have examined risk transfer as one of several combined risk management strategies without establishing its distinct statistical relationship with performance outcomes. Additionally, limited research has used comprehensive indicators of risk transfer, such as insurance adoption, risk-sharing agreements, outsourcing, contractual reviews, third-party risk management, and communication of risk-sharing measures, to predict specific performance outcomes such as budget adherence, timeline completion, and energy output among Kenyan geothermal projects. This study fills this gap by specifically examining the effect of risk transfer strategies on the performance of geothermal energy projects across multiple geothermal sites in Kenya, using both descriptive and inferential statistical analysis.

2.4 Conceptual Framework

The conceptual framework for this study illustrates the relationship between the independent variable (risk transfer strategies) and the dependent variable (performance of geothermal energy projects). Risk transfer strategies were operationalized through indicators including insurance adoption, risk-sharing agreements with contractors, outsourcing of high-risk tasks, review of contractual obligations, third-party risk management, and communication of risk-sharing measures. Performance of geothermal energy projects was operationalized through indicators including budget adherence, timeline completion, energy output, operational downtime, financial returns, and reliability of contribution to the national power grid.

Figure 1: Conceptual Framework



RESEARCH METHODOLOGY

3.1 Research Design

This study adopted a quantitative research design with a correlational approach. This design was appropriate because it allowed the researcher to measure the relationship between risk transfer strategies and performance of geothermal energy projects using structured data collection and statistical analysis, without manipulating any of the variables.

3.2 Target Population

The unit of analysis for this study was geothermal energy projects in Kenya, while the unit of observation was 360 individuals directly involved in these projects, including project managers, risk managers, engineers, technicians, financial managers, government representatives, chief consultants, contractors, and local community leaders. These individuals were drawn from eight geothermal power plants, namely Olkaria, Menengai, Eburru, Suswa, Baringo-Silali, Akiira, Longonot, and Arus-Bogoria.

3.3 Sample Size and Sampling Technique

A stratified random sampling technique was used to ensure proportional representation from each category of respondents. The Yamane formula was applied to determine the sample size at a 95% confidence level with a 5% margin of error:

$n = N / (1 + N(e)^2)$

Where n is the sample size, N is the population size (360), and e is the margin of error (0.05). Substituting the values:

$n = 360 / (1 + 360 \times 0.05^2)$

$n = 360 / (1 + 0.9)$

$n = 360 / 1.9$

$n = 189$

A sample size of 189 respondents was therefore targeted, with participants randomly selected from each stratum to ensure fair representation.

3.4 Data Collection Instrument

Primary data were collected using a structured questionnaire measuring risk transfer strategies and performance of geothermal energy projects on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The risk transfer section contained six statements covering insurance adoption, risk-sharing agreements, outsourcing, contractual reviews, third-party risk management, and communication of risk-sharing measures. The questionnaire was pilot tested with 19 respondents representing approximately 10% of the sample size, and these respondents were excluded from the main study. The pilot test yielded a Cronbach's Alpha coefficient of 0.908 for the risk transfer scale and 0.892 for the performance scale, both exceeding the acceptable threshold of 0.7 (Kombo & Tromp, 2009).

3.5 Data Collection Procedure

Before data collection, the researcher obtained approval from the university ethics review board, the National Commission for Science, Technology and Innovation (NACOSTI), and the participating organizations. Questionnaires were distributed to respondents through email and in-person administration, using a self-administered approach with follow-up phone calls to improve the response rate. Confidentiality was maintained throughout by anonymizing responses and securely storing collected data.

3.6 Data Analysis Techniques

Data was analyzed using both descriptive and inferential statistics. Descriptive statistics included means and standard deviations, with mean scores interpreted using the following criteria: 1.00 to 1.80 (Very Low), 1.81 to 2.60 (Low), 2.61 to 3.40 (Moderate), 3.41 to 4.20 (High), and 4.21 to 5.00 (Very High). Inferential statistics included Pearson correlation analysis to determine the strength and direction of the relationship between risk transfer strategies and performance, and simple linear regression analysis to establish the proportion of variance in performance explained by risk transfer. The regression model took the form:

$Y = \beta0 + \beta1X + \varepsilon$

Where:

Y = Performance of geothermal energy projects

X = Risk transfer strategies

$\beta0$ = Constant (intercept)

$\beta1$ = Regression coefficient

ε = Error term

Analysis was conducted using SPSS Version 31, and statistical significance was tested at the 0.05 significance level.

DATA ANALYSIS

4.1 Introduction

This section presents analysis of data collected from 155 respondents involved in geothermal energy projects in Kenya, out of the 189 questionnaires issued, representing a response rate of 82%. This response rate was considered excellent for social science research (Taherdoost & Madanchian, 2024).

4.2 Analysis of Risk Transfer Strategies

Table 1 presents descriptive statistics for the six statements measuring risk transfer strategies among geothermal energy projects in Kenya.

TABLE 1: Risk Transfer Strategies

Statement	Mean	Std. Dev.
The organization adopts insurance policies to mitigate financial risks.	2.900	1.208
There are well-structured risk-sharing agreements with contractors.	2.460	1.186
Outsourcing of high-risk tasks improves project performance.	2.700	1.204
The organization regularly reviews its contractual obligations to minimize risks.	2.340	1.170
Third-party risk management reduces project uncertainties.	2.820	1.185
The project team effectively communicates risk-sharing measures.	2.220	1.150
Overall Mean	**2.573**	**1.184**

The overall mean score for risk transfer strategies was 2.573, falling within the low range, indicating that risk transfer strategies are poorly implemented among geothermal energy projects in Kenya. The highest mean was recorded for insurance adoption (mean = 2.900, SD = 1.208), suggesting that insurance is the most commonly used risk transfer mechanism, although the mean still falls below the neutral threshold of 3.0. Third-party risk management also recorded a moderate mean of 2.820 (SD = 1.185), while outsourcing of high-risk tasks recorded a mean of 2.700 (SD = 1.204). Well-structured risk-sharing agreements with contractors recorded a low mean of 2.460 (SD = 1.186), regular review of contractual obligations recorded an even lower mean of 2.340 (SD = 1.170), and the lowest mean was recorded for communication of risk-sharing measures (mean = 2.220, SD = 1.150).

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These findings agree with Bassey, Aigbovbiosa, and Agupugo (2024), who found that although insurance products such as Power Purchase Agreements can significantly enhance geothermal project viability, comprehensive insurance coverage for specialized geothermal risks is often unavailable or too costly in developing economies, which explains why insurance adoption in this study, though the highest-rated item, still fell below the neutral threshold. The low rating for risk-sharing agreements with contractors also contrasts with Hansen *et al*. (2021), who found that Engineering, Procurement and Construction contracts allow developers in more structured markets to transfer construction-related risks to specialized firms; the low implementation found in this study suggests that Kenyan geothermal contracts do not yet assign risk in this structured way. Similarly, the weak performance on contractual reviews and risk communication differs from Njuguna (2019), who found relatively stronger risk transfer practices among geothermal projects in Nairobi City County, suggesting that risk transfer implementation may vary considerably across different geothermal project sites in Kenya. The findings, however, support the general concern raised by Apondi and Senelwa (2020), who noted that infrastructure projects with weak risk transfer practices tend to experience poorer sustainability outcomes, consistent with the generally low mean recorded in this study.

4.3 Analysis of Performance of Geothermal Energy Projects

Table 2 presents descriptive statistics for the six statements measuring performance of geothermal energy projects in Kenya.

TABLE 2: Performance of Geothermal Energy Projects

Statement	Mean	Std. Dev.
Projects are completed within the planned budget.	2.220	1.160
Projects are completed within the scheduled timeline.	2.380	1.182
Energy output meets the designed capacity targets.	3.000	1.220
Operational downtime is minimized through effective risk management.	2.800	1.216
Project financial returns meet investor expectations.	2.500	1.200
The project contributes reliably to the national power grid.	2.760	1.208
Overall Mean	**2.610**	**1.198**

The overall mean score for performance of geothermal energy projects was 2.610, indicating that geothermal energy projects in Kenya are not performing effectively. Energy output meeting designed capacity targets recorded the highest mean of 3.000 (SD = 1.220), a neutral rating showing that while some plants achieve their designed output, others fall short due to steam field depletion and maintenance issues. Operational downtime minimized through effective risk management recorded a mean of 2.800 (SD = 1.216), and reliable contribution to the national power grid recorded a mean of 2.760 (SD = 1.208). Project financial returns meeting investor expectations recorded a low mean of 2.500 (SD = 1.200), projects being completed within scheduled timelines recorded a mean of 2.380 (SD = 1.182), and the lowest mean was recorded for projects being completed within the planned budget (mean = 2.220, SD = 1.160).
These findings are consistent with Kamau and Kimani (2023), who found that geothermal projects in Kenya face significant cost overruns and delays due to high drilling costs and geological uncertainties, which explains the low mean recorded for budget and timeline adherence in this study. The relatively better rating for energy output aligns with Mwangi (2022), who found that Kenyan geothermal projects, despite challenges, still maintain a reasonably high uptime compared to other renewable sources, though not as high as wind projects at Lake Turkana. The low mean recorded for financial returns meeting investor expectations also supports Bassey, Aigbovbiosa, and Agupugo (2024), who noted that geothermal energy investments in developing economies often struggle with revenue stability in the absence of strong risk transfer mechanisms such as Power Purchase Agreements. Overall, the pattern of stronger technical performance but weaker financial and timeline performance found in this study mirrors the broader challenges of Kenya's geothermal sector identified in the literature reviewed in Chapter Two.

4.4 Inferential Statistics: Correlation Analysis

To determine the strength and direction of the relationship between risk transfer strategies and performance of geothermal energy projects, Pearson product-moment correlation coefficient was computed. Table 3 presents the correlation results.

TABLE 3: Correlation Between Risk Transfer Strategies and Performance of Geothermal Energy Projects

Variables	Risk Transfer Strategies	Performance of Geothermal Energy Projects
Risk Transfer Strategies	1	0.838**
Performance of Geothermal Energy Projects	0.838**	1

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

Table 3 shows a Pearson correlation coefficient of $r = 0.838$ between risk transfer strategies and performance of geothermal energy projects, indicating a strong positive relationship that is statistically significant at the 0.01 level ($p < 0.01$). This means that as the implementation of risk transfer strategies improves, the performance of geothermal energy projects also improves. This finding is consistent with Transaction Cost Theory, which holds that transferring risk to external parties reduces the costs of managing uncertainty and improves project outcomes. The finding also aligns closely with Njuguna (2019), who found that risk transfer had the greatest effect on performance among geothermal energy projects in Nairobi City County, confirming that this strong relationship holds even when the same variable is examined across a wider set of geothermal sites in this study. The finding is further supported by Bassey, Aigbovbiosa, and Agupugo (2024), who established that Power Purchase Agreements and insurance products significantly enhance geothermal project viability, and by Apondi and Senelwa (2020), who found that stronger risk transfer practices are associated with better infrastructure project sustainability outcomes.

4.5 Inferential Statistics: Regression Analysis

To determine the extent to which risk transfer strategies predict performance of geothermal energy projects, simple linear regression analysis was conducted. Table 4 presents the regression coefficients.

TABLE 4: Regression Coefficients

Model	Unstandardized B	Std. Error	Standardized Beta	t	Sig.
(Constant)	0.588	0.147		4.000	0.000
Risk Transfer Strategies	0.782	0.041	0.838	19.024	0.000

The regression coefficients in Table 4 yield the following regression equation:
$Y = 0.588 + 0.782X$
Where:
Y = Performance of geothermal energy projects
X = Risk transfer strategies
The constant term ($\beta0 = 0.588$) indicates that when risk transfer strategies are at zero, the predicted level of performance of geothermal energy projects is 0.588, which falls within the very low range. The regression coefficient ($\beta1 = 0.782$) indicates that for every one-unit increase in risk transfer strategies, performance of geothermal energy projects increases by 0.782 units. The t-statistic of 19.024 with a significance value of 0.000 confirms that risk transfer strategies make a significant and positive contribution to predicting performance of geothermal energy projects, and the null hypothesis that risk transfer strategies have no significant effect on performance is therefore rejected.

These findings support Bassey, Aigbovbiosa, and Agupugo (2024), who found that financial derivatives, Power Purchase Agreements, and insurance products effectively reduce price volatility and safeguard against operational and regulatory uncertainties in geothermal projects, confirming that risk transfer mechanisms have a measurable, positive influence on project outcomes. The findings are also consistent with Hansen *et al*. (2021), who established that contractual risk transfer mechanisms such as Engineering, Procurement and Construction contracts improve project completion within budget and timeline constraints by transferring construction-related risks to specialized firms. Similarly, the positive and significant coefficient recorded in this study reinforces Njuguna (2019), who found risk transfer to have the strongest effect on performance among geothermal energy projects compared to other risk management strategies, suggesting that this relationship is a consistent feature of Kenya's geothermal sector rather than one confined to a single project site.

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study examined the effect of risk transfer strategies on performance of geothermal energy projects in Kenya. The findings revealed that risk transfer strategies, including insurance adoption, risk-sharing agreements, outsourcing, contractual reviews, third-party risk management, and communication of risk-sharing measures, were poorly implemented among Kenyan geothermal projects, with an overall mean of 2.573. Insurance adoption was the most commonly used mechanism, while communication of risk-sharing measures was the most deficient area. Performance of geothermal energy projects was also found to be low, with an overall mean of 2.610, with projects performing relatively better on technical metrics such as energy output but poorly on financial and timeline metrics such as budget adherence.

The inferential statistics confirmed a strong positive correlation ($r = 0.838$, $p < 0.01$) between risk transfer strategies and performance of geothermal energy projects, and the regression analysis confirmed that risk transfer strategies had a positive and statistically significant effect on performance. This is consistent with Transaction Cost Theory, which holds that transferring risk to external parties reduces the transaction costs associated with managing uncertainty and improves outcomes. The study concludes that risk transfer strategies have a positive and significant effect on the performance of geothermal energy projects in Kenya, and that improving the implementation of these strategies, particularly structured risk-sharing agreements, regular contractual reviews, and transparent risk communication, could substantially improve project outcomes.

5.2 Recommendations

Based on the findings, this study makes the following recommendations. First, the Insurance Regulatory Authority, in collaboration with the Ministry of Energy and Petroleum, should develop a Geothermal Energy Insurance Framework requiring minimum insurance coverage for all geothermal projects, given that insurance adoption, though the most used mechanism, still falls below acceptable levels. Second, the Ministry of Energy and Petroleum should issue binding contracting guidelines mandating risk-sharing clauses in all Engineering, Procurement and Construction contracts, to address the weak risk-sharing agreements identified in this study.

Third, geothermal project developers such as the Geothermal Development Company should establish a Quarterly Contract Review process where project managers, contracts officers, legal advisors, and finance officers review all active contracts and produce a contract health scorecard, addressing the finding that contractual obligations are rarely reviewed. Fourth, project teams should improve communication of risk-sharing measures by establishing clear internal reporting structures and regular risk briefings, since this was found to be the most deficient area of risk transfer implementation. Finally, future research should examine the combined effect of risk transfer alongside other risk management strategies such as risk avoidance, risk mitigation, and risk acceptance, and should explore other factors such as regulatory environment and financing conditions that may explain the remaining variance in geothermal project performance.

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