Public–Private Partnership Practices and Performance of Geothermal Energy Projects in Kenya

Ronald Anguzu, Dr. Moses Oginda, Dr. Christine Bando

Department of Management Science, School of Business and Economics, Maseno University

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ABSTRACT

This study examined the effect of Public–Private Partnership (PPP) practices on the performance of geothermal energy projects in Kenya. Despite significant investments in geothermal energy through PPP arrangements, many projects continue to face cost overruns, delays, operational inefficiencies, and stakeholder dissatisfaction. The study focused on legal framework implementation, shared investment, and type of agreement as key PPP dimensions influencing project performance. A positivist philosophy and cross-sectional survey design were adopted. Data were collected from 214 respondents and analyzed using descriptive statistics, Pearson correlation, and multiple regression. Findings revealed that PPP practices significantly influenced project performance (β=.631, $p<.05$), explaining 39.8% of variation in performance. Type of agreement was the strongest predictor followed by legal framework implementation and shared investment. The study concludes that strengthening PPP arrangements can substantially improve geothermal project outcomes in Kenya.

Keywords: Public–Private Partnerships (PPP), Geothermal Energy Projects, Project Performance, Legal Framework Implementation, Shared Investment, Type of Agreement, Renewable Energy Infrastructure, Infrastructure Governance, Energy Project Management

BACKGROUND OF THE STUDY

The emergence of Public–Private Partnerships (PPPs) can be traced to broader public sector reforms initiated during the 1980s and 1990s. These reforms were influenced by New Public Management principles, which advocated greater private sector participation in public service delivery to improve efficiency, innovation, and accountability (Hood, 1991). PPPs became particularly attractive because they offered governments an opportunity to leverage private financial resources and managerial expertise while maintaining public oversight of critical infrastructure. The model gained significant prominence in countries such as the United Kingdom, Australia, Canada, and South Africa, where PPP arrangements were successfully applied in transportation, healthcare, water supply, and energy infrastructure projects (Yescombe, 2018). Over time, PPPs evolved from simple contractual arrangements into complex collaborative frameworks involving risk-sharing, joint investment, performance monitoring, and long-term service agreements between public and private entities.

Globally, PPPs have increasingly been adopted within the energy sector to address financing gaps associated with large-scale infrastructure investments. Renewable energy projects, including geothermal developments, require substantial upfront capital investment and involve significant technical and financial risks that often exceed the capacity of governments alone. PPP arrangements therefore provide mechanisms through which risks, responsibilities, and rewards can be shared between public institutions and private investors (Organisation for Economic Co-operation and Development [OECD], 2022). Studies have shown that well-structured PPPs can improve project efficiency, facilitate technology transfer, accelerate project implementation, and enhance long-term sustainability of infrastructure investments (World Bank, 2022). However, the success of PPP projects depends heavily on the quality of legal frameworks, institutional arrangements, financing structures, and contractual agreements governing partnerships.

In Africa, energy deficits continue to constrain economic growth and industrial development despite significant renewable energy potential. Many countries experience persistent electricity shortages, unreliable power supply,

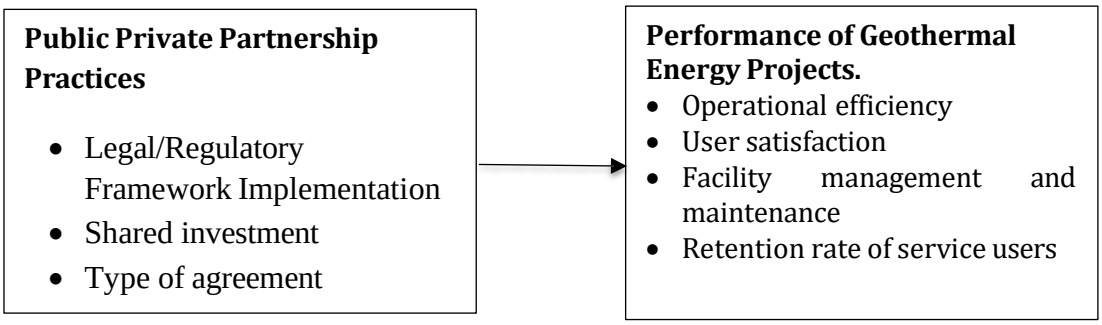
and inadequate energy infrastructure. To address these challenges, governments have increasingly embraced PPPs as mechanisms for attracting private investment into energy development projects. Countries such as South Africa, Morocco, Egypt, and Kenya have implemented various PPP initiatives within renewable energy sectors to expand electricity generation capacity and improve energy access (African Development Bank [AfDB], 2023). Nevertheless, many African PPP projects continue to encounter implementation challenges arising from weak regulatory frameworks, inadequate institutional capacity, political interference, financing constraints, and ineffective risk allocation mechanisms (Mugisha & Berg, 2020).

Kenya has emerged as one of Africa's leading renewable energy producers and is internationally recognized for its significant geothermal energy resources located within the East African Rift Valley. The country's geothermal development journey began during the 1950s with preliminary exploration activities in the Olkaria geothermal field. Commercial geothermal power generation commenced in 1981 following the commissioning of the first geothermal power plant at Olkaria. Since then, geothermal energy has become a central pillar of Kenya's energy strategy and currently contributes a substantial proportion of the country's electricity generation mix (Kenya Electricity Generating Company [KenGen], 2023). The Government of Kenya has consistently prioritized geothermal development because of its potential to provide reliable, affordable, and environmentally sustainable electricity capable of supporting industrialization and economic transformation.

Despite notable achievements, geothermal energy development in Kenya continues to face significant challenges. Geothermal projects require extensive exploration activities, sophisticated drilling operations, and large-scale infrastructure investments, all of which involve substantial financial risks and long project gestation periods. These characteristics have necessitated increased collaboration between government agencies and private investors through PPP arrangements. The enactment of the Public Private Partnership Act and subsequent policy reforms reflected Kenya's commitment to promoting private sector participation in infrastructure development, including renewable energy projects (Government of Kenya, 2021). Through PPP frameworks, the government aims to mobilize additional investment resources, improve project management efficiency, accelerate infrastructure delivery, and enhance sustainability of energy projects.

Although PPPs have become increasingly important in geothermal energy development, concerns regarding project performance continue to persist. Several geothermal projects have experienced delays in implementation, escalating costs, operational inefficiencies, stakeholder conflicts, and challenges in achieving intended performance outcomes. Such challenges raise questions regarding the effectiveness of existing PPP arrangements and the extent to which partnership practices contribute to project success. Project performance remains a critical concern because successful geothermal projects are expected to deliver reliable electricity generation, operational efficiency, financial sustainability, environmental compliance, and stakeholder satisfaction. Failure to achieve these outcomes can undermine investor confidence, increase public expenditure burdens, and slow progress toward national energy goals.

Conceptual Framework



Summary of Theoretical Review

The study was guided by New Public Management Theory, New Public Governance Theory, and Agency Theory. New Public Management emphasizes efficiency and accountability in public service delivery. New Public Governance highlights collaboration among stakeholders involved in infrastructure development. Agency

Theory explains contractual relationships and accountability between public and private partners. Together, these theories provide a foundation for understanding how PPP arrangements influence project performance.

Summary of Empirical Review

Existing literature suggests that specific PPP practices play an important role in determining project outcomes. Legal framework implementation provides the regulatory certainty necessary for attracting investment and managing stakeholder relationships. Shared investment mechanisms facilitate resource mobilization and risk sharing among project partners. Similarly, the type of agreement adopted influences accountability structures, allocation of responsibilities, dispute resolution mechanisms, and project governance arrangements (Yescombe, 2018). While these dimensions are widely recognized within PPP literature, empirical evidence regarding their influence on geothermal energy project performance remains limited, particularly within the Kenyan context.

Previous studies have largely concentrated on PPP implementation in transportation infrastructure, water supply systems, housing projects, and general infrastructure development. Studies focusing specifically on renewable energy projects have often emphasized financing challenges, investment attraction, and policy frameworks while paying limited attention to how specific PPP practices influence project performance outcomes (Fu et al., 2023; Kasri et al., 2022). Furthermore, many studies have been conducted in developed economies whose institutional environments differ significantly from those found in Kenya and other developing countries. Consequently, findings from such contexts may not adequately explain the realities of geothermal project implementation within Kenya's evolving energy sector.

In Kenya, empirical studies examining PPPs have predominantly focused on road infrastructure, public service delivery, and general investment performance. Relatively few studies have investigated geothermal energy projects despite their strategic importance within the country's energy development agenda. Even among existing geothermal studies, limited attention has been given to the combined influence of legal framework implementation, shared investment arrangements, and types of PPP agreements on project performance. This creates a significant contextual and empirical gap in understanding how partnership practices shape outcomes within geothermal energy developments.

The present study sought to address this gap by examining the influence of Public–Private Partnership practices on the performance of geothermal energy projects in Kenya. Specifically, the study focused on legal framework implementation, shared investment, and type of agreement as key dimensions of PPP practice. By investigating their relationship with project performance, the study contributes to existing knowledge on infrastructure governance, renewable energy development, and public–private collaboration. The findings are expected to provide valuable insights for policymakers, project developers, investors, and energy sector stakeholders seeking to strengthen geothermal project performance and enhance the effectiveness of PPP arrangements in Kenya.

METHODOLOGY

The study adopted a positivist philosophy and cross-sectional survey design. The target population consisted of 517 stakeholders involved in geothermal energy projects in Kenya. A sample of 222 respondents was selected. Data were collected using structured questionnaires. Reliability coefficients ranged from 0.83 to 0.89 while the Content Validity Index was 0.89. Data were analyzed using descriptive statistics, Pearson correlation analysis, and multiple regression analysis.

FINDINGS

To examine the effect of Public Private Partnership (PPP) practices on the performance of geothermal energy projects in Kenya, the study employed a multiple regression model. This approach was chosen because it allows simultaneous estimation of the unique contribution of each predictor variable namely legal framework implementation, shared investment, and type of agreement on project performance, while controlling for the influence of the other factors. The model was tested at the 0.05 level of significance, with results presented in Table 1. The regression model provides both the overall explanatory power of the predictors and the individual effect of each sub-construct on project performance.

Table 1 Effect of Public private partnership practices on performance of geothermal energy projects in Kenya

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.639[a]	.409	.400	.4707	.409	48.393	3	210	.000

a. Predictors: (Constant), Type of Agreement, Shared Investment, Legal Framework Implementation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.081	.082		13.166	.000
	Shared Investment	.096	.037	.157	2.596	.010
	Legal Framework Implementation	.179	.040	.293	4.491	.000
	Type of Agreement	.205	.042	.328	4.899	.000

a. Dependent Variable: Performance of Sosian Geothermal project

The results indicate that the model was statistically significant ($F(3,210) = 48.393$, $p < .001$), with an R value of .639 showing a strong positive association between PPP practices and performance of geothermal energy projects. The R Square value of .409 implies that 40.9% of the variation in project performance was explained by the three PPP sub-constructs included in the model. This was a substantial proportion, suggesting that PPP practices played a central role in shaping the success of geothermal energy projects. The remaining 59.1% of the variance was attributable to other factors not captured in this model, such as technical, environmental, or market-related considerations.

In terms of individual predictors, the results show that shared investment had a positive and significant effect on project performance ($\beta = .157$, $t = 2.596$, $p = .010$). Although its effect size was comparatively smaller than the other predictors, this finding implies that joint financial contributions between the public and private sector enhance resource availability, risk management, and commitment, which in turn improves project outcomes. This supports the argument that cost-sharing in capital-intensive projects like geothermal development reduces financial strain and increases the likelihood of timely implementation.

Legal framework implementation was also found to significantly influence project performance ($\beta = .293$, $t = 4.491$, $p < .001$). This highlights the importance of a clear, consistent, and enforceable regulatory environment in driving project success. Strong legal frameworks foster accountability, enhance transparency, and provide mechanisms for compliance, which ensures that projects proceed as planned. Finally, the type of agreement emerged as the strongest predictor of project performance ($\beta = .328$, $t = 4.899$, $p < .001$). This suggests that well-structured agreements that emphasize accountability, equitable risk-sharing, financial sustainability, and conflict resolution are most crucial in determining whether PPP geothermal projects succeed.

The constant term (B = 1.081, p < .001) represents the expected baseline level of performance of the Sosian geothermal project when all independent variables (shared investment, legal framework implementation, and type of agreement) are held at zero. In practical terms, this indicates that even in the absence of PPP practices captured in the model, a minimum level of project performance (1.081 units) would still be realized, likely due to other underlying factors not included in the model such as institutional structures or external support systems. The unstandardized coefficients show that project performance can be expressed as a linear function of the predictors, such that performance increases with improvements in shared investment, legal framework implementation, and type of agreement.

Specifically, holding other factors constant, a one-unit increase in shared investment leads to a 0.096 unit increase in performance, indicating a positive but modest contribution of joint financing to project outcomes. Similarly, a one-unit improvement in legal framework implementation results in a 0.179 unit increase in performance, suggesting that stronger regulatory enforcement and clarity significantly enhance project success. The type of agreement has the largest effect, where a one-unit improvement leads to a 0.205 unit increase in performance, implying that well-structured and clearly defined contractual arrangements are the most influential driver among the variables.

The findings of this study are consistent with existing literature, thereby reinforcing the robustness of the results. For instance, Kasri, Siddiq, and Wibowo (2022) emphasize that well-structured PPP agreements significantly enhance project efficiency and sustainability by providing clear roles, responsibilities, and performance expectations. Similarly, Fu et al. (2023) highlight that strong legal and institutional frameworks are essential in ensuring successful infrastructure performance, as they provide stability, enforceability, and investor confidence. In the same vein, Khaeriah (2024) and Martijn et al. (2023) argue that clearly defined contractual arrangements and effective risk-sharing mechanisms are critical in improving project outcomes, which aligns closely with the finding that the type of agreement is the strongest predictor of performance in this study. Furthermore, Wane, de Resende, and Xie (2025) and Chileshe et al. (2022) confirm that effective PPP structures, supported by sound governance and legal enforcement, positively influence infrastructure delivery, while Kavishe, Jefferson, and Chileshe (2018) stress that both institutional and financial arrangements are vital in ensuring project success.

In addition, the observed pattern of results suggests that institutional and contractual factors may be more influential than purely financial contributions in determining project performance. Specifically, while shared investment positively influences performance, its comparatively lower coefficient indicated that financial input alone was not sufficient to guarantee project success. Instead, it must be complemented by strong legal frameworks and well-structured agreements that clearly define risk allocation, accountability, and performance standards. Consequently, this highlights the critical importance of governance, regulatory clarity, and agreement design in PPP-driven geothermal projects. Moreover, it implies that integrated PPP structures, which combine financial, legal, and institutional elements, are more effective in enhancing project outcomes than approaches that focus solely on investment.

However, despite the explanatory strength of the model, the R^2 value of 0.409 indicates that 40.9% of the variation in project performance is explained by the included PPP variables, while the remaining 59.1% is accounted for by other factors not captured in the model. Therefore, this suggests that additional variables may also significantly influence geothermal project performance. Consequently, this represents a limitation of the current study, as it does not fully capture all the determinants of performance.

Accordingly, future research should adopt longitudinal research designs to examine how PPP practices influence project performance over time, rather than relying solely on cross-sectional data. Furthermore, future studies should consider mixed-method approaches to provide a more comprehensive understanding by integrating both quantitative and qualitative insights into PPP effectiveness. In addition, further research should explore the role of contextual factors such as policy stability, political environment, technological advancements, and institutional capacity in shaping the success of geothermal energy projects. By doing so, future studies will be able to provide a more holistic and nuanced understanding of the dynamics influencing PPP-driven infrastructure performance.

These findings affirm that individual PPP practices significantly shape the performance of geothermal projects in Kenya, with the type of agreement carrying the greatest weight. In addition to these findings, further analysis was carried out to determine the composite effect (mean of all public private partnership sub constructs) on performance of these companies. The findings are presented as shown in Table 2 that follows.

Table 2 Simple Linear Public private partnership practices on performance of geothermal energy project in Kenya

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.631[a]	.398	.396	.4725	.398	140.451	1	212	.000

a. Predictors: (Constant), Mean Public Private Partnership

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	31.354	1	31.354	140.451	.000[b]
	Residual	47.327	212	.223		
	Total	78.681	213			

a. Dependent Variable: Performance

b. Predictors: (Constant), Mean Public Private Partnership

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.069	.082		13.023	.000
	Mean Public Private Partnership	.484	.041	.631	11.851	.000

a. Dependent Variable: Performance

The analysis of the simple linear regression examining the effect of Public Private Partnership (PPP) practices on the performance of geothermal energy project in Kenya revealed a statistically significant relationship. The model summary shows a correlation coefficient of R = .631, with an R^2 value of .398. This indicates that 39.8% of the variance in performance can be explained by variations in PPP practices, suggesting a substantial association between the implementation of PPP frameworks and project outcomes. The standard error of the estimate (.4725) reflects the average deviation of observed performance scores from the predicted values based on PPP practices.

The ANOVA results further confirm the robustness of the model. The F-test value of 140.451 with a p-value less than .001 indicates that the regression model provides a better fit to the data than a model without predictors. This demonstrates that PPP practices collectively contribute meaningfully to explaining differences in geothermal project performance. In practical terms, this underscores the importance of structured partnerships, policy clarity, and coordinated efforts between public and private stakeholders in achieving project efficiency and sustainability.

The regression coefficients provide more detailed insight into the nature of this relationship. The unstandardized coefficient for PPP practices (B = .484) indicates that for every one-unit increase in PPP practices, the predicted performance of geothermal projects increases by 0.484 units. The constant term (B = 1.069) represents the baseline performance when PPP practices are absent. The standardized coefficient (β = .631) reflects a strong positive relationship, showing that PPP practices are a significant predictor of performance outcomes. This suggests that projects with well-established PPP frameworks tend to experience higher operational efficiency, improved maintenance, and better user satisfaction.

Overall, these findings highlight the critical role of PPP practices in enhancing geothermal energy project performance in Kenya. The model emphasizes that structured collaboration, clear contractual arrangements, and coordinated project management within PPP frameworks directly influence project outcomes. Stakeholders and policymakers can use these insights to strengthen PPP frameworks and optimize performance metrics for current and future geothermal energy projects in the country. The regression model can be expressed as follows.

$$Y=1.069+0.484(PPP)$$

This equation indicates that project performance is a linear function of PPP practices. The constant term (1.069) represents the expected performance score when PPP practices are at zero, serving as a baseline. The coefficient for PPP practices (0.484) quantifies the expected increase in performance for each additional unit of PPP implementation. In other words, as PPP practices improve through mechanisms such as clearer contracts, better stakeholder coordination, and more effective financing the predicted performance of geothermal energy projects increases proportionally. The model thus provides a straightforward predictive framework for understanding the contribution of PPP practices to project success in Kenya.

In terms of comparison with existing literature, the findings are strongly supported by prior studies. For example, Kasri et al. (2022) emphasize that well-structured PPP agreements enhance efficiency and sustainability by clarifying roles and improving coordination among stakeholders. Similarly, Chileshe et al. (2022) highlight that effective PPP arrangements contribute significantly to infrastructure performance through improved governance and accountability. Moreover, Chami (2015) and Osei-Kyei and Chan (2015) argue that PPP success was largely dependent on institutional arrangements, risk allocation, and stakeholder collaboration, all of which are reflected in the strong positive relationship observed in this study. In addition, Hodge and Greve (2019) note that PPPs enhance infrastructure delivery when supported by sound institutional frameworks, while Zhang et al. (2020) and Ng and Loosemore (2021) further emphasize that effective partnership structures improve project efficiency and long-term sustainability. Therefore, the findings of this study are consistent with, and reinforce, the conclusions drawn in existing literature.

Moreover, the observed pattern suggests that PPP practices are a critical driver of geothermal project performance, as evidenced by the high explanatory power of the model and the strong beta coefficient. This implies that effective collaboration between public and private actors enhances not only financial mobilization but also operational efficiency and strategic alignment. Consequently, the results highlight the importance of strengthening PPP frameworks, particularly in areas such as governance, coordination, and accountability, to improve project outcomes. In addition, the findings suggest that policy and institutional support are essential for maximizing the benefits of PPPs in geothermal energy development.

However, despite the relatively strong explanatory power of the model, the results indicate that approximately 60.2% of the variation in project performance is explained by factors not included in the model. This represents a limitation of the study and suggests that other variables may also play a significant role in determining project

performance. Therefore, while PPP practices are important, they are not the sole determinants of success in geothermal projects.

Finally, based on these findings, future research should consider adopting longitudinal research designs to examine how PPP practices influence project performance over time, rather than relying solely on cross-sectional data. Additionally, future studies should incorporate mixed-method approaches to capture both quantitative and qualitative dimensions of PPP effectiveness. Furthermore, researchers should explore additional contextual and moderating variables, such as policy stability, political environment, and technological advancement, to provide a more comprehensive understanding of the factors influencing geothermal project performance.

CONCLUSIONS

The study sought to establish the effect of Public Private Partnership (PPP) practices on the performance of the geothermal energy project in Kenya. The findings demonstrate that PPP practices positively influence project performance, indicating that structured collaboration between public and private actors enhances operational efficiency, accountability, and service delivery. This is reflected in the role of well-defined agreements, shared investments, and clear legal frameworks, which together strengthen coordination, resource mobilization, and governance. The results imply that when PPP arrangements are effectively designed and implemented, they provide a solid institutional foundation that supports sustainable project outcomes and improved facility management in geothermal energy projects. The study concluded that Public Private Partnership practices play a critical role in enhancing the performance of geothermal energy project in Kenya. Through structured collaboration, resource pooling, and effective stakeholder engagement, PPP practices were shown to significantly improve operational efficiency, user satisfaction, facility management, and the retention of service users. These results provide strong evidence against the null hypothesis (H_{01}), which stated that there is no significant relationship between PPP practices and performance of geothermal energy projects. Consequently, the hypothesis was rejected, affirming that PPP practices positively influence project performance.

Based on the finding that Public Private Partnership practices significantly enhance the performance of geothermal energy projects, it is recommended that policymakers and project developers strengthen institutional frameworks that support PPP implementation. This entails creating clear policy guidelines, streamlining regulatory approvals, and fostering transparency to encourage investor confidence. Furthermore, effective mechanisms for stakeholder engagement should be prioritized to ensure alignment of interests between the government, private sector, and host communities. By reinforcing these structures, PPP projects not only achieve higher operational efficiency but also sustain long-term performance outcomes in the geothermal energy sector.

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