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Article

Value-based construction management in a housing project: Stakeholder perceptions and project performance in Sudungdewo residence, Indonesia

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Abstract: This study examines the implementation of value-based construction management principles in the Sudungdewo Residence housing project developed by PT. Kreasi Mandiri Pratama in Wonosobo Regency, Central Java. The research aims to identify how value-based management values are applied in project governance and to evaluate stakeholder perceptions regarding their contribution to project performance. A quantitative descriptive approach was employed using a questionnaire distributed to 20 respondents directly involved in the project, including contractors, consultants, field supervisors, and workers. The assessed principles include justice, transparency, balance, and cooperation, while project performance indicators cover quality, time efficiency, cost efficiency, and sustainability. The results show that respondents generally perceived the application of value-based management principles as positive, reflected in dominant agreement levels across most indicators. High levels of approval were particularly evident in coordination among stakeholders, open communication practices, collaborative problem-solving, balanced consideration of quality–time–cost, and adherence to project standards. However, several items related to cost control, resource efficiency, and long-term community benefits recorded relatively higher neutral responses, indicating that these impacts may not yet be evenly felt or require further strengthening and monitoring. Overall, the study concludes that value-based construction management has been implemented consistently and supports ethical, accountable, and socially responsible project execution, while highlighting the need for improvement in financial efficiency practices and measurable long-term social outcomes.

Keywords: value-based construction management; project management; justice; transparency; stakeholder perception; project performance; housing project; sustainability

1. Introduction

Infrastructure development and construction projects are strategic sectors that play an important role in supporting economic growth, providing decent housing, and improving the quality of life of the community [1]. However, development practices are often faced with various problems, such as conflicts of interest between stakeholders, imbalances between quality, time, and cost, and weak ethical and social responsibility aspects in project management. These conditions require a management approach that is not only oriented toward achieving technical targets but is also capable of ensuring

fairness, transparency, accountability, and sustainability in every stage of construction project implementation [2].

Along with the development of the sustainable development paradigm, construction project management has begun to be directed toward a value-based management approach that places moral, ethical, and humanitarian aspects as an integral part of the project management system. This approach views construction projects not merely as technical-economic activities but as social processes involving human interaction, collective interests, and long-term impacts on society and the environment. Therefore, the integration of the values of fairness, openness, balance, and cooperation is becoming increasingly relevant to be studied empirically in the context of construction practices in Indonesia.

In addition to technical issues, construction projects are also greatly influenced by the quality of governance and the dynamics of relationships between the parties involved, such as project owners, contractors, consultants, supervisors, and field workers [3]. Differences in objectives, levels of authority, and access to information often lead to unsynchronized decisions and potential conflicts, which can ultimately result in work delays, waste of resources, and a decline in quality. Therefore, the success of a project cannot be assessed solely on the basis of physical output, but also on the quality of the management process, communication patterns, and the project team's ability to maintain trust and coordination consistently.

In this context, value-based management can function as an operational ethical framework guiding project actors when facing uncertainties in field implementation. Values such as fairness, transparency, balance, and cooperation are not merely normative ideals but can be translated into observable managerial practices, such as clear role distribution, structured coordination mechanisms, openness of relevant information, and collaborative problem-solving processes [4]. When consistently applied, such values contribute to stronger relational governance, reduced conflict risks, and improved decision-making efficiency in project implementation [5].

Nevertheless, a significant research gap remains. Many previous studies focus on traditional project performance indicators—cost, time, and quality—while ethical and governance dimensions are rarely operationalized as measurable constructs influencing project performance. Furthermore, although value-based or ethically grounded construction management principles, including culturally and religiously inspired governance approaches, are increasingly discussed, they are often presented normatively without being integrated into a coherent theoretical framework explaining how values influence project performance outcomes through stakeholder interactions.

This lack of a structured conceptual model limits analytical depth and empirical contribution, as the relationship between managerial values, stakeholder perceptions, and project performance dimensions remains insufficiently explored, particularly in medium-scale housing projects located in non-metropolitan or rural contexts. Moreover, empirical assessments that directly capture stakeholder perceptions regarding value implementation and its perceived influence on project performance are still limited. Understanding which aspects are strongly perceived and which still generate neutral responses is important for designing targeted managerial

improvements.

To address this gap, this study proposes that value-based construction management operates as a governance driver, shaping stakeholder perceptions and behavioral patterns within project implementation, which subsequently influence project performance outcomes. In this conceptual linkage, fairness and transparency enhance trust and communication quality; cooperation strengthens coordination and collective problem-solving; and balance guides decision-making between financial objectives and social–environmental responsibility. These governance dimensions are expected to influence project performance indicators, including quality achievement, time efficiency, cost efficiency, and sustainability impacts.

Based on these considerations, this study attempts to bridge the gap between the concept of value-based management and construction project practices in the field [6]. The research not only describes the level of implementation of value principles but also analyzes how stakeholders perceive the contribution of these principles to project performance. The results are expected to provide practical insights for project managers in strengthening governance mechanisms, particularly in performance dimensions that still require more measurable control instruments.

Construction management itself is a discipline that regulates the planning, organization, implementation, and supervision of construction project activities to achieve effectiveness and efficiency [7]. In practice, construction management encompasses not only technical aspects such as cost, time, and quality but also ethical and behavioral dimensions underlying stakeholder interactions [8]. In Indonesia, many projects have begun incorporating cultural and spiritual values into management practices to improve project outcomes holistically. One emerging approach is value-based construction management, which is grounded in principles such as fairness, honesty, trust, deliberation, and social responsibility [9]. This approach emphasizes that management success is not merely defined by technical completion but also by the fair and transparent fulfillment of stakeholder interests.

Value-based construction management therefore represents the integration of human values into project management processes, including adherence to ethical standards, fairness in contractual arrangements, and responsibility toward workers and the environment [10]. This approach is believed to strengthen trust between project owners, contractors, and other stakeholders while improving project outcomes from both technical and socio-moral perspectives [11].

This study contributes to construction management and project governance theory by positioning value-based construction management as a relational governance mechanism rather than merely a normative or ethical concept. In conventional construction management studies, project performance is commonly examined through technical indicators such as cost, time, and quality. However, this study argues that these performance outcomes are also shaped by governance values embedded in stakeholder interactions, including justice, transparency, balance, and cooperation. By operationalizing these values as measurable governance dimensions, the study extends the discussion of construction management from a purely technical-control perspective toward a socio-governance perspective.

The theoretical contribution of this study lies in its attempt to explain how governance values influence project implementation through relational processes. Justice clarifies roles and reduces potential conflict; transparency improves information flow and decision-making; balance guides trade-offs among cost, time, quality, and social-environmental considerations; and cooperation strengthens collective problem solving among stakeholders. These dimensions are not treated as separate moral ideals but as governance mechanisms that shape project behavior and perceived performance outcomes. Therefore, although the empirical evidence is derived from a single housing project case, the conceptual framework offers broader relevance for understanding how value-based governance can support project performance in construction management.

The Sudungdewo Residence housing project, implemented by PT. Kreasi Mandiri Pratama in Wonosobo Regency, Indonesia, was selected as the case study because it represents an ongoing effort to integrate ethical values into practical construction management. Preliminary observations indicate that stakeholders perceive principles of fairness, transparency, and social responsibility to have been applied during project implementation. Therefore, the project provides a relevant context for examining how value-based construction management principles operate in practice and how stakeholders perceive their influence on project performance outcomes.

2. Materials and methods

The project that is the subject of this study is the Sudungdewo Residence Development Project located in Wonosobo Regency, Central Java Province, Indonesia (**Figure 1**). This project is a residential development project that aims to provide adequate, safe, and comfortable housing facilities for the community. The project is being carried out by PT. Kreasi Mandiri Pratama as the implementing contractor.

Figure 1. Sudungdewo Regency project.

This study applies a descriptive quantitative approach within a single case study framework to examine stakeholder perceptions regarding the implementation of value-based construction management principles in a housing development project. The research is positioned as an exploratory case-based analysis aimed at understanding governance and management practices in a specific project context rather than producing statistically generalizable findings. Therefore, conclusions drawn from this study are limited to the examined project and are intended to provide contextual insights into how value-based management principles are perceived and implemented in practice.

The case selected for this study is the Sudungdewo Residence housing development project located in Wonosobo Regency, Central Java, Indonesia, and implemented by PT. Kreasi Mandiri Pratama. The project was chosen because it represents a medium-scale residential development involving multiple stakeholders and requiring continuous coordination between owners, contractors, consultants, supervisors, and field workers. At the time of data collection, the project was in the active construction phase, with several housing units completed, while others were still under construction. Conducting the survey during this implementation stage enabled respondents to evaluate management practices based on direct experience in ongoing project execution rather than only planning or post-completion conditions.

The study focuses on evaluating the implementation of value-based construction management principles reflected through managerial practices such as fairness in task and responsibility distribution, transparency in communication and decision-making, balance in considering quality–time–cost and social–environmental aspects, and cooperation among project stakeholders. These principles are operationalized through observable management practices already implemented in the project, including coordination mechanisms, wage distribution practices, communication processes, collaborative problem-solving, and governance arrangements influencing project performance (**Figure 2**).

Figure 2. Value-based construction management framework.

Data were obtained from questionnaires distributed to 20 respondents directly involved in project implementation, including contractors, consultants, field supervisors, and workers. Respondents were selected purposively to ensure that participants had direct knowledge of project operations and management practices. The relatively limited number of respondents reflects the actual number of active stakeholders available during data collection and corresponds with the exploratory nature of the case study. Accordingly, the study does not claim generalizability beyond the project context but aims to capture perception patterns within the examined case.

The survey instrument used in this study was designed based on construction management and value-based governance literature and adapted to match the actual managerial practices observed in the Sudungdewo Residence project. Questionnaire items measure perceptions regarding four main value-based management dimensions—justice, transparency, balance, and cooperation—as well as project performance dimensions, including quality achievement, time efficiency, cost efficiency, and sustainability impacts. Responses were recorded using a five-point Likert scale ranging from Strongly Disagree to Strongly Agree, enabling measurement of agreement levels across governance and performance indicators (**Table 1**).

Table 1. Operationalization of constructs and measurement items.

Construct	Dimension	Operational definition	Indicator
Value-based construction management	Justice	Fairness in role and benefit distribution	Fair task distribution Fair coordination among stakeholders Appropriate and fair wages
	Transparency	Openness of information and communication	Transparency of project cost information Open communication among stakeholders Decision-making based on clear information
	Balance	Equilibrium in project decision-making	A balance between cost, time, and quality Balance between economic and social aspects Consideration of environmental impact
	Cooperation	Collaboration among stakeholders	Effective teamwork Communication in problem-solving Harmonious working relationships
Project performance	Quality	Achievement of construction quality standards	Quality of construction output Quality of supervision Compliance with quality standards
	Time efficiency	Efficiency in project scheduling	Timely project completion Coordination improves time efficiency Efficient use of resources
	Cost efficiency	Efficiency in financial management	Cost control effectiveness Budget transparency reduces waste Reduction of unnecessary additional costs
	Sustainability	Long-term project impact	Consideration of social and environmental impacts Long-term benefits for the community Environmental sustainability practices

The mapping of questionnaire items to theoretical dimensions was conducted by aligning observable indicators with the conceptual constructs proposed in the study. Each construct was operationalized into measurable indicators, which were then translated into perception-based questionnaire items. For the justice dimension, items focus on fairness in task distribution, stakeholder coordination, and wage allocation, as these aspects represent the core principles of equity in project governance. The transparency dimension is operationalized through indicators related to openness of cost information, clarity of communication, and transparency in decision-making processes, which are essential elements of governance transparency. The balance dimension is represented by indicators reflecting the equilibrium between cost, time, and quality, as well as the integration of social and environmental considerations in decision-making. These indicators capture the concept of trade-off management in construction projects. Meanwhile, the cooperation dimension is mapped through indicators of teamwork, collaborative problem-solving, and harmonious relationships, which collectively represent relational governance among stakeholders. For the dependent variable, project performance is divided into four dimensions. The quality dimension includes indicators related to construction outcomes, supervision, and adherence to standards. The time efficiency dimension reflects schedule compliance and coordination effectiveness. The cost efficiency dimension focuses on cost control and resource optimization. Lastly, the sustainability dimension captures long-term social benefits and environmental responsibility.

Prior to distribution, questionnaire items were reviewed to ensure clarity and

relevance to project conditions. Because the study maintains the original research design and sample size, advanced statistical validation procedures were not conducted. However, questionnaire formulation followed established indicators commonly used in construction management perception studies, and survey results were supported by informal interviews and field observations to reduce misinterpretation and to confirm alignment between survey responses and actual project practices.

Data analysis was conducted using descriptive statistics supported by cross-dimensional pattern interpretation. Percentage distributions were first calculated to identify the dominant tendency of stakeholder responses for each questionnaire item. However, the analysis did not stop at the presentation of isolated percentages. The response patterns were further interpreted by comparing the four value-based construction management dimensions—justice, transparency, balance, and cooperation—with the four project performance dimensions—quality, time efficiency, cost efficiency, and sustainability. This approach enabled the study to identify convergence and divergence among dimensions, particularly between governance-related practices and perceived performance outcomes.

The analytical interpretation focused on three aspects. First, indicators with consistently high positive responses were examined as evidence of strong perceived implementation of value-based governance practices. Second, indicators with higher neutral or negative responses were interpreted as areas where the effects of value-based management were less visible or not yet evenly perceived by all stakeholders. Third, patterns across dimensions were analyzed to understand whether strong relational governance, such as cooperation and communication, corresponded with stronger perceptions of project quality, time efficiency, cost efficiency, and sustainability. Therefore, the analysis provides an integrated interpretation of stakeholder perception patterns rather than merely describing percentage distributions.

Several methodological limitations are acknowledged. The study relies on a single project case and a relatively small respondent group, which limits the ability to generalize findings to broader construction contexts. In addition, perception-based responses may vary depending on respondent roles and project involvement levels. This study is limited by its reliance on percentage distributions and pie chart analysis without cross-tabulation by stakeholder roles or statistical comparison between governance and performance dimensions. Therefore, the findings should be interpreted as descriptive and exploratory rather than inferential. Furthermore, descriptive analysis cannot fully explain causal relationships between management practices and project outcomes. Nevertheless, within these limitations, the method remains consistent with the exploratory objective of capturing stakeholder perceptions regarding value-based construction management implementation without altering the original research process or affecting reported results.

3. Results and discussion

The findings are interpreted as interrelated perception patterns across governance and performance dimensions rather than as separate percentage distributions. Overall, value-based construction management is perceived most strongly in relational

governance dimensions, particularly cooperation, communication, fairness, and coordination. These aspects show consistently positive responses because they are directly experienced by stakeholders in daily project interactions. In contrast, performance outcomes related to cost efficiency, resource utilization, and long-term community benefits show more varied responses, indicating that these outcomes are less directly observable and may require clearer monitoring mechanisms or longer evaluation periods.

A cross-dimensional reading reveals three main patterns. First, strong perceptions of cooperation and transparency correspond with positive perceptions of project quality and time efficiency, suggesting that open communication, harmonious relationships, and collaborative problem-solving support smoother project execution and reduce coordination-related delays. Second, although the balance principle is positively perceived, its connection with cost efficiency is less consistent because cost control and resource efficiency depend on managerial data, financial monitoring, and operational control systems. Third, sustainability indicators show mixed results: environmental consideration is more visible during construction, while long-term community benefits are likely to become clearer after project completion and occupancy.

These patterns indicate that value-based construction management primarily functions as a governance mechanism that strengthens relational stability and process coordination. Its contribution to quality achievement and schedule control is relatively visible because these outcomes are experienced directly during construction activities. However, its contribution to cost efficiency and long-term sustainability is less immediate because these outcomes depend on financial control, resource monitoring, and post-construction evaluation. Therefore, the findings show differentiated impacts across dimensions rather than uniform effects across all aspects of project performance.

Beyond the case context, this cross-dimensional pattern offers a theoretical contribution to construction management and project governance. The study suggests that value-based principles operate first at the relational governance level by shaping stakeholder behavior, communication quality, trust, coordination, and conflict management before supporting technical performance outcomes. Thus, values such as justice, transparency, balance, and cooperation should not be viewed merely as ethical aspirations but as operational governance resources that help stabilize project execution. This expands construction management theory by showing that project performance is influenced not only by technical planning, scheduling, cost control, and quality assurance, but also by the social and governance conditions under which construction processes are implemented.

The results show that governance-related indicators associated with value-based construction management receive consistently high agreement levels. Coordination between contractors, consultants, and field workers is generally perceived as effective, with communication flows functioning smoothly and reducing operational conflicts. Respondents indicate that role distribution and responsibilities are clearly understood, which supports orderly project execution. Collaborative problem solving and harmonious working relationships are also strongly perceived, suggesting that cooperation among project stakeholders functions as an important mechanism for

maintaining project stability.

Across project performance dimensions, indicators related to quality achievement and schedule compliance also show predominantly positive responses. Stakeholders generally perceive that work is carried out according to technical standards and project specifications, while coordination between parties supports the timely completion of activities. These findings suggest that stable relational governance contributes positively to maintaining operational performance, particularly in aspects directly observable during construction implementation.

However, indicators related to cost efficiency, resource utilization, and long-term community benefits show comparatively higher neutral responses. This tendency indicates that although governance practices are perceived positively, efficiency-related outcomes are less directly perceived by many stakeholders. Financial management and resource allocation processes are often handled at managerial levels and are not equally visible to all project participants. Similarly, long-term benefits for surrounding communities typically become evident only after project completion and occupancy phases, which may explain why respondents express uncertainty regarding these impacts during ongoing construction.

A comparative view between governance practices and performance outcomes reveals that improvements in cooperation and communication do not always produce equally strong perceptions of efficiency and sustainability impacts. While relational governance dimensions appear robust, operational efficiency indicators still show variation in stakeholder perception. This suggests that managerial efforts related to monitoring cost efficiency and resource optimization may need to be strengthened to ensure that performance improvements are more consistently perceived across stakeholder groups.

The presentation of graphical data and accompanying textual explanations follows the recorded survey results to ensure consistency between figures and interpretation. Each figure reflects the percentage distribution of responses obtained from the questionnaire, allowing visualization of perception trends while maintaining alignment with the analytical narrative.

The analysis focuses on identifying perception patterns across governance and performance dimensions rather than establishing causal relationships. Because evaluation is based on stakeholder perceptions during project implementation, some performance dimensions—particularly quality and coordination—are more readily observed, whereas financial efficiency and long-term sustainability outcomes require longer operational periods before their impacts become fully visible.

Overall, the results indicate that value-based construction management practices in the Sudungdewo Residence project are perceived positively in governance dimensions related to cooperation, communication, and fairness, which in turn support perceived quality achievement and schedule stability. Nevertheless, perceptions related to efficiency and long-term impacts remain less consistent, indicating areas where monitoring mechanisms and performance communication may be further improved to enhance stakeholder awareness and confidence in project outcomes.

3.1. Principle of justice

a. The division of tasks between contractors, consultants, and workers is carried out fairly.

Most respondents expressed positive perceptions of coordination, indicating that communication and work instructions function effectively. This suggests that the existing coordination mechanism supports smooth project implementation and helps minimize potential errors or overlaps (**Figure 3**).

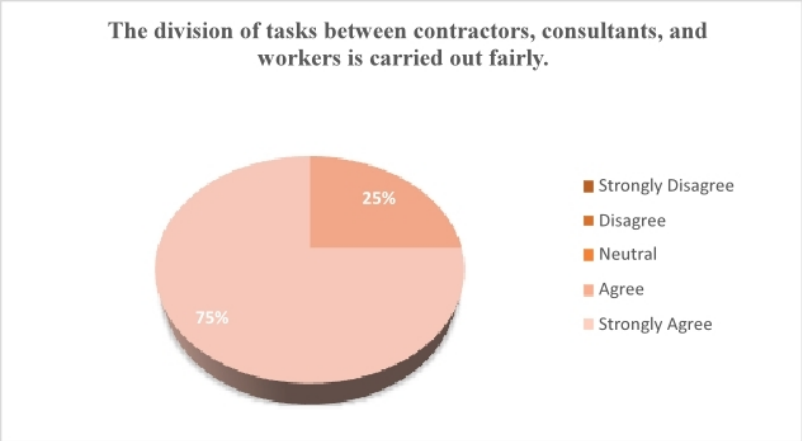

Figure 3. Percentage of fairness in task distribution.

b. Coordination between contractors, consultants, and field workers.

Most respondents perceived that rights are distributed fairly according to each party's contribution. This reflects a strong positive assessment of fairness in project management. Overall, the principle of fairness is considered to be well implemented in the project (**Figure 4**).

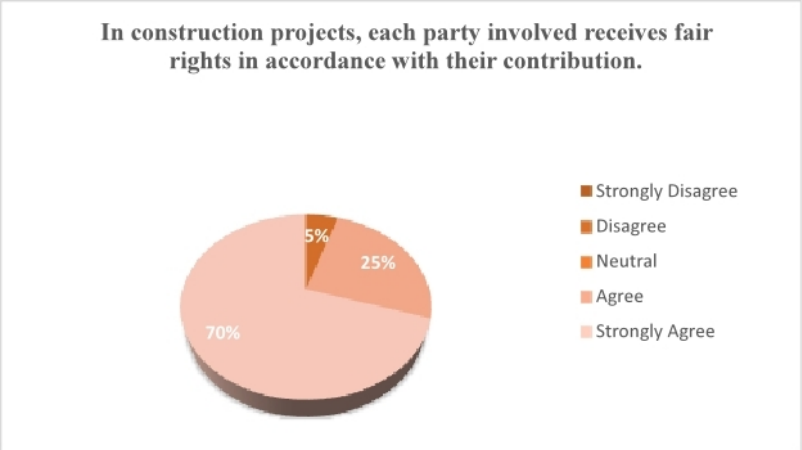

Figure 4. Percentage of fairness principle in coordination.

c. Providing fair and appropriate wages

Most respondents expressed a positive assessment of this statement. A small proportion remained neutral, while no respondents expressed disagreement. Overall, this indicates a generally favorable perception with some variation in certainty among participants (**Figure 5**).

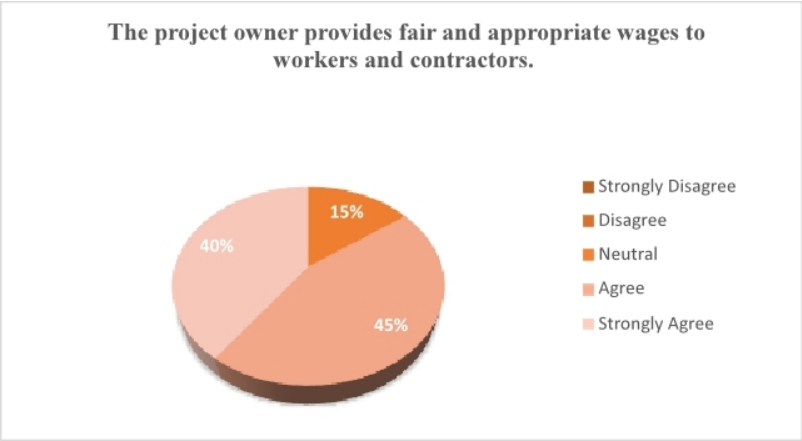

Figure 5. Percentage of fairness principle in remuneration.

3.2. Principle of transparency

a. All information related to project expenditure is disclosed openly to relevant parties.

Most respondents provided a positive assessment of this statement. However, a considerable proportion expressed neutral responses, indicating varying levels of perception among participants. Overall, no respondents reported negative views (**Figure 6**).

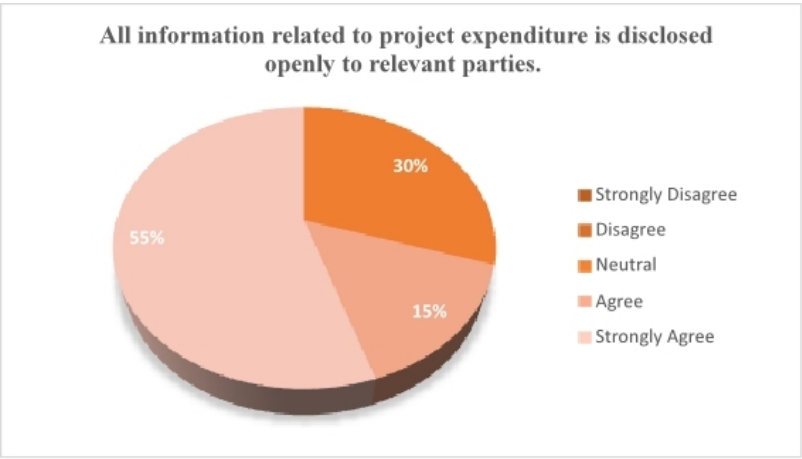

Figure 6. Percentage of transparency principles related to information.

b. Communication between the project owner, contractor, and consultant is conducted clearly and openly

All respondents expressed a positive assessment of this statement. No neutral or negative responses were recorded. This indicates a very strong and consistent perception among participants (**Figure 7**).

c. Decision-making in the project is based on clear and open information for all parties

Most respondents expressed a positive assessment of this statement. A small proportion indicated disagreement, while no neutral responses were recorded. Overall, the perception remains strongly favorable with minor variation (**Figure 8**).

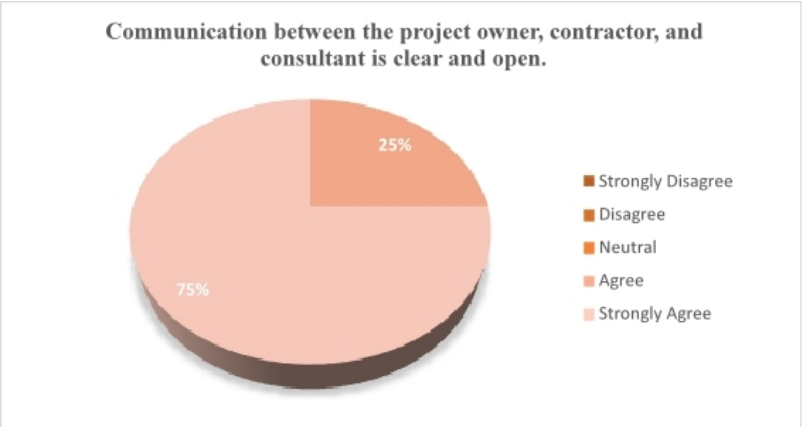

Figure 7. Percentage of transparency principles related to communication.

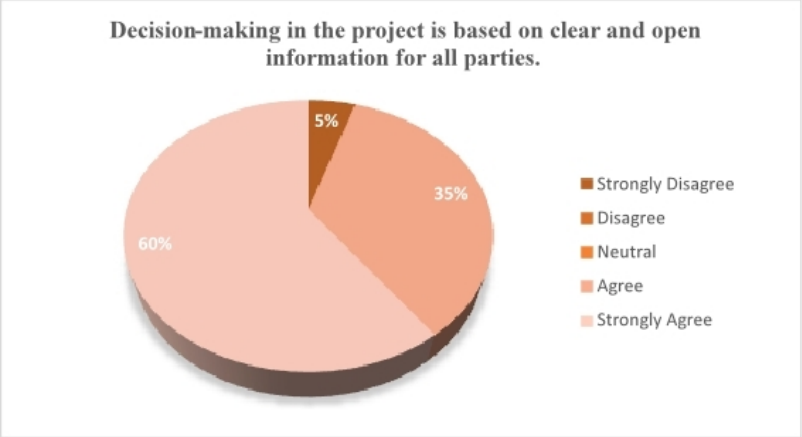

Figure 8. Percentage of transparency principles related to decision-making.

3.3. Principle of balance

a. Project cost management is carried out by considering the balance between quality, time, and cost

All respondents expressed a positive assessment of this statement. No neutral or negative responses were observed. This indicates a unanimous and strongly favorable perception among participants (**Figure 9**).

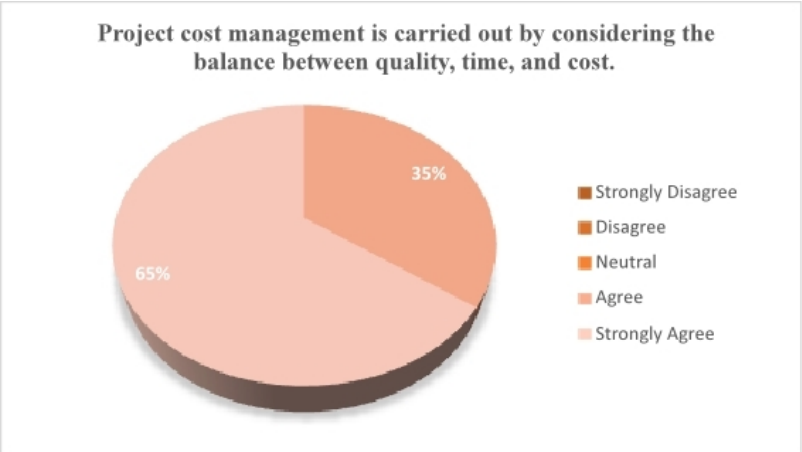

Figure 9. Percentage of balance principle in cost management.

b. Decision-making in the project is based on the principle of balancing financial

benefits and social sustainability

Most respondents expressed a positive assessment of this statement. A small proportion indicated disagreement, while no neutral responses were observed. Overall, the perception remains strongly favorable with minor variation (**Figure 10**).

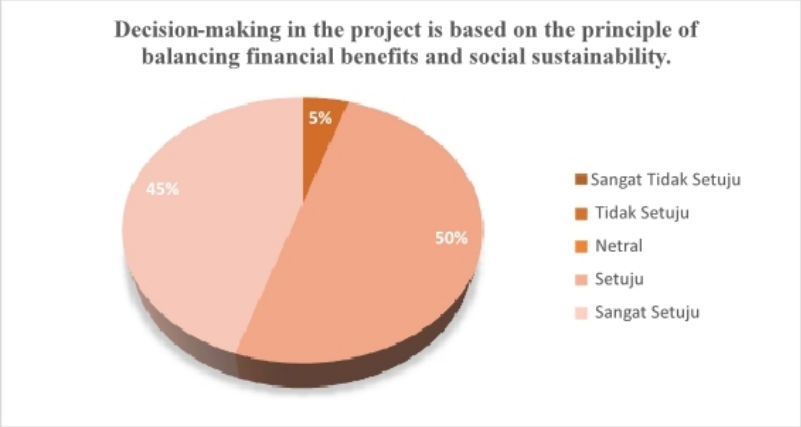

Figure 10. Percentage of the principle of balance in decision making.

c. The balance between the benefits of the project for the community and the environmental impact is always taken into consideration

Most respondents expressed a positive assessment of this statement. A small proportion remained neutral, while no respondents reported negative views. Overall, the perception is strongly favorable with slight variation in certainty (**Figure 11**).

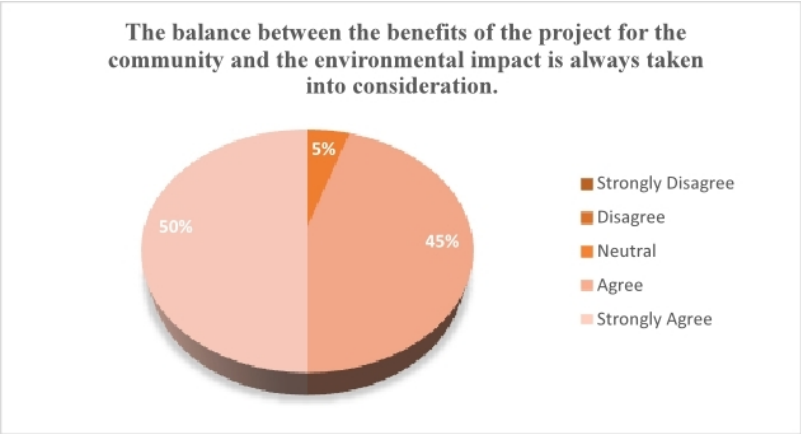

Figure 11. Percentage of the principle of balance related to project benefits.

3.4. Principles of cooperation

a. The parties involved in the project work well together to achieve the same project goals

All respondents expressed a positive assessment of this statement. No neutral or negative responses were recorded. This reflects a unanimous and strongly favorable perception (**Figure 12**).

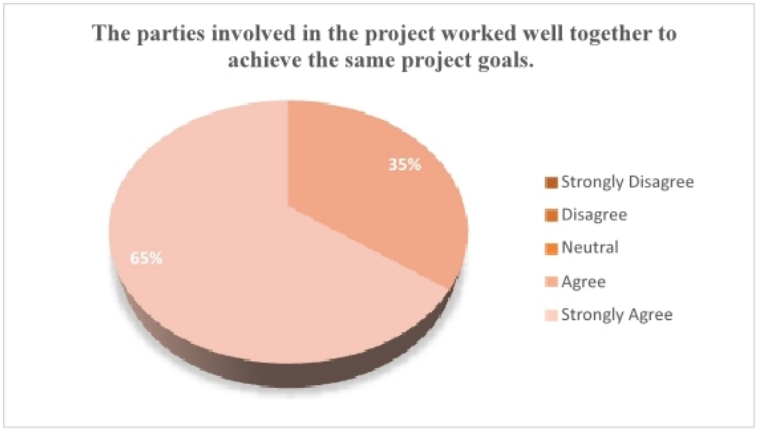

Figure 12. Percentage of cooperation principles in personnel involvement.

b. Contractors, consultants, and project owners communicate effectively to address issues that arise during the project

All respondents expressed a positive assessment of this statement. No neutral or negative responses were observed. This indicates a unanimous and strongly consistent perception among participants (**Figure 13**).

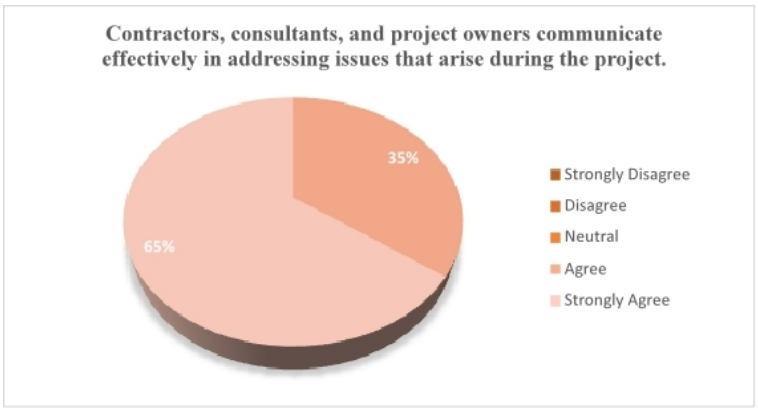

Figure 13. Percentage of cooperation principles in problem solving.

c. Relationships between parties involved in the project remain harmonious and mutually supportive throughout the project implementation process

All respondents expressed a positive assessment of this statement. No neutral or negative responses were recorded. This indicates a fully consistent and strongly favorable perception among participants (**Figure 14**).

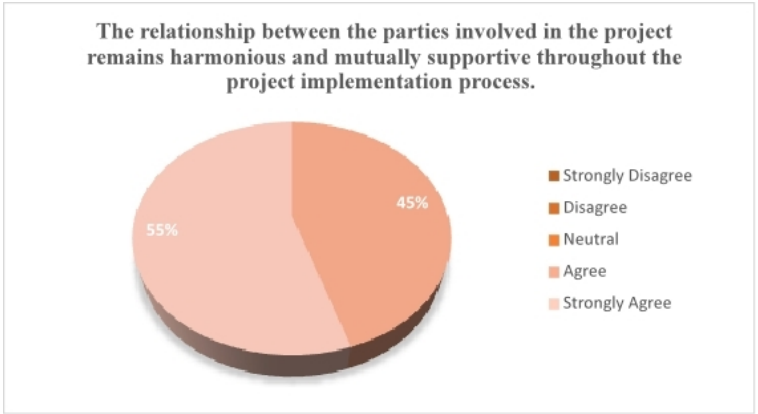

Figure 14. Percentage of cooperation principles in the implementation process.

3.5. Project quality principles

a. The application of value-based construction management principles in projects results in buildings of high quality

Most respondents expressed a positive assessment of this statement. A small proportion remained neutral, and a few indicated disagreement. Overall, the perception is generally favorable with some variation among participants (**Figure 15**).

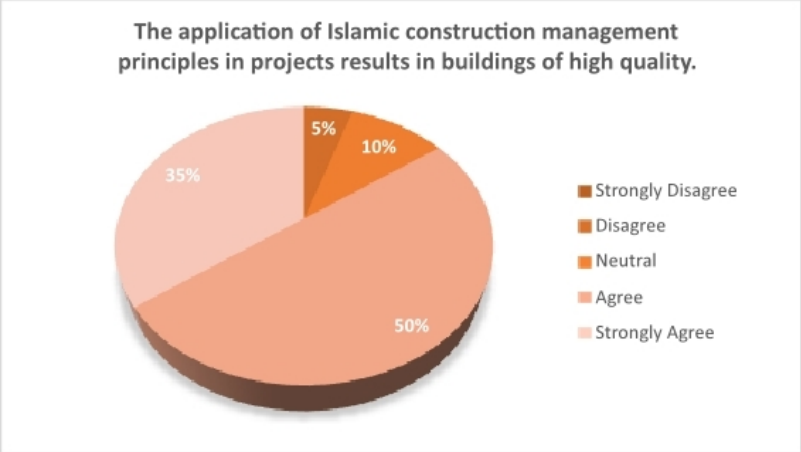

Figure 15. Percentage of project quality principles in the application of value-based principles.

b. The quality of supervision of fieldwork has improved due to the application of the principle of transparency in project management

Most respondents expressed a positive assessment of this statement. However, a notable proportion provided neutral and some negative responses. This indicates a generally favorable perception with relatively higher variation among participants (**Figure 16**).

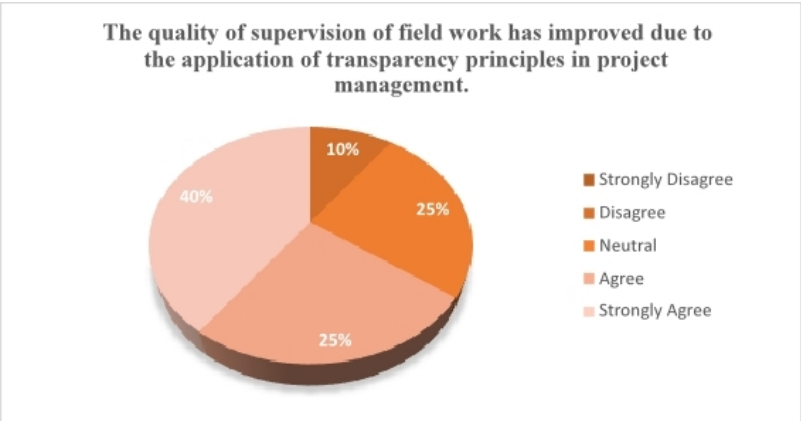

Figure 16. Percentage of project quality principles in supervision.

c. The quality standards set in the project are always met during project implementation

Most respondents expressed a positive assessment of this statement. A notable proportion remained neutral, while no respondents reported negative views. Overall, the perception is favorable, with some variation in certainty (**Figure 17**).

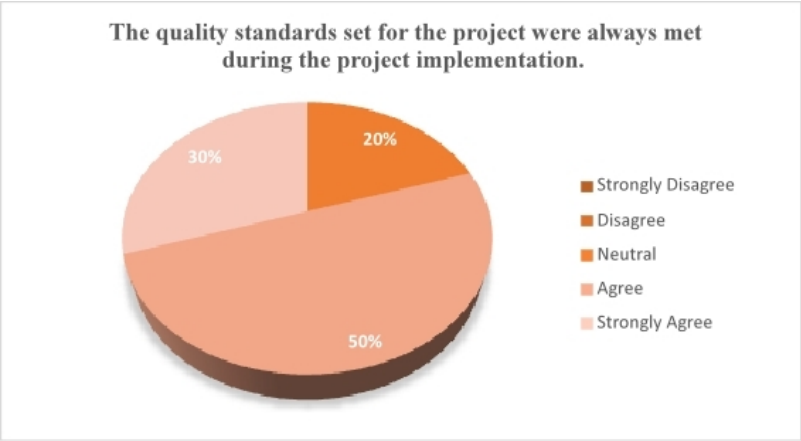

Figure 17. Percentage of project quality principles in minimum standards.

3.6. Principle of time efficiency

a. Projects managed according to value-based construction management principles can be completed according to the predetermined schedule

Most respondents expressed a positive assessment of this statement. A small proportion indicated disagreement, and no neutral responses were recorded. Overall, the perception remains strongly favorable with minor variation (**Figure 18**).

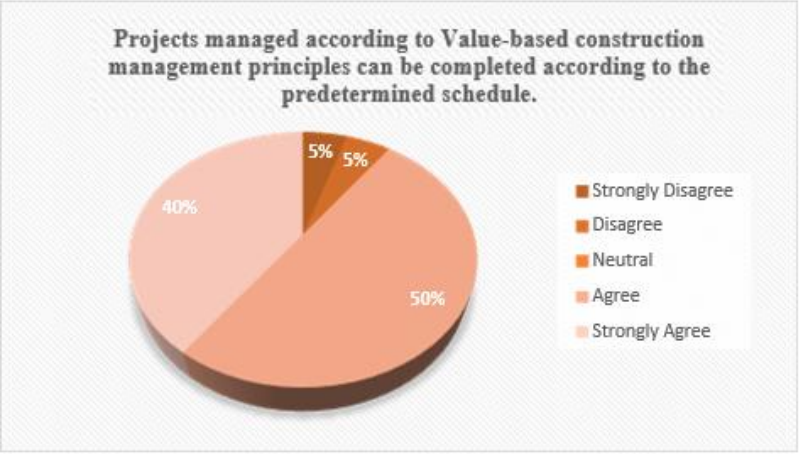

Figure 18. Percentage of time efficiency principles in schedule compliance.

b. Project completion time is more efficient with good coordination between all parties involved

Most respondents expressed a positive assessment of this statement. A small proportion remained neutral, while no respondents reported negative views. Overall, the perception is strongly favorable with minimal variation (**Figure 19**).

c. Efficient use of resources reduces delays in project completion

Most respondents expressed a positive assessment of this statement. However, a substantial proportion remained neutral, and a small percentage indicated disagreement. This suggests a moderate level of agreement with noticeable variation among participants (**Figure 20**).

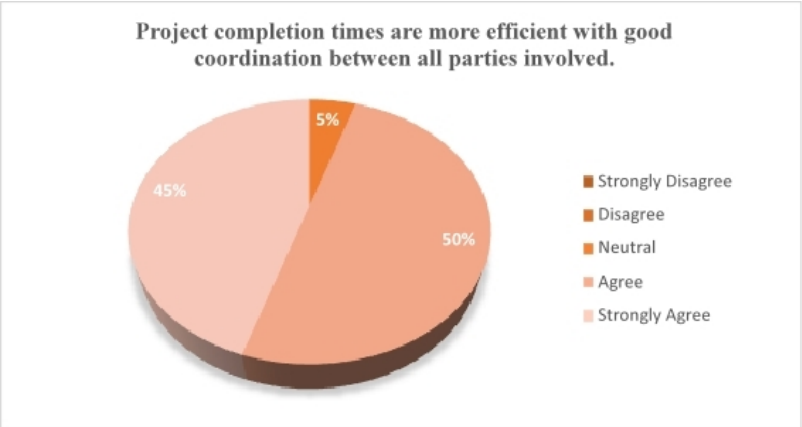

Figure 19. Percentage of time efficiency principles related to coordination.

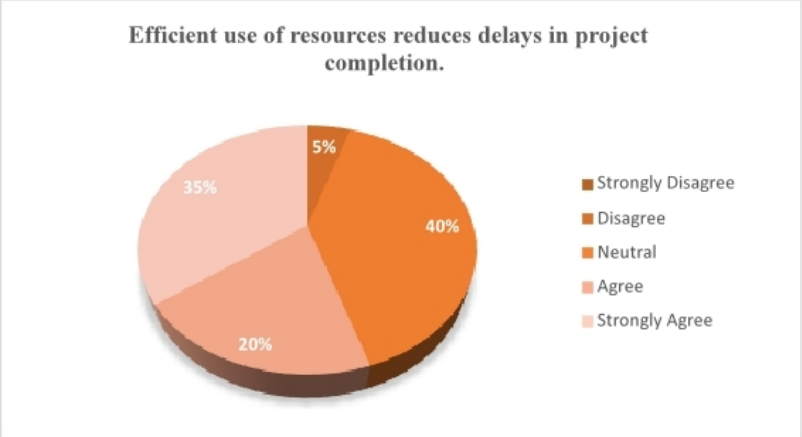

Figure 20. Percentage of time efficiency principles in resource use.

3.7. Principle of cost efficiency

a. The application of value-based construction management helps control project costs so that they do not exceed the predetermined budget

Most respondents expressed a positive assessment of this statement. However, a considerable proportion remained neutral, and a small percentage indicated disagreement. This indicates a moderate level of agreement with notable variation among participants (**Figure 21**).

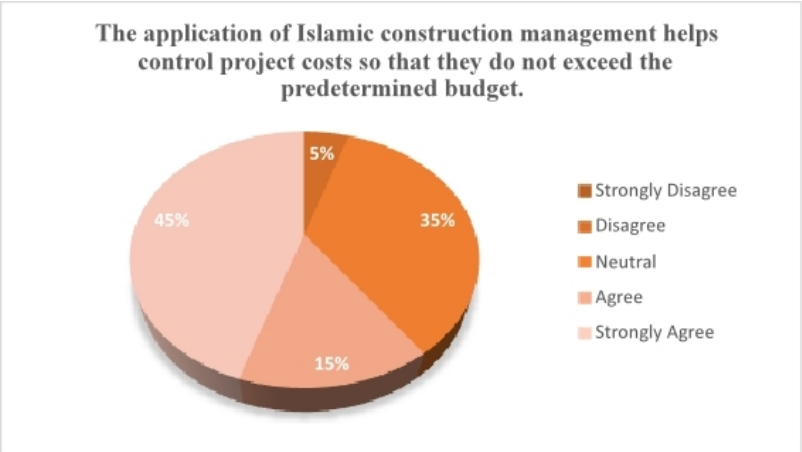

Figure 21. Percentage of time efficiency principles in cost control.

b. Transparent budget management helps reduce waste in projects

Most respondents expressed a positive assessment of this statement. A small proportion indicated disagreement, while no neutral responses were recorded. Overall, the perception is strongly favorable with minor variation (**Figure 22**).

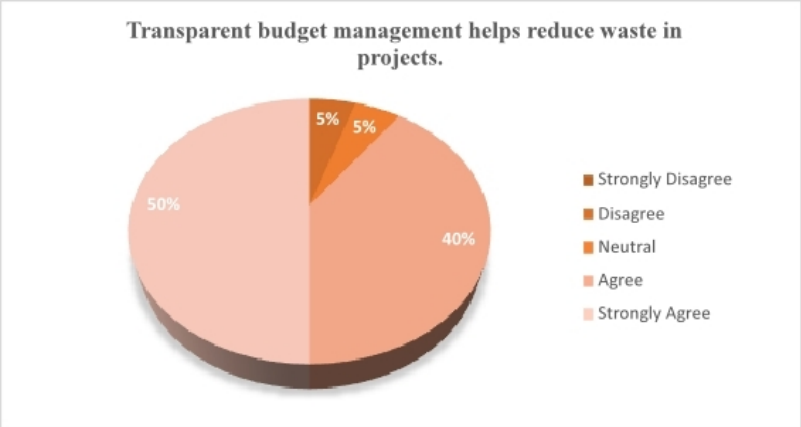

Figure 22. Percentage of time efficiency principle in budget transparency.

c. The application of the principle of cooperation between the parties involved reduces unnecessary additional costs

All respondents expressed a positive assessment of this statement. No neutral or negative responses were recorded. This indicates a unanimous and strongly favorable perception (**Figure 23**).

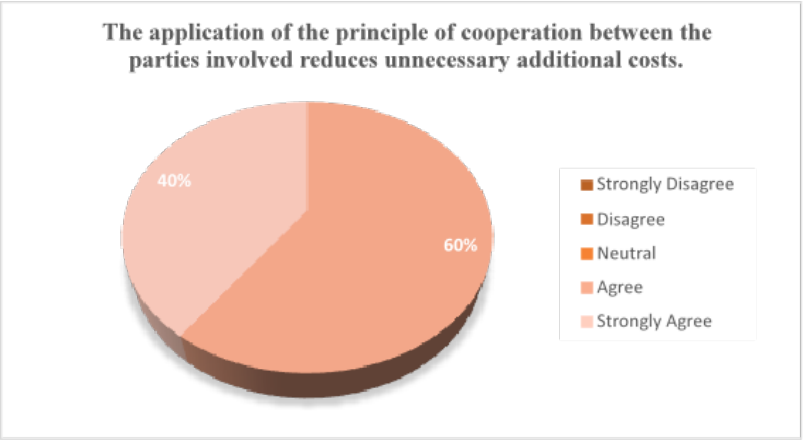

Figure 23. Percentage of time efficiency principles in cooperation.

3.8. Project sustainability principles

a. Value-based construction management principles consider social and environmental impacts at every stage of the project

Most respondents expressed a positive assessment of this statement. However, a substantial proportion remained neutral, and no negative responses were recorded. This indicates a moderate level of agreement with considerable variation in certainty among participants (**Figure 24**).

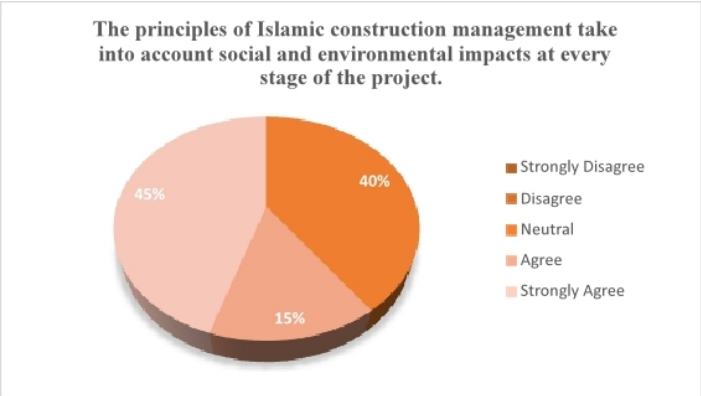

Figure 24. Percentage of project sustainability principles related to social impact.

b. Projects implemented based on value-based principles can provide long-term benefits for the surrounding community

Most respondents expressed a positive assessment of this statement. However, nearly half of the respondents remained neutral, and no negative responses were recorded. This indicates a moderate level of agreement with substantial variation in certainty among participants (**Figure 25**).

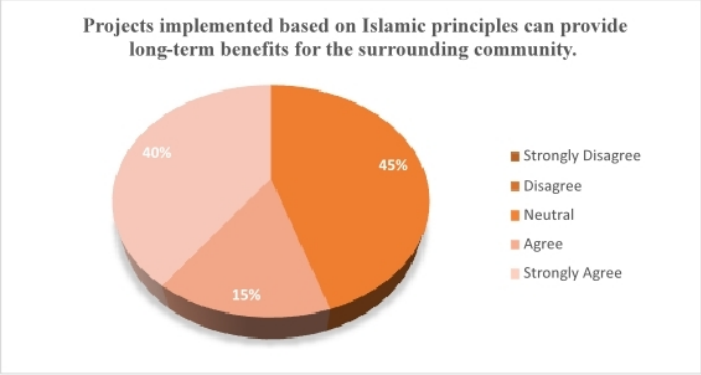

Figure 25. Percentage of project sustainability principles related to benefits.

c. Project management takes into account environmental conservation and natural resource sustainability

Most respondents expressed a positive assessment of this statement. Only a small proportion remained neutral, and no negative responses were recorded. Overall, the perception is strongly favorable with minimal variation (**Figure 26**).

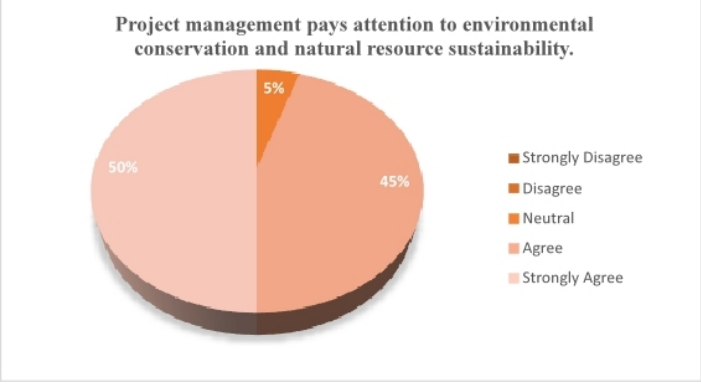

Figure 26. Percentage of project sustainability principles related to environmental sustainability.

Overall, most indicators received predominantly positive responses, although several aspects still require further attention (**Table 2**).

Table 2. Summary of comparison of indicators and percentage of respondents.

Principle/dimension	Indicator	Positive response (%)	Neutral (%)	Negative (%)
Justice Principle	Coordination among contractors, consultants, and workers functions well	100	0	0
	Task distribution is perceived as fair	95	0	5
	Wages are paid fairly and appropriately	85	15	0
Transparency Principle	Project expenditure information is openly disclosed	70	30	0
	Communication among stakeholders is clear and open	100	0	0
	Decision-making is based on transparent information	95	0	5
Balance Principle	Cost management balances quality, time, and cost	100	0	0
	Decisions balance financial and social sustainability	95	0	5
	Community benefits and environmental impacts are balanced	95	5	0
Cooperation Principle	Stakeholders collaborate effectively toward project goals	100	0	0
	Communication effectively resolves project problems	100	0	0
	Relationships among stakeholders remain harmonious	100	0	0
Project Quality Performance	Value-based management improves building quality	85	10	5
	Transparency improves supervision quality	65	25	10
	Project quality standards are consistently met	80	20	0
Time Efficiency Performance	Projects are completed according to schedule	90	0	10
	Coordination improves completion efficiency	95	5	0
	Efficient resource use reduces delays	55	40	5
Cost Efficiency Performance	Value-based management helps control project costs	60	35	5
	Transparent budgeting reduces waste	90	0	10
	Cooperation reduces unnecessary additional costs	100	0	0
Sustainability Performance	Social and environmental impacts are considered	60	40	0
	Projects provide long-term community benefits	55	45	0
	Environmental sustainability is maintained	95	5	0

4. Discussion

The results show that value-based construction management in the Sudungdewo Residence project is perceived positively by most stakeholders, particularly in governance-related dimensions. However, the strength of perception is not evenly distributed across all dimensions. The strongest responses are concentrated in cooperation, communication, coordination, fairness, and harmonious working relationships, while cost efficiency, resource utilization, supervision quality, and long-term community benefits show more varied responses. This pattern indicates that value-based management is more immediately visible as a relational and governance practice than as a measurable efficiency or long-term impact mechanism.

The first key pattern concerns the relationship between relational governance and operational stability. Strong perceptions of cooperation, teamwork, problem-solving, communication, and harmonious relationships suggest that the project is supported by a cooperative culture. In construction projects, cooperation functions not only as a social attribute but also as an operational mechanism that enables quicker problem identification, smoother coordination, and more effective responses to field constraints. This helps explain why project quality and schedule-related indicators are also perceived positively. When communication is open, responsibilities are clear,

and problems are solved collectively, stakeholders are more likely to perceive project implementation as effective [12].

The second pattern relates to fairness. Positive responses to task distribution and coordination indicate that roles and responsibilities are perceived as relatively fair and proportional. Fairness strengthens operational clarity by reducing overlapping work, misunderstandings, and potential conflict. In this sense, justice functions as a governance foundation that supports work discipline and coordination stability. However, neutral responses in the wage-related indicator suggest that compensation practices may still require clearer communication, particularly regarding wage standards, workload differences, overtime mechanisms, and payment procedures [13].

The third pattern concerns transparency. Transparency is strongly perceived in communication among project owners, contractors, consultants, and field actors, particularly regarding work progress, field instructions, and problem-solving. This supports project quality and time efficiency because construction activities require continuous coordination and rapid decision-making. However, transparency related to project expenditure receives more neutral responses, indicating a visibility gap between communication transparency and financial transparency. Cost-related information is usually accessible only to certain managerial or administrative actors, so neutral responses should be understood as limited visibility rather than necessarily as weak transparency [14].

This finding implies that transparency should be designed according to stakeholder roles and information needs. Field workers may need practical information on material availability, work targets, resource use, and schedule implications, while supervisors and managers require cost deviations, procurement status, and budget control indicators. Thus, improving transparency requires not only openness but also appropriate information structuring so that stakeholders can understand how their work contributes to cost efficiency and project performance.

The fourth pattern appears in the balance dimension. Respondents generally perceive that project management considers the balance between quality, time, and cost, as well as between financial benefits and social-environmental considerations. However, when compared with cost efficiency and resource utilization indicators, the results are less consistent. This suggests that balance is recognized as a decision-making principle, but its practical effect on operational efficiency is not yet fully visible to all stakeholders. Cost and resource efficiency still depend on technical and operational factors such as procurement, labor productivity, equipment availability, rework control, weather conditions, and design changes. Therefore, value-based management should be complemented by measurable control instruments such as resource-use records, cost deviation monitoring, work-package evaluation, and periodic efficiency reporting [15].

The fifth pattern concerns project quality. Most respondents perceive that value-based construction management contributes to building quality and compliance with standards, indicating that governance values can support technical performance when translated into disciplined supervision, clear communication, and responsibility among project actors. However, supervision quality shows more varied responses, suggesting that transparency alone is insufficient unless supported by structured

supervision procedures, clear reporting systems, technical competence, inspection routines, documentation, and corrective action.

The sixth pattern relates to time efficiency. Stakeholders generally perceive that the project is implemented according to schedule and that coordination contributes to more efficient completion. This supports the interpretation that cooperation and communication have a direct relationship with time-related performance because many delays arise from miscommunication, unclear instructions, late decisions, or weak coordination. However, resource efficiency receives more neutral responses, indicating that time performance also depends on labor, materials, tools, and other supporting resources.

The seventh pattern concerns cost efficiency. Although cooperation is perceived to reduce unnecessary additional costs by preventing mistakes, rework, and conflict-related costs, formal cost-control mechanisms are less directly observed by many stakeholders. Cost efficiency is usually recorded in managerial documents and financial reports rather than experienced in daily field activities. Therefore, cost-efficiency perceptions tend to be weaker among stakeholders without access to budget planning, procurement records, or cost monitoring reports. This reinforces the need for clearer performance communication across stakeholder levels.

The eighth pattern appears in sustainability. Environmental sustainability is perceived more positively because practices such as site cleanliness, material handling, waste control, drainage management, and environmental disturbance reduction can be observed during construction. In contrast, long-term community benefits are less visible during the construction phase. Benefits such as improved settlement quality, increased property value, social acceptance, and long-term livability generally become clearer after project completion and occupancy. Therefore, neutral responses in this dimension should be interpreted as a limitation of the observation period rather than as evidence of weak social benefit.

Based on these cross-dimensional patterns, value-based construction management can be understood as a form of social and governance infrastructure within construction projects. Its most visible contribution lies in strengthening trust, cooperation, communication, fairness, and coordination. These relational dimensions stabilize project implementation and support perceived quality and schedule achievement. However, relational governance alone does not automatically guarantee strong perceptions of cost efficiency, resource optimization, or long-term sustainability. These outcomes require additional managerial systems, technical controls, measurable monitoring instruments, and longer evaluation horizons.

This interpretation moves the findings beyond simple descriptive percentage distributions. The results reveal a layered influence of value-based construction management. At the first layer, it shapes stakeholder behavior and project relationships. At the second layer, it supports smoother implementation and technical compliance. At the third layer, its influence on cost and sustainability depends on measurable monitoring systems and post-construction evaluation. Theoretically, this strengthens the view that construction project performance should be assessed not only through cost, time, and quality, but also through governance and relational dimensions. Justice,

transparency, balance, and cooperation can therefore be operationalized as measurable governance dimensions in construction management.

Practically, the findings imply that project managers should maintain strong cooperation, communication, and fairness while improving cost visibility, resource efficiency, supervision quality, and long-term impact measurement. This can be done through simplified cost-progress reports, better resource-use documentation, clearer supervision checklists, communication of efficiency targets to field teams, and post-construction or post-occupancy evaluation. Overall, the study confirms that value-based construction management does not automatically solve all project performance issues, but it creates the governance conditions necessary for more accountable, collaborative, and socially responsible project implementation.

In general, the results of the study show that the application of value principles is strongly perceived in the aspects of working relationships and social governance of projects. Indicators of cross-party coordination, open communication, problem-solving collaboration, and compliance with standards received predominantly agree–strongly agree responses. Meanwhile, several indicators related to resource efficiency, cost control, and long-term benefits for the community tended to elicit more neutral responses. This pattern indicates a strengthening of the relational and governance dimensions, but the impact of values/ethics on the cost dimension and long-term social outcomes has not been felt evenly.

These findings are in line with recent literature developments that begin to view values as a construct that can be measured at the project management team level. The ethical performance of the project management team is multidimensional and has implications for the quality of the process and the legitimacy of the project implementation [16]. Thus, the high level of stakeholder approval of fairness, open communication, and cooperation in this project can be interpreted as an indicator that "ethical performance" in terms of behavior and work interactions has been positively established, thereby supporting the stability of work implementation and the control of field problems.

4.1. Fairness as the foundation of orderly roles and work stability

On the principle of fairness, the majority of respondents strongly agreed that the distribution of tasks and responsibilities was proportional, and that rights were granted according to contribution. This high level of agreement indicates that the project's organizational structure, division of roles, and work instruction mechanisms are understood as a relatively orderly system. In project management practice, operational justice is not only related to a "sense of fairness" but also functions as a social control mechanism that suppresses conflict, strengthens compliance, and maintains productivity because workers and implementers feel that their workload and rewards are managed fairly.

Fairness is also related to the clarity of cross-party coordination. When roles are clear and do not overlap, coordination becomes more efficient because communication channels and decision-making authority are known from the outset [17]. This reduces the risk of delays due to waiting for approval or rework due to misinterpretation of tasks.

The project governance measurement literature also emphasizes the importance of the project participants' governance capabilities to manage coordination, decision-making, and accountability. Thus, the high perception of fairness in this study can be interpreted as part of the governance capabilities that support work orderliness and coordination effectiveness.

However, on indicators related to wages, there are still some respondents who remain neutral. This is common because the perception of "fair wages" is relative and influenced by local standards, job type variations, risk levels, and the timeliness of payment. A neutral response does not always indicate unfairness, but it can signal the need to strengthen basic communication on wage setting, transparency of overtime/incentive rules, and clear complaint mechanisms. This strengthening is important because compensation stability correlates with work discipline, loyalty, and consistent productivity during the project implementation period.

4.2. Transparency has been strong in communication, but not yet evenly distributed in terms of costs

In terms of transparency, the results show strong agreement on clear and open communication between project owners, contractors, and consultants. Transparency in communication is an important element in construction projects because field decisions are dynamic [18]. When progress, technical constraints, and changing requirements are communicated quickly and accurately, corrective decisions can be made earlier to prevent schedule deviations and quality deterioration. In addition, transparency in communication builds trust and reduces coordination friction, resulting in faster problem-solving collaboration [19]. Recent literature also shows that ethical leadership and work climate contribute to project performance through psychological mechanisms and team stability. In the context of this study, high support for transparent communication can be positioned as an indicator of a conducive work climate that allows collaboration to proceed without the pressure of conflicts that hinder decision-making.

Conversely, transparency related to cost expenditures elicits a relatively larger proportion of neutral responses compared to general communication. This is understandable because access to financial information in projects is usually layered, and not all stakeholders need or have the authority to know the cost details. In addition, even if cost information is available, the form of presentation may be less relevant to field stakeholders, so that the benefits of cost transparency are not immediately apparent. Implicitly, cost transparency should not be interpreted as full disclosure of all financial details, but rather needs to be directed towards "targeted transparency." A summary of costs per work package, the status of procurement of key materials, indicators of deviation from the baseline, and a list of items prone to waste are more relevant for building awareness of efficiency in the field [20]. This practice is also in line with the idea of strengthening data-driven decisions in value management, including approaches that emphasize transparency of decisions and accountability to achieve efficiency [21].

4.3. Balance is well accepted, but operational efficiency remains an agenda for strengthening

On the principle of balance, respondents tend to agree that projects consider the balance of quality–time–cost and continue to pay attention to social–environmental aspects. These findings indicate a decision orientation that is not extreme on just one indicator. In construction projects, balance is an important challenge because trade-offs are often unavoidable: acceleration can reduce quality if inspections are reduced, cost savings can reduce material quality or increase the risk of rework, and a profit orientation can encourage neglect of environmental impacts. Nevertheless, resource efficiency and cost control indicators still elicit a greater neutral response. This phenomenon can be interpreted as a difference between the policy level and the execution level. At the policy level, decision balance is considered good and visible in general; however, at the execution level, efficiency depends on operational details such as material logistics, labor productivity, tool availability, and minimal rework. If one of these aspects is unstable, field stakeholders tend to assess the impact of efficiency as "unclear" or uneven, even though relational governance is considered good [22].

The literature on project performance also emphasizes that the measures of project success are not limited to cost–time–quality but need to consider stakeholder dimensions and more holistic outcomes. In the context of this study, neutral findings on efficiency and long-term benefits can be positioned as a signal of the need for more measurable indicators so that decision balance is not only "perceived" but also operationally proven.

4.4. Cooperation and collaboration as social capital that strengthens quality and timeliness

In terms of cooperation, stakeholder responses show very high support for indicators of collaborative problem solving, coordination, and harmonious working relationships. This finding is important because construction projects are collective work systems that involve many functions and disciplines. Strong cooperation enhances the project's ability to deal with uncertainties such as weather, supply delays, changing requirements, and technical disruptions. Collaboration accelerates the identification of root causes, speeds up the negotiation of solutions, and expedites the execution of corrective actions so that quality and schedules are better maintained [23].

However, recent literature also reminds us that collaboration/partnering practices do not always automatically result in overall performance, especially in terms of cost and productivity, as they require formal mechanisms, clear roles, and consistent control instruments [24]. This helps explain the findings of this study: cooperation is rated very highly, but cost and resource efficiency indicators still elicit neutral responses. This means that collaboration has become the social capital of the project, but it needs to be supported by cost control and operational control so that its impact is felt across all dimensions of performance.

4.5. Values as project social infrastructure and their relationship to performance

If the four principles are viewed as a single system, then the application of values/ethics acts as the social infrastructure of the project, shaping behavior, guiding communication, and maintaining the quality of working relationships. This social infrastructure strengthens technical performance because quality and timeliness are easier to achieve when coordination is smooth, communication transparency is high, and conflicts are minimized [25]. In other words, project performance is not only determined by work methods and equipment, but also by the quality of human interactions within the project.

However, the emergence of neutral responses to long-term costs and benefits indicates that some aspects of performance require different data and time horizons. Quality and time progress are visible and easily observed on a daily basis, making them easy to evaluate by all stakeholders [26]. In contrast, cost efficiency requires access to financial data and clear recording systems, while long-term social benefits only become apparent after the project is completed and the area begins to operate. Recent research on long-term value creation confirms that much of a project's value emerges in the operational phase after the project output has been handed over. Therefore, the neutral response to long-term community benefits can be understood as a limitation of the observation period. This reinforces the need for follow-up evaluations, such as post-construction or post-occupancy evaluations, to measure socio-economic impacts more accurately.

4.6. Theoretical contribution to construction management and project governance

This study offers a theoretical contribution by extending the concept of construction management beyond the conventional technical-control orientation. Traditional construction management commonly emphasizes planning, organizing, scheduling, cost control, quality assurance, and supervision. Although these aspects remain central, the findings of this study indicate that project performance is also shaped by value-based governance practices embedded in stakeholder relationships. Justice, transparency, balance, and cooperation function as relational governance mechanisms that influence how project actors coordinate, communicate, solve problems, and maintain accountability during project implementation.

The first contribution is the operationalization of value-based construction management into measurable governance dimensions. Rather than treating values as abstract ethical principles, this study translates them into observable project governance practices, such as fair role distribution, open communication, balanced decision-making, and collaborative problem-solving. This operationalization contributes to project governance theory by showing that ethical values can be analyzed as part of governance capacity. In this sense, values are not external to construction management but are internal mechanisms that structure interaction and decision-making within the project organization.

The second contribution is the proposed governance–performance linkage.

The findings suggest that value-based governance influences project performance through relational processes. Cooperation and transparency, for example, strengthen information flow and collective problem solving, which support quality achievement and time efficiency. Fairness reduces potential role conflict and supports work discipline, while balance guides decision-making across technical, financial, and socio-environmental considerations. This linkage helps explain how values may contribute to project performance without assuming a direct or automatic causal effect. Instead, the study conceptualizes value-based governance as an enabling condition that supports performance through improved coordination and relational stability.

The third contribution lies in the identification of a differentiated effect across performance dimensions. The findings show that value-based governance is more strongly reflected in relational and short-term operational outcomes, such as communication, quality, and schedule stability, than in cost efficiency and long-term sustainability outcomes. This contributes to project governance theory by indicating that governance values may have layered effects. Their immediate contribution is seen in stakeholder interaction and process stability, while their contribution to financial efficiency and long-term impact depends on additional technical monitoring systems and longer evaluation periods. This layered interpretation provides a more nuanced theoretical understanding of how governance values operate in construction projects.

The fourth contribution is the extension of project governance discussion into the context of medium-scale housing projects. Much of project governance literature focuses on large infrastructure, complex megaprojects, or formal institutional arrangements. This study demonstrates that governance theory is also relevant for smaller and medium-scale construction projects, where informal coordination, interpersonal trust, and value-based decision-making play important roles in maintaining project implementation. Therefore, the study broadens the applicability of project governance concepts by showing how governance values function in a non-megaproject, housing-based construction context.

Overall, this study contributes to construction management and project governance theory by proposing value-based governance as a socio-managerial layer that complements technical project controls. The study does not claim that ethical values alone are sufficient to ensure project success. Instead, it shows that values create the relational conditions necessary for effective implementation, while measurable performance outcomes still require technical control mechanisms. This theoretical position strengthens the relevance of value-based construction management as a bridge between ethical project governance and practical construction performance.

Based on the proposed value-based construction management framework, this study formulates several theoretical propositions to clarify the expected relationships between governance values and project performance outcomes. Justice is proposed to strengthen role clarity and operational order by ensuring fair task distribution, proportional responsibility, and appropriate treatment among stakeholders (P1). Transparency is proposed to improve information flow and decision-making quality by reducing misunderstanding and enabling faster responses to project problems (P2). Balance is proposed to support trade-off management between quality, time,

cost, and socio-environmental considerations, preventing project decisions from being dominated by a single performance objective (P3). Cooperation is proposed to strengthen relational governance and collective problem-solving among project stakeholders, thereby supporting smoother implementation, quality achievement, and schedule stability (P4).

Furthermore, this study proposes that value-based governance contributes more directly to relational and process-oriented performance than to cost efficiency and long-term sustainability outcomes (P5). Governance values such as justice, transparency, balance, and cooperation are expected to produce immediate effects on communication, coordination, trust, and work stability. However, their influence on cost efficiency, resource optimization, and long-term community benefits may depend on additional managerial control systems, financial monitoring, resource-use documentation, and post-construction evaluation. Therefore, the influence of value-based construction management is conceptualized as layered rather than uniform: it first shapes stakeholder relationships, then supports technical implementation, and finally contributes to broader efficiency and sustainability outcomes when supported by measurable control mechanisms (P6).

5. Conclusion

This study investigates stakeholder perceptions regarding the implementation of value-based construction management practices in the Sudungdewo Residence housing project and their perceived contribution to project performance outcomes. The findings indicate that value-based governance practices are generally perceived positively, particularly in dimensions related to coordination, communication openness, collaborative problem solving, and fair role distribution among stakeholders. These governance practices support the perceived achievement of project quality standards and contribute to maintaining implementation schedules. However, perceptions regarding cost efficiency, resource optimization, and long-term community benefits show greater variation among respondents. These aspects appear less directly observable during ongoing construction activities and may require longer-term evaluation and stronger performance monitoring mechanisms to become more evident to stakeholders. The study confirms that value-based construction management practices contribute most clearly to relational governance stability and process coordination. At the same time, efficiency and sustainability outcomes require additional managerial strengthening and performance evaluation systems to ensure consistent impacts across all performance dimensions. The conclusions presented are limited to the examined project context and should be interpreted as insights derived from an exploratory case study rather than generalizable findings. Nevertheless, the study provides practical implications for project managers seeking to strengthen governance practices while improving monitoring of efficiency and sustainability outcomes in housing development projects.

Theoretically, this study contributes to construction management and project governance by conceptualizing value-based construction management as a relational governance mechanism. The study demonstrates that justice, transparency, balance,

and cooperation can be operationalized as governance dimensions that shape stakeholder interaction, coordination, decision-making, and perceived project performance. This contribution extends construction management beyond a purely technical-control perspective by emphasizing the role of ethical and relational values in supporting project implementation. The findings also suggest that the influence of value-based governance is layered: it is most directly reflected in relational stability and short-term operational performance, while its contribution to cost efficiency and long-term sustainability requires complementary monitoring systems and longer evaluation periods.

Beyond the Indonesian case context, this study contributes to project governance theory by demonstrating how value-based governance can operate as a relational mechanism in construction projects. The case shows that justice, transparency, balance, and cooperation are not only context-specific ethical values but also transferable governance dimensions that shape stakeholder coordination, communication, trust, and collective problem solving. These findings extend project governance theory by showing that project performance is influenced not only by formal contracts, schedules, and control systems, but also by the relational and ethical conditions under which project actors interact. Therefore, the study offers a conceptual contribution that may be relevant to other construction project contexts where stakeholder coordination, trust, and accountability are critical to project implementation.

Given its exploratory case-study design, this study does not aim to test causal relationships or produce broad statistical generalizations. Instead, its contribution lies in theory-building and hypothesis generation by identifying how value-based governance dimensions may relate to project performance outcomes. The study provides contextual insights into how justice, transparency, balance, and cooperation operate as relational governance mechanisms in a housing construction project. These insights can serve as a conceptual basis for future studies using larger samples, comparative cases, or inferential methods to test the proposed governance–performance relationships.

Several limitations should be acknowledged when interpreting the findings of this study. First, the research is based on a single case study, which limits generalization of results to other construction projects or geographical contexts. Second, the number of respondents is limited to stakeholders directly involved in the project during data collection, reflecting contextual rather than statistical representation. Third, the analysis relies on perception-based data, which may vary depending on respondents' roles, levels of involvement, and access to project information. Fourth, descriptive statistical analysis does not allow causal inference regarding relationships between governance practices and project performance outcomes. Future research is recommended to examine multiple project cases, include larger respondent groups, and employ more advanced analytical techniques to better understand causal relationships between value-based management practices and measurable performance outcomes.

Author contributions: Conceptualization, HH and RA; methodology, RA; software, NKK; validation, EMH, HH and RA; formal analysis, HH; investigation, RA; resources,

NKK; data curation, HH; writing—original draft preparation, HH; writing—review and editing, HH; visualization, NKK; supervision, NKK; project administration, RA; funding acquisition, EMH. All authors have read and agreed to the published version of the manuscript.

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AI use statement: During the preparation of this work, the authors used ChatGPT in order to help add explanations in the discussion of the article. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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