

Risk Evaluation of Harmonized Contracts in Sulawesi Post-Disaster Reconstruction

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ABSTRACT

The 2018 Central Sulawesi earthquake caused major infrastructure damage and led to post-disaster reconstruction using harmonized contracts. This study evaluates risks in permanent housing projects in Palu, Central Sulawesi, through a mixed-method approach combining interviews and questionnaires. The research aims to: (1) identify and classify emerging risk characteristics in harmonized contract implementation, (2) assess the application and effectiveness of harmonization contracts in post-disaster reconstruction, and (3) examine the extent to which these contracts facilitate cross-sector collaboration in recovery efforts. SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis was used to identify internal and external factors, while FMEA (Failure Mode and Effect Analysis) assessed risk priorities. Results show strengths in funding and eco-friendly design (IFAS=1.54), but substantial external pressures from environmental and economic uncertainties (EFAS=-0.19). FMEA identified extreme weather (RPN=512) and currency fluctuation (RPN=512) as highest-priority risks requiring immediate mitigation, alongside bureaucratic complexity (RPN=384) and community relocation resistance (RPN=384). The findings highlight the need for adaptive risk management and strong coordination for successful contract implementation.

Keywords: Harmonized contract, risk management, SWOT, FMEA.

Note:

- This paper was received on June 26, 2025 and accepted for publication by the Editorial Board on June 12, 2026.
- Discussions on this paper will be accepted by xxxxxxxx xx, xxxx.
- <https://doi.org/>

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1. INTRODUCTION

The 7.5 magnitude earthquake that struck Central Sulawesi, Indonesia in 2018 caused severe damage to infrastructure and buildings, including the collapse of Palu IV Bridge and significant destruction of both residential and commercial structures. The disaster also triggered a tsunami that hit the Sulawesi coastline, especially in Palu Bay and Donggala City, in Indonesia, destroying more than 42,864 buildings and displacing 164,626 people [1]. Liquefaction and landslides were major contributors to the infrastructure damage, particularly in areas like Balaroa and Petobo, which experienced large-scale flow slides. These events led to massive ground displacement, damaging housing infrastructure, irrigation systems, and road networks [2]. The geotechnical failure was worsened by the stratified soil conditions with varying permeability layers [2].

The total loss caused by the disaster was estimated at over IDR 18.4 trillion. In response to this massive damage, the Indonesian government collaborated with international institutions such as the World Bank to support rehabilitation and reconstruction through various construction projects. However, differences in contract systems between national and international frameworks posed implementation challenges.

In Indonesia, construction contracts are governed by Law No. 2 of 2017 concerning Construction Services. In practice, both work and service contracts contain specific provisions to ensure quality and safety. However, issues such as structural failures and environmental impacts are often insufficiently addressed [3]. Service contracts involving design and supervision require clarity in responsibility, particularly when construction failures occur [4]. Additionally, lump sum contracts that fix the overall project cost are often difficult to apply strictly in the field, despite being legally bound by the Construction Services Law and Presidential Regulation No. 54 of 2010 [5].

In the context of post-disaster reconstruction projects funded by international institutions, harmonized contracts refer to contractual frameworks that integrate national procurement systems with international standards to facilitate international cooperation, reduce transaction costs, and enhance legal certainty [6]. This harmonization is particularly critical in post-disaster contexts where efficient and standardized contract frameworks significantly impact recovery efforts [7].

The World Bank and FIDIC (Fédération Internationale Des Ingénieurs-Conseils) play pivotal roles in promoting harmonized contracts. The World Bank supports harmonization through financial assistance and establishes environmental and social standards for projects, as demonstrated in its post-disaster recovery support in Turkey [8]. Additionally, the World Bank's Standard Bidding Documents for Procurement of Works, based on FIDIC conditions, highlight its role in promoting globally harmonized contract standards [9]. Meanwhile, FIDIC contracts are widely recognized for standardizing international construction contracts, providing a common framework adaptable to various legal systems and promoting efficiency and transparency in public procurement [10;11]. FIDIC's adaptability is also evident in provisions for force majeure events, such as pandemics, which are crucial for managing unforeseen circumstances in international projects [12].

In CSRRP (Central Sulawesi Rehabilitation and Reconstruction Project) projects, harmonized contracts incorporated three distinctive provisions: (1) dispute resolution following FIDIC's tiered mechanism (Engineer's determination → Dispute Adjudication

Board → arbitration) rather than direct litigation under Indonesian courts [9,10]; (2) payment procedures adopting World Bank's advance payment system (up to 20% mobilization advance) contrasting with Presidential Regulation No. 16/2018 termin-based milestones (0%-20%-40%-70%-100%) [9]; and (3) unlimited time and cost amendment provisions subject to World Bank approval, diverging from Indonesian contracts' strict 10% amendment ceiling [5] a flexibility that paradoxically emerged as a critical weakness (W1, W2) in this study's findings.

In the context of post-disaster recovery, multi-stakeholder collaboration becomes crucial. Effective communication and coordination between government agencies, Non-Governmental Organization (NGOs), local communities, and the private sector can significantly enhance the recovery process, as demonstrated in a case study in East Lombok [13]. However, previous research has primarily focused on construction risks in conventional contracts [3;4], while evaluative studies on the risks involved in using harmonization contracts in post-disaster projects remain very limited, especially in Indonesia.

The application of harmonization contracts—a blend of national and international contract systems such as those used by the World Bank—requires adaptation to local dynamics, institutional complexities, and stakeholder coordination [6;14]. Therefore, this study specifically evaluates the various risks involved in implementing harmonization contracts in post-disaster rehabilitation and reconstruction projects in Central Sulawesi Province. The aim is to understand the emerging risk characteristics, assess the application of harmonization contracts, and examine the extent to which these contracts can strengthen cross-sector collaboration in post-disaster recovery efforts.

Internationally, the application of harmonized contracts in post-disaster reconstruction has been increasingly documented, particularly in projects funded by multilateral development banks such as the World Bank and the Asian Development Bank. These institutions utilize harmonized methodologies like the Post-Disaster Needs Assessment (PDNA) to ensure coordinated approaches among international stakeholders [15]. Studies have shown that standard forms of construction contracts, such as those developed by the International Federation of Consulting Engineers (FIDIC), are widely favored by international developers and aid organizations for post-disaster reconstruction projects [16].

However, recent research has revealed significant challenges in applying these international contract frameworks to post-disaster contexts in developing countries. Evidence from Nepal's reconstruction following the 2015 Gorkha earthquake demonstrates that conventional construction contracts—including FIDIC-based agreements—contributed to increased project complexity and administrative obstacles, as they were not specifically designed for post-disaster scenarios [17]. The evolving nature of post-disaster reconstruction presents significant possibilities for variations, yet managing these becomes challenging through the lengthy administrative procedures inherent in standard contracts, particularly concerning when disasters predominantly impact developing nations where English is not the primary language [17].

Studies from Nepal identified critical challenges including resource constraints, legal complexities, coordination difficulties among multiple stakeholders, and the inadequacy of procurement frameworks in addressing urgent post-disaster needs [18]. Similar findings

have emerged from other disaster-affected regions, highlighting the universal nature of these contractual challenges while also emphasizing the importance of context-specific adaptations [19].

Recent experiences from other seismically-active regions provide important comparative contexts. Following the 2023 Turkey-Syria earthquakes, reconstruction efforts encountered challenges in coordinating international aid frameworks with national procurement systems and managing financial volatility due to currency depreciation, which significantly affected reconstruction costs and displaced populations [20;21]. However, Turkey's pre-existing disaster management infrastructure led by AFAD (Presidency of Disaster and Emergency Management) facilitated more streamlined bureaucratic processes compared to developing country contexts [22;23]. Japan's reconstruction following the 2011 Tōhoku earthquake demonstrated effective mitigation of financial risks through government-backed insurance mechanisms and rapid intergovernmental coordination structures [24], approaches less readily available in resource-constrained settings like post-disaster Indonesia. New Zealand's Christchurch earthquake recovery (2011) offers relevant insights into community engagement strategies, where structured stakeholder consultation protocols successfully reduced relocation resistance [25] a challenge analogous to community reluctance issues documented in Indonesian contexts.

Despite these international experiences, research on harmonized contracts in the Indonesian context remains critically limited. While global studies provide valuable insights into the general challenges of contract harmonization, Indonesia's unique institutional landscape characterized by decentralized governance structures, distinct land tenure systems, complex regulatory frameworks, and specific socio-cultural dynamics necessitates dedicated investigation. The 2018 Central Sulawesi disaster provides a particularly relevant case for examining how these international contract frameworks perform when adapted to Indonesia's specific post-disaster reconstruction environment.

In the Indonesian context, Hakim (2008) explored the implementation of permanent housing programs for disaster victims in Palu City, Central Sulawesi. The study suggested that harmonized contracts could enhance efficiency and transparency in the procurement process. However, it also highlighted risks, such as uncertainties in cost estimation and project timelines [26].

Jailani et al. (2020), in their study on housing rehabilitation after the earthquake in West Nusa Tenggara, pointed out that harmonized contracts can help reduce potential conflicts between stakeholders. However, they emphasized that such contracts can also be risky especially when parties involved do not fully understand the contract contents. Successful conflict mitigation using harmonized contracts, according to their findings, can only happen if all stakeholders receive sufficient and clear guidance [27]. In line with that, the study by Tawashi et al. (2025) shows that the rehabilitation of disaster-affected buildings not only restores physical structures but also contributes to reducing environmental risks and enhancing sustainability by adopting efficient materials and applying green construction principles [28]. Meanwhile, Malahayati et al. (2021) investigated pre-construction risks in the context of a reconstruction project in Pidie Jaya. They stressed the importance of setting clear standards in harmonized contracts to avoid ambiguity, which could lead to negative consequences during project execution [29].

Kurniawan et al. (2017) discussed the need for stronger and more detailed regulations in Indonesia's infrastructure financing sector. They argued that better regulatory frameworks are essential to minimizing risks in harmonized contracts especially in post-crisis rehabilitation projects [30]. Similarly, Simanjuntak et al. (2021) explored the role of effective contract agreements in reducing risks in construction projects. Their recommendations included improving stakeholder capacity through training, enforcing stricter regulations, and integrating technology to increase transparency and accountability in contract management. From these previous studies, it's clear that the risks involved in harmonized contracts are multi-layered touching on technical, legal, institutional, and social aspects. This means a comprehensive risk analysis is absolutely necessary.

To this end, two complementary methods were employed: SWOT (Strengths, Weaknesses, Opportunities, Threats) and FMEA (Failure Mode and Effect Analysis). While SWOT helps explore internal and external conditions of the project environment, FMEA is more structured in identifying potential failures and assessing their severity, occurrence, and detectability. Together, these tools offer a complete picture of possible risks and support better decision-making for managing harmonized contracts in post-disaster construction projects.

2. MATERIALS AND METHODS

This study applied a descriptive mixed-methods approach to evaluate risks in harmonized contract implementation for post-disaster rehabilitation projects in Central Sulawesi. A qualitative approach was used through semi-structured interviews, while a quantitative approach was carried out using structured questionnaires.

2.1. Scope and Research Object

The research focused on permanent housing development sites (hunatap) in Tondo 2, Talise, and Petobo, under the CSRRP. These three sites were purposively selected based on several

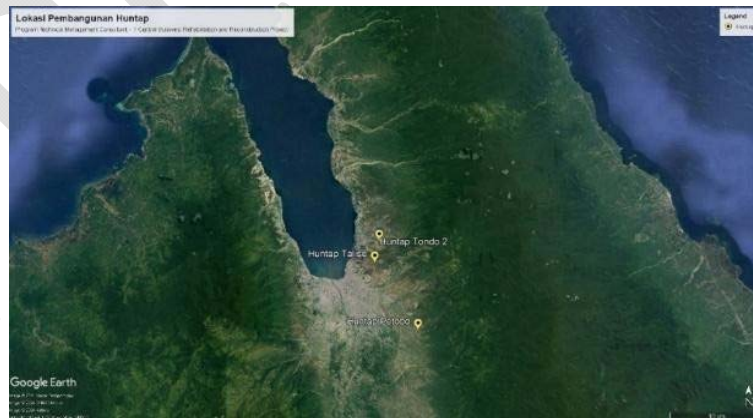


Figure 1 - Satellite Imagery Data of the Permanent Housing Development Sites in Tondo 2, Talise, and Petobo.

strategic considerations. First, all projects were executed under World Bank-funded CSRRP contracts requiring integration of international procurement standards with Indonesian national regulations, making them exemplary cases of harmonized contract application. Second, the sites experienced significant contractual complexities including substantial time extensions (58-118% of original duration) and budget amendments, providing rich data for risk analysis. Third, the locations represented diverse disaster scenarios—Petobo (liquefaction), Tondo 2 (tsunami), and Talise (combined impacts)—offering varied perspectives on contract performance. The multi-year contract structure characteristic of harmonized contracts, combined with completion status at data collection (PHO achieved August-November 2024), enabled comprehensive retrospective analysis. Furthermore, availability of complete contract documentation from Balai Prasarana Permukiman Wilayah Sulawesi Tengah facilitated thorough document analysis, establishing these sites as representative and information-rich cases for evaluating harmonized contract implementation.

2.2. Data Collection Techniques

The semi-structured interviews were designed to explore in-depth perspectives on the implementation challenges and risk dynamics of harmonized contracts in post-disaster reconstruction. Interview questions focused on four main risk categories as outlined in the research framework: (1) technical risks, including design mismatches, infrastructure limitations, and construction quality issues; (2) managerial risks, such as coordination challenges, stakeholder communication, and community participation barriers; (3) environmental risks, particularly restrictions related to disaster-prone zones and potential secondary disasters; and (4) financial risks, including budget limitations, funding delays, currency fluctuations, and contractual amendments. Each interview session lasted approximately 60-90 minutes and was conducted in Indonesian to ensure clear communication and comprehensive understanding.

The structured questionnaires were developed to systematically assess risk factors through quantitative scoring methods using FMEA (Failure Mode and Effect Analysis) and SWOT (Strengths, Weaknesses, Opportunities, Threats) frameworks. Respondents evaluated each identified risk based on standardized parameters as detailed in Table 1.

Both interview guides and questionnaires were developed through a systematic process informed by existing research and project documentation. First, an extensive literature review was conducted to identify common risk categories in harmonized contracts and post-disaster reconstruction projects, drawing from previous studies on FIDIC contracts, World Bank-funded projects, and disaster reconstruction cases in developing countries. Second, a comprehensive analysis of CSRRP contract documents, project implementation reports, and relevant national regulations (including Law No. 2 of 2017 on Construction Services and Presidential Regulation No. 16 of 2018) was performed to identify context-specific risks relevant to the Central Sulawesi case. This document analysis ensured that the research instruments captured the unique characteristics of harmonized contracts in the Indonesian post-disaster context.

Table 1 - Questionnaire Assessment Parameters

Method	Parameter	Definition	Scale	Scale Description
FMEA	Severity (S)	Potential impact of the risk on project objectives	1 - 10	1 = negligible impact
				10 = catastrophic impact
	Occurrence (O)	Likelihood of the risk materializing	1 - 10	1 = highly unlikely
10 = almost certain				
Detection (D)	Difficulty in detecting and preventing the risk before it causes significant harm	1 - 10	1 = easily detectable	
			10 = nearly impossible to detect	
SWOT	Internal Factors	Strengths and Weaknesses	Rating	Respondent perception of significance to project
	External Factors	Opportunities and Threats	Rating	Respondent perception of significance to project

A total of 20 participants were purposively selected based on three criteria: (1) minimum 6 months of direct involvement in CSRRP project implementation, (2) holding decision-making or technical roles, and (3) comprehensive knowledge of harmonized contract procedures. The 5 interview participants comprised one CSRRP project manager, one World Bank representative, one contract administrator, one technical supervisor, and one community liaison officer. The 15 questionnaire respondents included 7 consultants, 5 contractors, and 3 government officials. All participants had 8-15 years of experience in construction project management, with 2-5 years specifically in post-disaster reconstruction, ensuring that diverse technical, administrative, and social perspectives were represented in the study.

To illustrate the integration of qualitative and quantitative approaches, Figure 2 presents the research design flow diagram showing the sequential and complementary nature of data collection and analysis methods.

The sample size was determined through purposive sampling aimed at achieving informational adequacy rather than statistical representativeness. For interviews, thematic saturation was reached after the fifth participant, as no new risk themes emerged beyond those identified in the first four interviews a pattern consistent with [31] finding that thematic saturation in homogeneous expert samples typically occurs within 6-12 interviews. The five interview participants represented all key decision-making roles in CSRRP implementation (project management, international financing, contract administration, technical supervision, and community liaison), ensuring comprehensive coverage of stakeholder perspectives across managerial, financial, technical, and social domains. For questionnaires, the 15 respondents represented all primary stakeholder categories involved in CSRRP execution (consultants n=7, contractors n=5, government officials n=3), ensuring perspective diversity across design, construction, and regulatory

functions. This sample size aligns with established practices for expert-based FMEA risk assessment in construction projects, where 10-20 subject matter experts provide sufficient reliability for RPN calculations [32]. The inclusion of participants with 8-15 years of construction management experience and direct involvement in all three study sites (Tondo 2, Talise, Petobo) ensured that ratings reflected substantive professional judgment rather than superficial assessment.

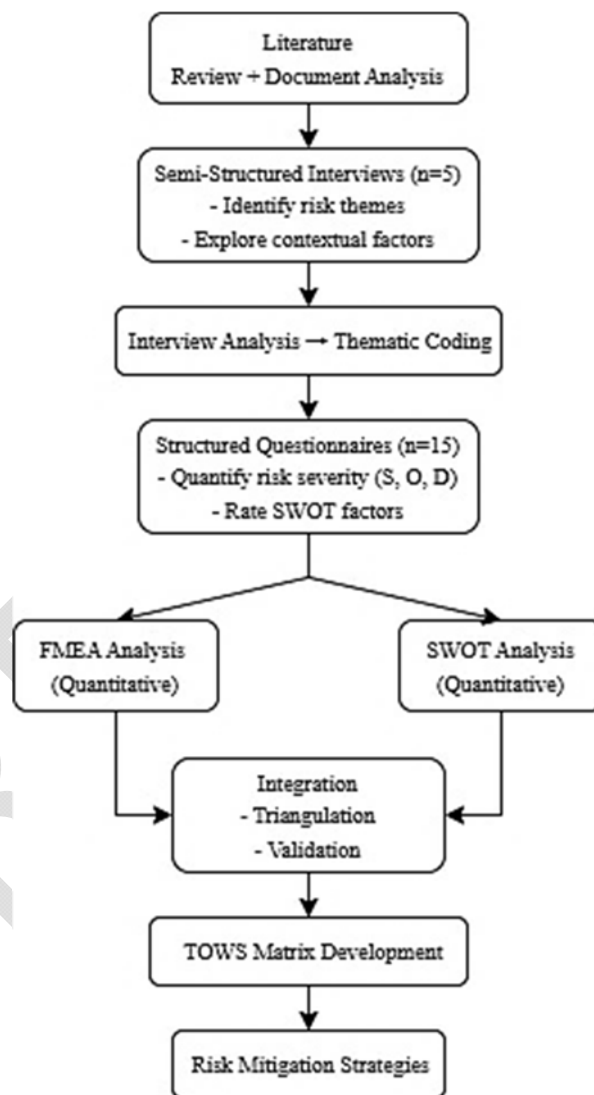


Figure 2 - Mixed-Methods Research Design Flow Diagram

2.3. Operational Definition of Variables

Risks were grouped into four categories based on established risk classification frameworks in construction and post-disaster reconstruction projects (Table 2). This categorization aligns with risk management standards commonly applied in infrastructure projects and has been validated in previous post-disaster reconstruction studies.

Table 2 - Risk Classification Framework

Risk Category	Definition	Risk Factors Identified in This Study	Literature Sources
Technical Risks	Risks arising from design inadequacies, construction methods, material specifications, and technical capacity limitations that may affect project quality and performance	<ul style="list-style-type: none"> • Design mismatches with field conditions • Limited infrastructure support • Potential secondary disasters • Poor waste management systems 	[Malahayati et al., 2021; Jaya, 2020]
Managerial Risks	Risks related to project management processes, coordination among stakeholders, communication effectiveness, and organizational capacity	<ul style="list-style-type: none"> • Weak inter-agency coordination • Low community participation • Land ownership disputes • Complex bureaucracy 	[Jailani et al., 2020; Hakim, 2008]
Environmental Risks	Risks stemming from environmental conditions, natural hazards, regulatory restrictions, and sustainability considerations	<ul style="list-style-type: none"> • Construction in disaster-prone zones • Environmental compliance requirements • Ecological impact concerns 	[Tawashi et al., 2025; Malahayati et al., 2021]
Financial Risks	Risks associated with project funding, budget management, cost fluctuations, and financial sustainability	<ul style="list-style-type: none"> • Budget limitations and amendments • Delayed fund disbursement • Currency fluctuations and inflation • Potential fund misuse • Contract time and cost extensions 	[Kurniawan et al., 2017; Simanjuntak et al., 2021]

2.4. Data Analysis Technique

Data were analyzed using a mixed-method approach combining qualitative and quantitative techniques. SWOT analysis was used to identify and categorize internal and external factors affecting project success, while FMEA assessed risk priorities based on severity, occurrence, and detectability. These methods were applied in a complementary manner to provide a comprehensive understanding of risks and support the formulation of effective mitigation strategies.

1) Qualitative Data Analysis

Qualitative data from semi-structured interviews were analyzed using thematic content analysis to identify recurring patterns, challenges, and insights related to harmonized contract implementation. Interview transcripts were systematically reviewed and coded to extract key themes corresponding to the four risk categories (technical, managerial, environmental, and financial). These themes informed the identification of SWOT factors and provided contextual depth to the quantitative risk assessments. The qualitative findings helped explain the underlying causes of identified risks and enriched the interpretation of statistical results.

2) Quantitative Data Analysis - SWOT]

For SWOT analysis, quantitative data from questionnaires were processed using descriptive statistics. Each SWOT factor was evaluated by calculating the rating as the average of all respondent scores:

$$Rating = \frac{(x_1 + x_2 + x_3 + \dots + x_n)}{n} \quad (1)$$

where x represents individual respondent scores and n is the number of respondents. The weight of each factor was then determined by dividing its rating by the sum of all ratings within the same category:

$$Weight = \frac{Rating}{\sum Ratings} \quad (2)$$

Finally, the score for each factor was calculated by multiplying the weight with the rating:

$$Score = Weight \times Rating \quad (3)$$

The total scores for Strengths, Weaknesses, Opportunities, and Threats were summed separately to determine IFAS (Internal Factor Analysis Summary) and EFAS (External Factor Analysis Summary) values, which were then plotted on a Cartesian diagram to identify the strategic position of the project.

3) Quantitative Data Analysis – FMEA

For FMEA analysis, each identified risk was evaluated based on three parameters: Severity (S), Occurrence (O), and Detection (D), each rated on a scale of 1-10 as defined in Table 1. The Risk Priority Number (RPN) for each risk was calculated using the formula:

$$RPN = S \times O \times D \quad (4)$$

Risks were then ranked based on their RPN values, with higher values indicating greater priority for mitigation. A Pareto chart was constructed to visualize risk distribution and identify the critical few risks that required immediate attention. Risks with RPN values above 100 were classified as high priority, while those below 50 were considered low priority.

4) Data Integration and Validation

The integration of qualitative and quantitative data followed a convergent parallel design, where both data types were collected simultaneously, analyzed separately, and then merged during the interpretation phase. Qualitative insights from interviews provided explanatory context for quantitative patterns observed in the questionnaire data, while quantitative results validated and generalized the themes identified in the interviews. This triangulation approach enhanced the credibility and comprehensiveness of the findings. Data processing was conducted using Microsoft Excel for calculations (rating, weight, score, RPN) and SPSS for descriptive statistics and data validation. Manual cross-checking was performed to ensure accuracy and consistency across all analytical procedures.

3. RESULT

This study focuses on permanent housing sites in Tondo 2, Talise, and Petobo, Central Sulawesi, under the TMC-1 CSRRP program—areas severely affected by the 2018 disaster. Data were gathered from 20 purposively selected respondents (15 questionnaires, 5 interviews) representing consultants, contractors, and service users, whose direct involvement provided practical insights into risk dynamics. Risk identification, based on CSRRP contract documents and standards, revealed four key categories—technical, managerial, environmental, and financial. These risks were then analyzed using SWOT to map internal and external factors, and FMEA to assess failure severity and likelihood. Together, both methods offered a structured basis for formulating effective mitigation strategies.

3.1. SWOT Analysis

SWOT factors were systematically scored based on respondent assessments (n=15). Each factor's rating was calculated as the average of respondent scores, then converted to a weight (rating divided by sum of all ratings in the category) and score (weight multiplied by rating). Table 3 illustrates the calculation process for internal factors, demonstrating how the aggregate scores of Strengths (2.67) and Weaknesses (1.13) were derived. External factors were scored using the same methodology, yielding Opportunities (1.80) and Threats (1.99).

To summarize the SWOT analysis, the evaluation shows that the project demonstrates solid internal strengths, particularly in the quality of construction, environmentally friendly design, and strong budget availability, which resulted in a higher Strengths score (2.67) compared to Weaknesses (1.13). On the external side, Opportunities (1.80) are slightly lower than Threats (1.99), highlighting that while the project benefits from innovations such as waste management improvement and transparent procurement systems, it still faces notable risks like sudden design changes, extreme weather, and legal disputes over land ownership.

Table 3 - SWOT Scoring Calculation - Internal Factors

Factor	Code	Rating	Weight	Score	Calculation
STRENGTHS					
Material quality maintained	S1	4.27	0.13	0.55	0.13×4.27
Environmental design	S2	4.00	0.12	0.49	0.12×4.00
Sustainable infrastructure	S3	4.40	0.13	0.59	0.13×4.40
Budget availability	S4	3.87	0.12	0.45	0.12×3.87
Disaster mitigation	S5	4.40	0.13	0.59	0.13×4.40
→ Total Strengths				2.67	Sum of scores
WEAKNESSES					
No time amendment limit	W1	2.67	0.08	0.22	0.08×2.67
No budget amendment limit	W2	3.47	0.11	0.36	0.11×3.47
Land claims	W3	2.27	0.07	0.16	0.07×2.27
Currency fluctuation	W4	3.60	0.11	0.39	0.11×3.60
→ Total Weaknesses				1.13	Sum of scores

To clarify the strategic position of the project, further calculation was conducted using the IFAS (Internal Factor Analysis Summary) and EFAS (External Factor Analysis Summary) values, with the following results:

$$IFAS = (+) Strengths + (-) Weaknesses \quad (5)$$

$$IFAS = (+) 2,67 + (-) 1,13$$

$$IFAS = 1,54$$

$$EFAS = (+) Opportunities + (-) WThreats \quad (6)$$

$$EFAS = (+) 1,80 + (-) 1,99$$

$$EFAS = -0,19$$

These values were then plotted on the SWOT Cartesian diagram, the project falls into a quadrant that reflects strong internal capacity but significant external challenges. This positioning suggests that strategies should focus on leveraging internal strengths to counter potential threats, while also making use of available opportunities to support long-term resilience.

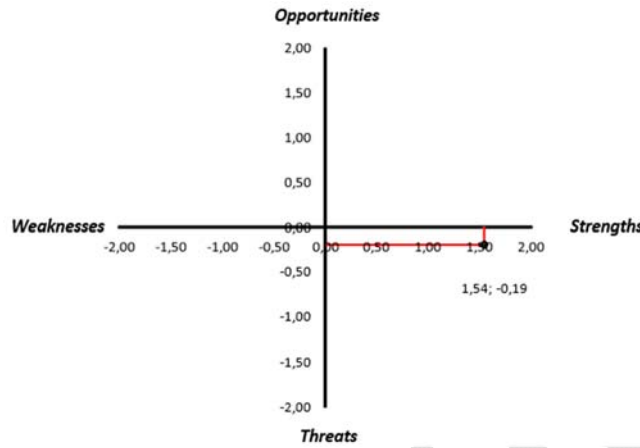


Figure 3 - SWOT Cartesian Diagram

Finally, the TOWS (Threats, Opportunities, Weaknesses, Strengths) matrix was developed to translate these findings into actionable strategies. For example, maximizing sustainable design practices and budget strength can help optimize procurement transparency and improve communication with stakeholders. At the same time, strategies such as stricter risk management for extreme weather and legal disputes, as well as community engagement to reduce relocation resistance, are necessary to minimize vulnerabilities.

Eksternal / Internal	STRENGTH	WEAKNESS
	a. The quality of materials and construction implementation is well-maintained. b. The design takes into account the surrounding development environment. c. Provision of sustainable supporting infrastructure. d. Availability of sufficient budget. e. Follow-up disaster mitigation efforts are in place.	a. No clear limit on time amendments. b. No clear limit on budget amendments. c. Land ownership claims. d. Exchange rate fluctuations and inflation.
OPPORTUNITIES	SO Strategies	WO Strategies
a. Improvement of construction waste management systems as an environmental advantage. b. Utilization of disaster-prone zone maps to mitigate location-based risks. c. Optimization of procurement technology to enhance project transparency. d. Strengthening communication with communities and the government.	a. Maximize material quality and sustainable design with the support of procurement technology to ensure project transparency. b. Utilize disaster-prone zone maps and sustainable infrastructure to mitigate location-based risks. c. Strengthen communication with the community and government to accelerate project implementation.	a. Utilize waste management optimization to reduce land claims due to environmental impacts. b. Strengthen time and budget amendment limits through procurement technology transparency. c. Encourage stronger communication to control budget fluctuations.
THREATS	ST Strategies	WT Strategies
a. Sudden design changes. b. Aftershocks, floods, and extreme weather. c. Complex bureaucracy and numerous stakeholders. d. Community reluctance to relocate from previous areas. e. Land ownership disputes and potential legal claims.	a. Ensuring sufficient budget availability to address the risks of sudden design changes and extreme weather. b. Mitigating secondary disasters by providing infrastructure that is adaptive to extreme weather conditions. c. Utilizing high-quality materials to minimize the legal dispute impacts resulting from land claims.	a. Limiting budget and time amendments to avoid losses caused by complex bureaucracy. b. Strengthening legal certainty to reduce the risk of land ownership disputes. c. Educating the community to minimize relocation rejection from affected areas.

Figure 4 - TOWS Matrix

The TOWS strategies presented in Figure 4 were formulated through systematic synthesis of SWOT factors and validation against stakeholder insights from semi-structured interviews. Each strategy was developed by methodically pairing internal factors (Strengths and Weaknesses) with external factors (Opportunities and Threats) following the TOWS framework: SO strategies leverage Strengths to maximize Opportunities, ST strategies deploy Strengths to counter Threats, WO strategies utilize Opportunities to overcome Weaknesses, and WT strategies adopt defensive measures to minimize both Weaknesses and Threats. The formulation process involved cross-referencing SWOT factors with interview findings and project documentation to ensure contextual relevance. For instance, the SO strategy of utilizing sustainable infrastructure design to enhance stakeholder communication emerged from combining the project's strength in long-term infrastructure planning (S3) with the opportunity for improved government-community coordination (O4). Similarly, the WT strategy of establishing strict amendment controls to avoid bureaucratic losses was derived from addressing the weakness of unlimited time amendments (W1) while mitigating the threat of complex bureaucracy (T3). This systematic approach ensured that all proposed strategies were grounded in empirical data and aligned with the practical realities of harmonized contract implementation in post-disaster contexts.

3.2. FMEA Analysis

In this study, the Failure Mode and Effect Analysis (FMEA) was applied to prioritize risks in the implementation of harmonized contracts under the post-disaster rehabilitation and reconstruction program in Central Sulawesi. Using the FMEA methodology, risks were ranked by their RPN values. High-priority risks ($RPN \geq 256$) require immediate mitigation, while moderate risks ($RPN < 200$) need monitoring. To present the results more clearly, a Pareto chart was constructed, which arranges risks from the highest to the lowest RPN. This makes it easier to highlight the most significant risks that could disrupt project success.

Table 4 presents the calculated RPN values for each identified risk factor based on respondent assessments ($n=15$). The RPN calculation followed the formula (4), where Severity (S), Occurrence (O), and Detection (D) were each rated on a scale of 1-10. For example : T2 (aftershocks, floods, extreme weather), received the highest priority with $S = 8$ (indicating catastrophic potential impact on project safety and continuity), $O = 8$ (high likelihood given the disaster-prone location), and $D = 8$ (difficult to predict and prevent), yielding

$$RPN = 8 \times 8 \times 8 = 512$$

Risks with $RPN \geq 256$ were classified as high-priority (7 risks total), requiring immediate and comprehensive mitigation strategies, while those with $RPN < 200$ were designated as moderate to low priority. The Pareto analysis (Figure 4) demonstrates that the top 7 high-priority risks account for approximately 70% of total risk exposure, following the 80/20 principle commonly applied in risk management.

The FMEA results show that the highest risks come mainly from external factors, such as aftershocks, floods and extreme weather (T2), as well as exchange rate fluctuations and inflation (W4), with RPN scores up to 512. Other high risks include sudden design changes,

complex bureaucracy, and community resistance to relocation. Legal and regulatory issues, like land disputes and unclear budget amendments, also remain critical concerns.

Table 4 - FMEA Method RPN Score Results

No.	Code	Risk	RPN Value
1	T2	Aftershocks, floods, extreme weather	512
2	W4	Exchange rate fluctuation and inflation	512
3	T1	Sudden design changes	384
4	T3	Complex bureaucracy and numerous stakeholders	384
5	T4	Community reluctance to relocate from previous area	384
6	W3	Land claims	256
7	T5	Land ownership disputes, potential legal claims	256
8	W1	No time amendment limitations	216
9	W2	No budget amendment limitations	216
10	S4	Sufficient budget availability	192
11	S5	Follow-up disaster mitigation	192
12	O1	Improved construction waste management system as an environmental advantage	192
13	S1	Maintained material quality and construction implementation	128
14	S2	Environmentally conscious design	128
15	S3	Provision of sustainable infrastructure	128
16	O2	Utilization of disaster-prone zone maps for location risk mitigation	128
17	O3	Procurement technology optimization for project transparency	128
18	O4	Strengthening communication between the community and the government	128

Meanwhile, lower RPN scores for aspects such as material quality, eco-friendly design, and effective communication reflect internal strengths that can support mitigation. Overall, the analysis highlights the need for stronger coordination, adaptive contract systems, and better risk management capacity to ensure project success.

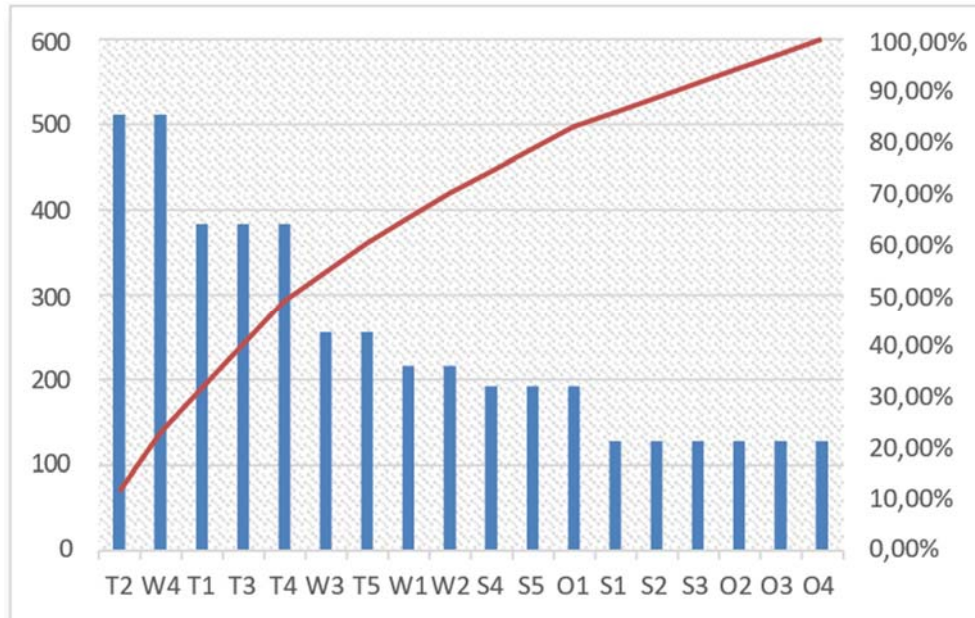


Figure 5 - Pareto Chart of Risk Factors

3.3. Risk Mitigation Strategy

SWOT and FMEA analysis reveal that harmonized contract implementation in Central Sulawesi’s post-disaster projects faces both challenges and opportunities. Key strengths include available funding and eco-friendly design, while weaknesses stem from procedural differences and bureaucracy. Opportunities arise from technology and cross-sector collaboration, but threats include currency shifts, secondary disasters, and relocation resistance.

FMEA identifies priority risks—such as procurement delays, sudden design changes, and community opposition—that demand technical, administrative, and social mitigation. The proposed action plan emphasizes clear responsibilities, timelines, and stakeholder involvement to strengthen project resilience.

The risk mitigation action plan presented in table 5 was formulated through systematic integration of FMEA risk priorities, TOWS strategic frameworks, and stakeholder recommendations from semi-structured interviews. Mitigation strategies were developed using a three-step process: First, risks were prioritized based on RPN values, with those scoring $RPN \geq 256$ designated as requiring immediate action. Second, appropriate mitigation approaches were identified by cross-referencing with TOWS strategies for instance, mitigation for T2 (extreme weather) aligns with the ST Strategy (using Strengths to counter Threats) by leveraging the project's disaster mitigation capacity (S5) and adequate budget (S4) to strengthen building structures and establish emergency protocols. Third, specific mitigation actions were validated against stakeholder insights from

interviews and best practices documented in post-disaster reconstruction literature. For example, the strategy of implementing fixed-rate contracts and hedging mechanisms for W4 (currency fluctuation) was recommended by finance consultants during interviews and supported by similar approaches in World Bank-funded projects documented in the literature. Responsibility assignments were determined based on functional expertise (Technical & Safety for structural risks, Finance for budget-related risks, Social & Safeguard for community-related risks), while implementation timelines reflected the urgency indicated by RPN levels and project phase requirements.

Table 5 - Matrix Action Plan

Code	Priority Risk	Mitigation Strategy	Responsible Team	Time Target
T2	Aftershocks, floods, extreme weather	Strengthen building structure, prepare emergency SOPs, team training	Technical & Safety Team	Immediately, before and during construction
W4	Exchange rate fluctuation and inflation	Lock initial prices, use fixed-rate contracts, and apply hedging	Finance Team	From the beginning of the project
T1	Sudden design changes	Finalize initial design, conduct regular reviews, involve all stakeholders	Planning & Project Management Team	At the start and periodic evaluations
T3	Complex bureaucracy and multiple stakeholders	Establish intensive communication with government and all relevant stakeholders	Social & Safeguard Team	Throughout project implementation
T4	Community reluctance to relocate	Socialization of relocation programs, provide incentives	Social & Safeguard Team	From the beginning of the project
W3	Land claims	Legal validation of land, legal assistance	Social & Safeguard Team	Before implementation
T5	Land ownership disputes, potential lawsuits	Mediation and acceleration of legal process	Social & Safeguard Team	As needed

4. DISCUSSION

This study revealed that harmonized contracts in Central Sulawesi's post-disaster reconstruction demonstrate strong internal capacities but face substantial external risks,

particularly from environmental and economic uncertainties. The following sections interpret these findings against existing literature, examine harmonized contract-specific challenges, and articulate the study's contributions to post-disaster reconstruction knowledge.

4.1. Strategic Position and Risk Profile of Harmonized Contracts

The SWOT analysis reveals that harmonized contract implementation in Central Sulawesi's post-disaster reconstruction demonstrates a strong internal capacity (IFAS = 1.54) but faces significant external pressures (EFAS = -0.19), positioning the project in Quadrant I of the strategic matrix. This finding aligns with Jailani et al. (2020), who documented similar internal-external imbalances in post-earthquake housing rehabilitation in West Nusa Tenggara, where adequate funding and technical capacity coexisted with substantial external challenges including community resistance and regulatory complexity.

However, the current study extends this understanding by identifying harmonized contract specific risks that were not prominent in conventional procurement settings. Specifically, the absence of amendment limitations for time (W1) and budget (W2) inherent features of World Bank funded harmonized contracts designed to provide implementation flexibility paradoxically emerged as critical weaknesses. This contrasts with findings from Simanjuntak et al. (2021) in their analysis of Indonesian construction contracts, where rigid amendment controls were identified as constraints. The present study suggests that in post-disaster contexts characterized by high uncertainty, excessive flexibility without adequate monitoring mechanisms can lead to project delays and cost overruns, as evidenced by time extensions ranging from 58% to 118% of original durations across the three study sites.

The dominance of internal strengths in sustainable infrastructure design (S3, score=0.59) and disaster mitigation capacity (S5, score=0.59) reflects successful integration of "Build Back Better" principles advocated by international development agencies. This finding resonates with Saya et al. (2017), who emphasized that post-disaster reconstruction presents unique opportunities to enhance resilience through improved design standards. The lower scores for weaknesses related to land claims (W3, score=0.16) compared to other studies [20] may indicate effective pre-implementation land clearance processes in CSRRP projects, representing a procedural improvement over earlier post-disaster interventions in Indonesia.

4.2. Risk Prioritization and the Predominance of External Threats

The FMEA analysis identified external environmental and economic risks as the highest priorities, with T2 (extreme weather, RPN=512) and W4 (currency fluctuation, RPN=512) requiring immediate mitigation. This finding is consistent with Malahayati et al. (2021), who documented similar risk patterns in post-earthquake housing projects in Pidie Jaya, Aceh, where environmental uncertainties dominated pre-construction risk profiles. The high severity and occurrence ratings for T2 reflect Central Sulawesi's continued vulnerability to secondary disasters a reality confirmed by multiple aftershocks recorded during the reconstruction period (2022-2024).

However, the emergence of W4 (currency fluctuation) as a co-equal highest risk represents a novel finding not prominently featured in previous Indonesian post-disaster reconstruction literature. This can be attributed to the multi-year contract structure characteristic of harmonized contracts (713-718 calendar days across study sites), which exposes projects to prolonged macroeconomic volatility. Kurniawan et al. (2017) identified similar financial risks in infrastructure financing but did not examine their interaction with disaster reconstruction timelines. The present study reveals that harmonized contracts' extended implementation periods amplify currency risk exposure, necessitating specialized hedging mechanisms not typically employed in shorter-duration conventional contracts.

The identification of bureaucratic complexity (T3, RPN=384) and community relocation resistance (T4, RPN=384) as high-priority risks echoes findings from Jailani et al. (2020), who noted that social and administrative challenges often overshadow technical risks in post-disaster contexts. The high detection difficulty (D=8) assigned to T3 reflects the unpredictable nature of multi-stakeholder coordination when integrating World Bank procurement procedures with Indonesian national regulations a challenge unique to harmonized contracts. Jaya (2020) documented similar coordination difficulties in FIDIC contract implementation in Bali, suggesting that international contract standards consistently encounter adaptation challenges in Indonesian institutional contexts.

Notably, the Pareto analysis revealing that 7 high-priority risks account for 70% of total risk exposure validates the focused risk management approach. This distribution is more concentrated than patterns observed by Malahayati et al. (2021), who found risk exposure more evenly distributed across 15 factors. The concentration in the present study may reflect the unique risk profile of harmonized contracts, where external environmental and regulatory factors exert disproportionate influence compared to technical and managerial factors that dominate conventional projects.

4.3. International Comparative Perspectives

The risk profile identified in this study finds both parallels and contrasts with post-disaster reconstruction experiences in other seismically-active regions. The prominence of currency fluctuation (W4, RPN=512) as a co-highest risk mirrors challenges documented in Turkey's 2023 earthquake reconstruction, where Turkish Lira depreciation significantly impacted multi-year contract costs [Sakarya, 2023; The Territorial Impact..., 2023]. However, Turkey's reconstruction benefited from more established disaster response frameworks that mitigated bureaucratic complexity—in contrast to the high-priority bureaucratic risk (T3, RPN=384) identified in this study [Oktay, 2015; Günaydm, 2024].

Japan's post-Tōhoku reconstruction offers a contrasting case where financial volatility was effectively managed through government-backed insurance mechanisms and coordinated intergovernmental transfer systems [Ural, 2025], institutional safeguards largely unavailable in Indonesia's decentralized governance structure. The community relocation resistance (T4, RPN=384) documented in this study resonates with New Zealand's Christchurch experience, where early stakeholder engagement protocols embedded within contract frameworks successfully reduced opposition [Demir, 2025]. These international comparisons suggest that while certain risks (currency volatility, community resistance) are universal to post-disaster contexts, their severity and manageability are highly contingent

on pre-existing institutional capacities and governance structures—factors that distinguish Indonesia's reconstruction challenges from those in more developed economies.

4.4. Effectiveness of TOWS-Derived Mitigation Strategies

The TOWS matrix-derived strategies demonstrate systematic integration of strengths to counter threats (ST strategies) and exploitation of opportunities to overcome weaknesses (WO strategies), consistent with strategic management frameworks applied in construction risk mitigation (e.g., Simanjuntak et al., 2021). However, the present study's emphasis on adaptive contract management and enhanced stakeholder communication reflects lessons learned specifically from harmonized contract implementation.

The recommended mitigation for T2 (structural reinforcement, emergency SOPs) aligns with Saya et al. (2017)'s Build Back Better framework but adds a contractual dimension by proposing contingency clauses for disaster interruptions a provision not standard in conventional Indonesian construction contracts but essential for harmonized contracts in high-risk environments. Similarly, the mitigation for W4 (fixed-rate contracts, hedging) represents a novel contribution by explicitly addressing the financial instruments required for multi-year international contracts, extending beyond the general cost control measures discussed by Kurniawan et al. (2017).

The integration of FMEA derived risk priorities with TOWS strategic directions exemplified in the correlation matrix provides a methodologically rigorous approach to mitigation planning that synthesizes quantitative risk assessment with qualitative strategic analysis. This integrated approach addresses a gap noted by Malahayati et al. (2021), who called for more systematic risk management frameworks in post-disaster contexts.

4.5. Implications for Harmonized Contract Implementation

The findings carry significant implications for harmonized contract design and implementation in post-disaster reconstruction. First, the study demonstrates that harmonized contracts can successfully leverage international best practices (evidenced by high scores for sustainable design and disaster mitigation) while remaining vulnerable to local institutional and environmental challenges. This suggests that harmonization should be selective rather than comprehensive, prioritizing technical and financial integration while accommodating local administrative procedures.

Second, the prominence of external risks highlights the need for enhanced risk-sharing mechanisms between international financing institutions and implementing agencies. The current study reveals that excessive project duration flexibility, while intended to accommodate post-disaster uncertainties, can paradoxically increase risk exposure to macroeconomic fluctuations and bureaucratic delays. Future harmonized contracts should incorporate milestone-based amendment controls that balance flexibility with accountability.

Third, the concentration of high-priority risks in external factors suggests that pre-contract risk assessments for harmonized contracts must extend beyond conventional technical and financial evaluations to include institutional capacity analyses and political economy

assessments of stakeholder coordination dynamics. This expands upon recommendations by Hakim (2008) and Jailani et al. (2020) by emphasizing the unique challenges posed by integrating international and national procurement systems.

4.6. Research Contributions and Novelty

This study makes three primary contributions to the literature on post-disaster reconstruction and contract management:

First, it provides the first systematic risk evaluation of harmonized contracts in Indonesian post-disaster contexts, addressing a gap identified in previous studies that examined either conventional contracts (e.g., Simanjuntak et al., 2021) or FIDIC contracts (e.g., Jaya, 2020) but not hybrid harmonization approaches.

Second, it demonstrates the amplifying effect of multi-year contract structures on currency and bureaucratic risks, revealing that harmonization introduces temporal risk dimensions not adequately addressed in existing literature focused on shorter-duration projects.

Third, it validates the integration of SWOT and FMEA methodologies for post-disaster risk management, offering a replicable framework that combines strategic analysis with quantitative risk prioritization—a methodological advancement over single-method approaches used in prior studies (e.g., Malahayati et al., 2021 used only HIRA; Jaya, 2020 used only FMEA).

These contributions enhance understanding of how international-national contract integration functions in high-uncertainty environments, providing both theoretical insights and practical guidance for future harmonized contract implementations.

5. CONCLUSION

This study evaluated the implementation of harmonized contracts in post-disaster rehabilitation and reconstruction projects in Central Sulawesi, specifically addressing three research objectives through integrated SWOT and FMEA methodologies.

Addressing research objective (1) (identify and classify emerging risks), the study successfully identified 18 distinct risk factors organized into four categories: technical risks (design mismatches, infrastructure limitations, waste management), managerial risks (coordination challenges, community participation barriers, land disputes), environmental risks (disaster-prone zone restrictions), and financial risks (budget limitations, currency fluctuations, contractual amendments). This comprehensive risk taxonomy, validated through stakeholder interviews and document analysis, provides a structured framework for understanding the multifaceted challenges in harmonized contract implementation.

Regarding objective (2) (assess application and effectiveness), the integrated SWOT-FMEA analysis revealed that harmonized contracts demonstrate strong internal capacities (IFAS=1.54) particularly in funding availability and sustainable design, but face substantial external pressures (EFAS=-0.19) from environmental uncertainties and bureaucratic complexity. The FMEA prioritization identified seven high-priority risks ($RPN \geq 256$) accounting for 70% of total risk exposure, with extreme weather (T2, $RPN=512$) and

currency fluctuation (W4, RPN=512) requiring immediate mitigation. Notably, the study uncovered a flexibility-control paradox: while harmonized contracts provide adaptive flexibility through unlimited amendments, this feature paradoxically contributed to time extensions of 58-118% across study sites, suggesting that excessive flexibility without disciplining mechanisms can undermine project efficiency.

Concerning objective (3) (examine cross-sector collaboration facilitation), the findings reveal that harmonized contracts can enhance collaboration by integrating international best practices with local implementation, as evidenced by successful stakeholder coordination in sustainable design and disaster mitigation. However, collaboration effectiveness is contingent upon institutional readiness, clear communication protocols, and balanced risk-sharing mechanisms between international financing institutions and local implementing agencies. The bureaucratic complexity (T3, RPN=384) and coordination challenges identified in the study highlight that harmonization is not merely a technical exercise but a complex institutional adaptation requiring continuous negotiation between international standards and local capacities.

This research provides actionable guidance for practitioners and policymakers involved in post-disaster reconstruction. First, for project managers, the risk prioritization framework and action plan (Table 4) offer specific mitigation strategies with designated responsibilities and timelines. Second, for government agencies, the findings recommend implementing milestone-based amendment controls to balance flexibility with accountability, rather than the current unlimited amendment approach. Third, for international financing institutions (e.g., World Bank), the study suggests developing specialized hedging mechanisms and currency risk-sharing clauses for multi-year contracts in volatile economic contexts. Fourth, for community engagement teams, the identification of relocation resistance (T4, RPN=384) as a high-priority risk underscores the need for early, transparent, and incentivized community consultation processes.

Academic Implications: This study makes three significant contributions to scholarly literature. First, it provides the first systematic risk evaluation of harmonized contracts in Indonesian post-disaster contexts, filling a critical gap in research that has examined either conventional contracts or FIDIC contracts separately but not hybrid harmonization approaches. Second, it advances methodological practice by demonstrating the effectiveness of integrating SWOT (strategic analysis) with FMEA (quantitative risk prioritization) for post-disaster risk management a replicable framework superior to single-method approaches. Third, it extends theoretical understanding of contract harmonization by revealing that integration of international-national procurement systems introduces meta-risks (risks arising from the harmonization process itself) not adequately addressed in current literature. These meta-risks including the flexibility-control paradox and amplified currency exposure in multi-year structures challenge assumptions in World Bank guidelines that harmonization primarily yields efficiency gains, revealing instead a more nuanced reality requiring context-specific adaptations.

Furthermore, comparative analysis with post-disaster reconstruction experiences in Turkey (2023), Japan (2011), and New Zealand (2011) demonstrates that while certain risks such as currency volatility and community resistance are universal across disaster contexts, their severity and manageability are highly contingent on pre-existing institutional capacities and governance structures—a finding that contributes to the emerging literature on context-

dependent disaster reconstruction frameworks and challenges assumptions of universal applicability in international development guidelines.

The study acknowledges limitations including its focus on three sites in Central Sulawesi, which may limit generalizability to other disaster contexts. Future research should explore harmonized contract performance across diverse disaster types, geographic settings, and institutional environments. Additionally, longitudinal studies tracking project outcomes beyond the construction phase would provide valuable insights into the long-term effectiveness of implemented mitigation strategies.

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