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Research Paper

Risk Management of Urban River Rehabilitation Using Severity Index and ISO 31000:2018: Evidence from the Veteran River

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ABSTRACT: *Urban river rehabilitation in dense cities combines hydrological, technical, logistical, occupational-safety, and stakeholder risks. This study identifies, evaluates, and prioritizes construction risks in the Veteran River Rehabilitation and Improvement Project in Banjarmasin, South Kalimantan, Indonesia, and formulates practical responses within an ISO 31000:2018-oriented process. A quantitative case-study survey was supported by field observation, project documents, preliminary interviews, and questionnaire assessment. Nineteen risk variables were retained after project-specific identification. Likelihood and consequence were rated on five-point scales, aggregated using the Severity Index, converted to ordinal values, and combined through a probability-consequence risk matrix and Risk Score. The detailed results classify four risks as high, thirteen as medium, and two as low. The highest priorities are uncertain weather conditions (P=4, I=5, R=20) and downstream drought during temporary flow interruption (P=4, I=5, R=20), followed by incomplete land-survey, hydrological, and subsurface planning data (P=3, I=4, R=12) and low labor productivity (P=3, I=4, R=12). Priority treatments emphasize weather-adaptive scheduling, supplementary technical investigation, tighter productivity management, alternative downstream water supply, stakeholder communication, and compensation where impacts occur. The study shows that a Severity Index and risk-matrix workflow can convert field perceptions into an actionable risk register for urban river works, while the single-project and small-respondent design limits generalization.*

KEYWORDS: *Construction risk, ISO 31000:2018, river rehabilitation, severity index, urban flood infrastructure.*

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I. INTRODUCTION

Urban river rehabilitation is undertaken to restore conveyance capacity, reduce flood exposure, improve drainage performance, and support the environmental quality of built-up areas. In Banjarmasin, river corridors also have direct social and economic functions, so construction interventions must be managed while maintaining access, water-flow continuity, public safety, and surrounding livelihoods. The Veteran River Rehabilitation and Improvement Project therefore represent more than a conventional civil-work package: it is a constrained urban infrastructure project in which technical decisions interact with hydrology, land conditions, community activity, equipment access, labor performance, and construction safety [1-4].

The source thesis describes the Veteran River as an urban drainage corridor connected to the wider river system of Banjarmasin. Rehabilitation includes normalization, riverbank strengthening, and related improvement works in a dense urban setting. The project is exposed to uncertain weather, subsurface conditions, design adjustment, material and equipment problems, workforce issues, occupational-safety concerns, and downstream social effects. If these risks are not assessed systematically, they can translate into schedule delay, additional cost, reduced productivity, quality problems, or impacts on communities located near and downstream of the work area.

Construction-risk management is intended to support decisions under uncertainty rather than eliminate uncertainty itself. ISO 31000:2018 frames risk management as a coordinated process of identification, analysis, evaluation, treatment, monitoring, review, recording, reporting, and communication [1]. For field projects, a semi-quantitative approach is often useful because it combines professional judgment with an explicit priority structure.

Severity Index aggregation can summarize several respondent ratings, while a likelihood-consequence matrix translates the results into decision categories that are easier for project personnel to discuss and act upon [5-8].

This article converts the thesis findings into an international-journal format and focuses on the quantitatively supported results. The objectives are to: (1) identify the project-specific construction risks; (2) determine their likelihood, consequence, and priority category; (3) interpret the dominant high risks in relation to site conditions; (4) summarize the risk-treatment measures identified through stakeholder interviews; and (5) discuss the implications for ISO 31000:2018-oriented risk management in urban river rehabilitation.

II. LITERATURE REVIEW

2.1. Construction Risk in River Rehabilitation

Construction projects are temporary systems with interdependent resources, activities, contracts, and stakeholders. Risk may originate from design, site conditions, labor, materials, equipment, management, safety, external events, or environmental interaction. In infrastructure projects, these sources are particularly important because a disruption in one work package can propagate into time, cost, quality, and safety performance [3,4,9]. River rehabilitation adds hydrological uncertainty, limited working space, active flows, weak ground, adjacent communities, and environmental obligations to the conventional construction-risk profile.

Previous Indonesian construction studies cited in the thesis show that risk priorities vary by project context. Building, road, wastewater, and water-resource projects have reported dominant risks related to material availability, occupational safety, technical uncertainty, social interaction, and implementation management [5,6,9-11]. This variation supports the use of project-specific identification rather than applying a generic list without field validation.

2.2. ISO 31000:2018 and Risk-Based Project Control

ISO 31000:2018 emphasizes principles, a management framework, and an iterative process for dealing with risk [1]. The process requires the organization to establish context and then identify, analyze, evaluate, and treat risks while maintaining communication, consultation, monitoring, review, recording, and reporting. In construction management, these activities should be linked to real decision rights and project responsibilities so that risk information is converted into preventive or corrective action rather than remaining only as documentation.

Risk treatment may involve avoidance, reduction, transfer, or retention depending on the source, consequence, controllability, and contractual allocation of each risk [1,7]. The appropriate choice is project-specific. For example, weather exposure may be reduced through schedule adaptation and temporary protection, while incomplete investigation data may require additional specialist input and coordination with designers. The thesis applies these treatment categories to the Veteran River project through interviews with project stakeholders.

2.3. Severity Index and Semi-Quantitative Risk Prioritization

The Severity Index (SI) is used in the thesis to combine multiple ordinal responses into a percentage representing the collective assessment of likelihood or consequence. For a five-point scale, the calculation is expressed as $SI = [\Sigma(a_i x_i)/(5N)] \times 100\%$, where a_i is the rating weight, x_i is the number of respondents selecting that rating, and N is the number of responses. The resulting percentage is converted back to a five-point ordinal scale. A Risk Score is then calculated as $R = P \times I$, where P is the converted likelihood rating and I is the converted consequence rating.

The project subsequently maps the P-I combination into low, medium, or high priority. This matrix-based categorization is more informative than the product alone because the same numerical product can arise from different likelihood-consequence combinations. The purpose of the assessment is not statistical generalization but structured prioritization: risks occupying the most severe matrix cells receive earlier management attention and more explicit treatment plans.

III. RESEARCH METHOD

3.1. Research Design and Study Context

The research used a quantitative case-study survey focused on the Veteran River Rehabilitation and Improvement Project in Banjarmasin, South Kalimantan, Indonesia. Primary information was obtained through observation, preliminary interviews, questionnaires, and follow-up interviews with personnel familiar with the project and construction-risk management. Secondary information consisted of project documentation, previous research, ISO 31000:2018, SNI IEC/ISO 31010:2016, and other references used in the thesis.

Risk identification began with literature review and field observation, followed by a preliminary survey to validate whether candidate risks were relevant to the project. The final assessment contained 19 risk variables. Chapter IV of the thesis reports seven completed assessment responses and uses seven responses in the Severity Index calculation. A separate respondent-criteria table lists four contractor respondents; because the numerical results are explicitly calculated from seven responses, this article follows the seven-response dataset and treats the difference as a source-document limitation.

3.2. Risk Variables and Data Collection

The retained variables cover weather, planning information, materials, equipment, design adjustment, quantities and measurement, labor productivity, personal protective equipment, subcontractor performance, geology, natural hazards, concrete works, estimation, and downstream water-flow impacts. Respondents assessed each variable using five-point likelihood and consequence scales. Follow-up interviews were used to compare matrix results with field experience and to identify treatment measures and responsible project functions.

3.3. Analytical Procedure

For each risk, likelihood and consequence responses were aggregated using the Severity Index and converted to five-point ratings. Risk Score was calculated from the product of the two converted ratings. The probability-consequence matrix was then used to classify risks into low, medium, and high priority. The thesis also compares the project team's practices with the process elements of ISO 31000:2018 and documents treatment measures such as schedule adaptation, supplementary surveys, coordination, training, inspection, temporary access works, safety controls, alternative water sources, and stakeholder communication.

Table 1. Research framework and analytical outputs

Element	Application in the Study	Main Output
Risk identification	Literature review, field observation, preliminary questionnaire, and interviews	Project-specific register of 19 risks
Risk assessment	Five-point likelihood and consequence questionnaire	Respondent ratings for each risk
Severity aggregation	Severity Index for likelihood and consequence	Collective percentage and converted P-I ratings
Risk evaluation	Risk Score and probability-consequence matrix	Low, medium, and high-priority categories
Risk treatment	Stakeholder interviews and project controls	Avoidance, transfer, and reduction measures
Process review	Comparison with ISO 31000:2018 activities	Assessment of implementation strengths and gaps

IV. RESULT AND DISCUSSION

4.1. Risk Identification and Assessment Profile

Nineteen risk variables were retained for the project assessment. The list reflects the combined technical and management character of urban river rehabilitation: some risks concern direct construction operations, while others arise from hydrology, incomplete planning data, community exposure, labor performance, or external events. The assessment therefore extends beyond conventional production risk and includes conditions that can affect downstream users and the continuity of urban water management.

The detailed matrix classifies four variables as high risk, thirteen as medium risk, and two as low risk. This distribution indicates that most identified conditions require active management attention even when they are not in the highest priority category. The two low risks are material damage/delay/loss and natural disaster under the specific respondent ratings used in this case, while several technical and logistical variables remain medium because their likelihood-consequence combinations are significant but below the high-risk cells of the project matrix.

Table 2. Severity Index, Risk Score, and priority category for the 19 identified risks

No	Risk Variable	P	I	R	Category
1	Uncertain weather conditions	4	5	20	High
2	Incomplete land-survey, hydrological, and subsurface planning data	3	4	12	High
3	Damage, delay, or loss of materials	2	2	4	Low
4	Damage, delay, or loss of equipment	2	3	6	Medium

No	Risk Variable	P	I	R	Category
5	Materials not conforming to specifications	2	4	8	Medium
6	Difficulty of heavy-equipment access to the project site	4	3	12	Medium
7	Design and technical changes due to adjustment to field conditions	3	3	9	Medium
8	BOQ quantities inconsistent with field conditions	3	2	6	Medium
9	Field measurement data inconsistent with drawings	2	3	6	Medium
10	Low labor productivity	3	4	12	High
11	Low worker awareness of PPE use	3	3	9	Medium
12	Errors in contract-volume estimates	3	3	9	Medium
13	Design changes to suit field conditions	3	3	9	Medium
14	Selection of a poorly performing partner/subcontractor	3	3	9	Medium
15	Geological conditions inconsistent with the plan	4	3	12	Medium
16	Natural disaster	2	2	4	Low
17	Delayed concrete works	2	4	8	Medium
18	Inaccurate work estimates	3	3	9	Medium
19	Downstream drought during temporary flow interruption	4	5	20	High

4.2. High-Risk Priorities

Two variables reach the maximum observed Risk Score of 20: uncertain weather and downstream drought. Weather is rated high because changing rainfall and site conditions directly affect the timing and continuity of river works. The project therefore requires schedules that can respond to forecasts, protection for exposed work, and readiness of equipment and crews when safe work windows are available. In a river corridor, weather can also interact with access conditions, water levels, earthwork stability, and concrete activities, magnifying the consequences of delay.

Downstream drought is also rated P=4 and I=5. The thesis associates this risk with temporary interruption of river flow during closure or plugging activities and reports impacts on downstream livelihoods, including fish-farming activities dependent on river discharge. This finding is important because it links a construction method directly to a social and environmental consequence. The appropriate control therefore cannot be limited to internal schedule management; it must include advance communication, alternative water arrangements, and compensation or other agreed measures when affected users incur losses.

Table 3. Detailed indicators for the four high-risk variables

Risk	SI(P), %	P	SI(I), %	I	R	Category
Uncertain weather conditions	65.71	4	82.26	5	20	High
Incomplete planning data	54.29	3	74.29	4	12	High
Low labor productivity	48.57	3	77.14	4	12	High
Downstream drought	77.14	4	94.29	5	20	High

Incomplete land-survey, hydrological, and subsurface planning data and low labor productivity each receive a Risk Score of 12 and are categorized as high in the source matrix. Incomplete planning information can produce uncertain quantities, design revision, inefficient work sequencing, and repeated technical decisions in the field. Low labor productivity has a direct relationship with duration and can compound weather-related disruption. These findings indicate that preconstruction information quality and workforce performance are as important as physical site hazards in controlling the project schedule.

4.3. Interpretation of Medium Risks

The medium-risk group includes equipment problems, nonconforming materials, difficult heavy-equipment access, design and technical adjustment, BOQ inconsistency, measurement discrepancies, insufficient PPE awareness, estimation errors, subcontractor performance, geological uncertainty, and delayed concrete works. Several of these risks have Risk Scores close to those of the high group. For example, difficult heavy-equipment access and geological inconsistency both have R=12 but remain medium in the project matrix because their likelihood-consequence cells differ from the high-risk combinations. This illustrates why management should retain the full P-I profile and not rank risks only by the product value.

The medium-risk variables are also interconnected. Limited access can delay equipment movement and material supply; inaccurate survey or quantity data can trigger design adjustment and contract changes; geological uncertainty can alter construction methods; and weak PPE compliance can turn routine field activities into safety incidents. Effective controls should therefore be coordinated across engineering, operations, quality, safety, and contract administration rather than assigned as isolated actions.

4.4. Risk-Response Priorities

Stakeholder interviews in the thesis map the identified risks to avoidance, transfer, and reduction responses. The terminology is preserved from the source document, although some described actions function operationally as reduction even when labelled transfer. The most useful managerial value lies in the action itself: assigning a responsible function, changing work planning, obtaining better information, strengthening supervision, or providing protection to affected stakeholders.

Table 4. Priority treatment plan for the four high-risk variables

Priority Risk	Source Response Category	Key Treatment Measures
Uncertain weather conditions	Avoidance	Prepare alternative schedules from weather forecasts; use temporary covers/protection; keep required equipment and resources ready for available work windows.
Incomplete land-survey, hydrological, and subsurface planning data	Transfer	Conduct supplementary surveys and technical investigation with competent specialists; coordinate results with the designer; document and verify field data before decisions.
Low labor productivity	Transfer	Provide targeted training, clearer daily work instructions, performance incentives, and closer supervision of output against the work plan.
Downstream drought during temporary flow interruption	Avoidance	Provide or facilitate alternative water sources; communicate the closure plan in advance; coordinate with downstream users; apply compensation or agreed mitigation when livelihoods are affected.

For other risks, the thesis recommends strengthened site security, routine equipment maintenance and standby mechanics, material inspection and supplier qualification, temporary access improvements, repeated design coordination, remeasurement of quantities, revised field drawings, PPE training and supervision, additional geotechnical expertise, emergency procedures, concrete-method adjustment, and re-evaluation of estimates. Together, these measures show that the risk register should be integrated with schedule control, procurement, quality assurance, safety management, technical review, and stakeholder engagement rather than treated as a stand-alone report.

4.5. ISO 31000:2018 Implementation, Managerial Implications, and Limitations

The thesis reports that the project team had implemented many elements of the ISO 31000:2018 process, including identification, evaluation, treatment, monitoring, review, recording, reporting, and coordination among responsible functions. However, it also concludes that implementation was not yet complete. For practice, the main implication is that risk management should be embedded in routine project control: risks must be updated as field conditions change, treatments must be assigned to accountable personnel, and monitoring results must feed back into engineering and management decisions.

The results also support a stronger risk culture. Urban river projects expose contractors to consequences beyond direct construction performance, particularly where water-flow changes affect adjacent communities. Project managers should therefore treat social and environmental impacts as part of the same decision system as cost, time, quality, and safety. Early communication and documented mitigation are especially important for risks that can transfer project disruption to downstream users.

Several limitations must be considered. First, the study is a single-project case with a small respondent group, so the priority order should not be generalized statistically to other river projects. Second, the source thesis contains internal reporting inconsistencies, including a respondent count of four in one methodological table versus seven responses used in Chapter IV calculations, and differences between its summary statements and detailed risk matrix. This article uses the detailed Chapter IV quantitative tables as the primary basis for reported priorities. Third, response categories are sometimes not conceptually identical to the operational action described; future studies should distinguish contractual risk transfer from practical risk reduction more explicitly. Broader samples and comparative methods such as FMEA, AHP/ANP, or Monte Carlo simulation would improve robustness.

V. CONCLUSION

The Veteran River Rehabilitation and Improvement Project were assessed using a project-specific register of 19 construction risks. Severity Index aggregation, five-point likelihood and consequence ratings, Risk Score, and a probability-consequence matrix produced four high, thirteen medium, and two low-risk variables. The high-risk priorities are uncertain weather conditions (R=20), incomplete land-survey, hydrological, and subsurface planning data (R=12), low labor productivity (R=12), and downstream drought associated with temporary interruption of river flow (R=20).

The recommended controls combine weather-adaptive planning, additional technical investigation, better coordination between field and design teams, productivity improvement, stronger supervision, alternative downstream water arrangements, early communication, and mitigation for affected communities. Medium risks require coordinated treatment across equipment, materials, access, design, quantities, safety, subcontractor management, geology, concrete operations, and estimation. These findings reinforce that risk management in urban river rehabilitation must integrate engineering decisions with project-control and stakeholder responsibilities.

For managerial use, the principal value of the method is transparency: field judgments are converted into a ranked register and linked to explicit actions. The study remains exploratory because of its small, single-project dataset and source-document inconsistencies. Future research should validate the priority structure with larger and more diverse stakeholder samples and compare the results with more advanced risk-analysis methods.

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