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Deciding Financial Problem Solution for a Construction Company using Fault Tree Analysis (FTA) and Fuzzy Analytic Hierarchy Process (Fuzzy AHP)

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ABSTRACT: PT X is a construction company with clients spread among Central Java, West Java, Papua, Kalimantan, and Sulawesi. This company experienced financial problem and with the absence of financial bookkeeping, the financial issue was difficult to trace and each manager and also the owner had different perceptions toward the financial problem. One said that it was caused by bad financial investment decision, many said that it is because client late payment, while the other said that it is due to lack of orders and competition. In other word, this problem is still a perceived financial problem. This research was conducted to find the root cause of perceived financial problem in PT X as well as to find the best solution to solve it. By establishing 2 methods that consisted of fault tree analysis (FTA) and fuzzy analytical hierarchy process (fuzzy AHP), employing the thinking framework of value-focused thinking (VFT), the best solution was decided. FTA was used to identify the root cause of the problem which was bad investment decision. After that, reverse brainstorming was conducted to find all possible solutions. Before jumping into alternative solutions, VFT, a thinking framework, identified that control and simplicity was the value that the owner considered. 3 alternative solutions which were asking to financial consultant, hiring financial analyst, and training current financial manager, then analysed using fuzzy AHP with context suitability, sustainability, time needed, and cost as the criterion, and found out that training current financial manager is the best alternative to be chosen.

KEYWORDS: construction company, fault tree analysis, financial problem, fuzzy AHP, investment decision.

INTRODUCTION

In a global context, 49 nations have a majority Muslim population, with Indonesia having the highest percentage of Muslims at 87.2%, totaling around 209 million individuals [1]. A study forecasted that by 2050, the global Muslim population will reach 2.76 billion, constituting 29.7% of the total population [1]. In Islamic belief, constructing a mosque is considered virtuous, ensuring a place in heaven and continuous rewards, known as *sadaqah jariyah* [2]. In line with that, as of July 2023, Indonesia has 299,644 registered mosques, with the Grand Mosque of Istiqlal in Jakarta being the largest in Southeast Asia, accommodating up to 120,000 worshippers. Due to the abundance of mosques in Indonesia, there are also many mosque renovations and enhancements projects, such as domes constructing or enhancement, mihrabs enhancement, and ceiling interiors enhancement.

Since 1995, PT X has been operating as the reputable gypsum ceiling supplier in Purwokerto, Central Java, Indonesia, renowned for its unique and well-crafted ceilings, motives, carvings, and ornaments. It has diverse client ranging from personal homes, offices, schools, banks, local governments, and housing areas and has maintained a strong market presence [3]. Notably, PT X serves a niche market, catering to customers who prioritize superior quality over price competitiveness. Since 2013, it converted the focus to glass reinforced concrete (GRC) construction and installation as the market evolved. PT X vision is to become one of Indonesia's largest and premier GRC construction and installation company, emphasizing sustainable growth, competency development, human resource enhancement, technological management, and good corporate governance. To achieve this vision, PT X has formulated missions centered on enhancing competitiveness, delivering innovative GRC models, providing exemplary customer service, and investing in human resource training and a conducive work environment.

PERCEIVED FINANCIAL PROBLEM IN PT X

PT X, with clients spread among Central Java, West Java, Papua, Kalimantan, and Sulawesi, has successfully built a strong trust and brand image. However, COVID-19 in 2020 led to severe financial challenges for the company, affecting its ability to meet employee

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payment obligations due to insufficient cash reserves. To address this, the owner borrowed money from both banks and relatives. However, the financial problem persisted beyond the initial outbreak, with recurring instances of inadequate revenue to cover expenses. Notably, the construction industry faces a higher risk of insolvency compared to other sectors [4]. The financial problem was exacerbated by a lack of detailed financial bookkeeping and accounting, resulting in unclear financial records. The recording of income and expenses from April 2023 to September 2023 indicated negative net operating income in August and September 2023, a discrepancy with the company actual good operations during those months. It could be said that the financial records did not accurately reflect the true financial condition due to missing data.

The longstanding financial problem trace back several years, compounded by lack of thorough discussions among the owner and managers. Consequently, diverse perceptions emerged regarding the root cause of the problem. Three stakeholders, which were the owner, Central Java financial manager and West Java manager, perceived that thing related to client payment is the cause. West Java manager also added that client intention toward the mosque building underlies the cause. While the Central Java financial manager argued that the expenses for less urgent thing are the thing that underlies the causes. Unlike others, the marketing manager in Central Java actually believed that the problem is related to orders and competition. This lack of consensus has rendered the problem still perceived and unclear, with no articulated solution as discussions surrounding the problem's nature remain inconclusive. This research aimed to identify the root cause of PT X' perceived financial problem and decide the best solution to solve it.

Table 1. Stakeholder Perceptions

Stakeholder	***Perception Toward the Business Issue***
Owner	"Many payments are delayed, so the finances are not running smoothly."
Central Java Financial Manager	"There are many expenses for less urgent things, and at the same time, incomes hindered because many do not pay. As a result, the finances are disturbed."
Central Java Marketing Manager	"Now, the orders have decreased. In the past, we used to get around 20 projects in a month, but now even getting 5 is rare. Competitors are also emerging."
West Java Manager	"Many face difficulty in collecting payments, and sometimes, people who build mosques do not always have sincere intentions for worship. They may have other motives."

LITERATURE REVIEW

In the construction industry, maintaining sufficient cash is important for successful execution of projects. Implementing financial analysis enables construction companies to manage their funds effectively, identify lucrative investment opportunities, and showcase financial robustness, thereby influencing their operational efficiency and profit margins [5]. Inadequate cash reserves may lead to missed opportunities and increased operational risks, while excess cash may result in missed chances for growth and investment, potentially hindering overall profitability [6]. Construction companies, compared to other business types, frequently encounter financial challenges and are more prone to going out of business. Challenges such as requesting additional funds at the project's outset and underestimating costs towards completion can contribute to financial difficulties, particularly for rapidly growing companies lacking new projects [4]. Company adept at assessing their financial needs can proactively prevent financial crises caused by issues such as payment delays, order changes, profit margin fluctuations, retention conditions, and alterations in supplier credit arrangements [5].

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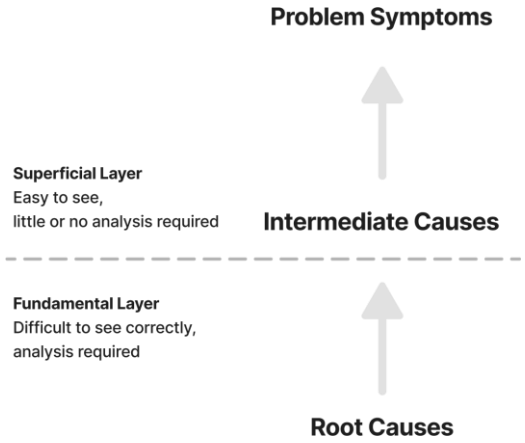

Figure 1. Problem Structure

Every problem inherently possesses a root cause, prompting an investigation that traces backward from the problem symptoms in the superficial layer to identify root causes in fundamental layer. The effectiveness of solutions relying on the ability to address fundamental causes rather than merely covering symptoms. Root cause analysis, particularly through fault tree analysis (FTA), becomes an appropriate method to identify the fundamental causes of complex problems. FTA functions as a detective tool, systematically examining various factors contributing to a problem, investigating how a machine failure or human error leads to a more significant issue. Focused on an "undesired state," the fault tree analysis visually depicts branches representing different ways things can go wrong, with the major problem at the top. The success of this analysis hinges on precisely defining the problem. If the problem is too broad, it may lead to complexity, while if it is too narrow, it might fail to encompass the entire system' picture. FTA, although not a detailed numerical model, provides a general guide to understand the basics of potential problems within a system, emphasizing a qualitative understanding over quantitative details [7].

Real-world decision-making often involves a multitude of factors, some of which may conflict with each other, making it challenging to arrive at a single decision. Multi-criteria decision-making (MCDM) provides a systematic process to aid in choosing the best alternatives by considering numerous factors. Through mathematical and computational techniques, MCDM assists decision-makers in weighing and prioritizing conflicting factors, facilitating a comprehensive decision-making process. This approach proves valuable for solving complex problems, offering decision-makers a structured method to analyze and prioritize alternatives based on various criteria such as cost, time, quality, environmental impact, and others. The analytic hierarchy process (AHP), developed by Thomas L. Saaty in 1980, integrates mathematics and psychology to analyze complex decisions [8]. Comprising the main goal or problem, alternative solutions, and solution criteria assessment, AHP converts these components into numerical values linked to the main goal during MCDM. However, a limitation of AHP lies in its inability to replicate the natural thinking style of humans, as judgment values must be fixed. On the other hand, fuzzy AHP, a fuzzy version of AHP, combines fuzzy set theory and hierarchical structure analysis to address issues related to alternative selection. By incorporating both qualitative and quantitative data, fuzzy AHP allows decision-makers to make interval judgments instead of fixed value judgments, providing a more flexible decision-making approach [9].

In the conventional approach, one considers solution alternatives first and then evaluates them based on goal. This process known as alternative-focused thinking. Keeney proposes an alternative method, called value-focused thinking (VFT) [10]. In VFT, the emphasis is on identifying values first, converting them into objectives, and using these objectives to generate solution alternatives. By clarifying values from the outset, individuals can better discern their importance and, subsequently, make more informed decisions. Unlike alternative-focused thinking, which aims to choose solution alternatives, VFT centers on uncovering opportunities for favorable solution alternatives.

RESEARCH METHODS

Data collection involved interviews, focus group discussions (FGD), and company archives analysis. This study involved 4 stakeholders which were the owner, Central Java financial manager, Central Java marketing manager, and West Java manager.

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Initially, from the problem statement "perceived financial problem in PT X", the intermediate cause and the root cause were identified using FTA. Further, the possible solutions were established using the thinking framework of VFT, by asking questions to the owner as the main decision maker in PT X, like "what do you value?" "what do you think is good or bad about an alternatives?", "what has occurred that was good or bad?", and "what limitations are placed upon you?" to trigger the identification of solution value and objective. The most ideal and most desirable alternative solution came to mind at first. However, achieving ideal conditions may not always be achieved in the reality. Therefore, the objectives compromised to a lower standard to generate other alternative solutions that are more realistic. 3 alternative solutions that were derived from value-focused thinking method were then analyzed using Fuzzy AHP with 4 criterions to decide the best solution.

Table 2. Stakeholder Involved

Stakeholder	***Job Description and Responsibility***
Owner	Control the work of the managers and workers. Make strategic decisions.
Central Java Financial Manager	Do day-to-day business operational and finances in Central Java as instructed by the owner. Handle payment and bank loan.
Central Java Marketing Manager	Handle several projects in Central Java. Create project budget and draw 2D project design.
West Java Manager	Do day-to-day business operational and finances in West Java as instructed by the owner.

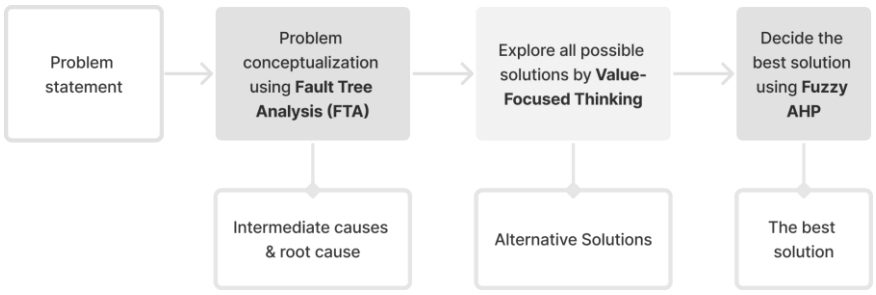

Figure 2. Research Methods

RESULT AND ANALYSIS

The Central Java financial manager, knows a lot about PT X's financial situation, highlighted the issue of high expenses during low revenue, especially in tight financial conditions. He referred this to the owner's decisions on non-day-to-day business operations, particularly investment decisions. The financial manager precepted certain investments as imprudent, emphasizing that substantial investments during financial constraints exacerbate issues if returns are delayed. He also pointed out the accumulation of overdue payments from clients, expressing confusion about effective resolution despite attempts like contract letters. The West Java manager supported this perspective, citing tight financial conditions due to clients' delayed payments, which collectively impact the company's finances significantly.

Following the discussion, the West Java manager elaborated on different client types, noting that some initially well-funded clients face difficulties in settling payments later, often due to personal pride in building a mosque. Others, initially appearing financially limited, maintain communication and fulfill payments responsibly. He emphasized that a client's sense of responsibility and genuine intentions, rather than economic factors, determine payment fulfillment. Contrarily, the marketing manager of Central Java attributed the financial challenge to increased competition. Although competitors offer cheaper products, PT X's strong product quality

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differentiation remains a competitive advantage. The marketing manager mentioned clients shifting to competitors due to lower prices and some canceling deals over design costs.

The owner initially attributed the financial problem to late payments but, upon reviewing fault tree analysis results, reconsidered. Issues such as client commitment, internal disagreements, and design-related problems were acknowledged but not considered root causes. The owner identified bad investment decisions as the primary contributor to the financial problem, acknowledging imprudent decisions and the delayed returns on investments as significant challenges.

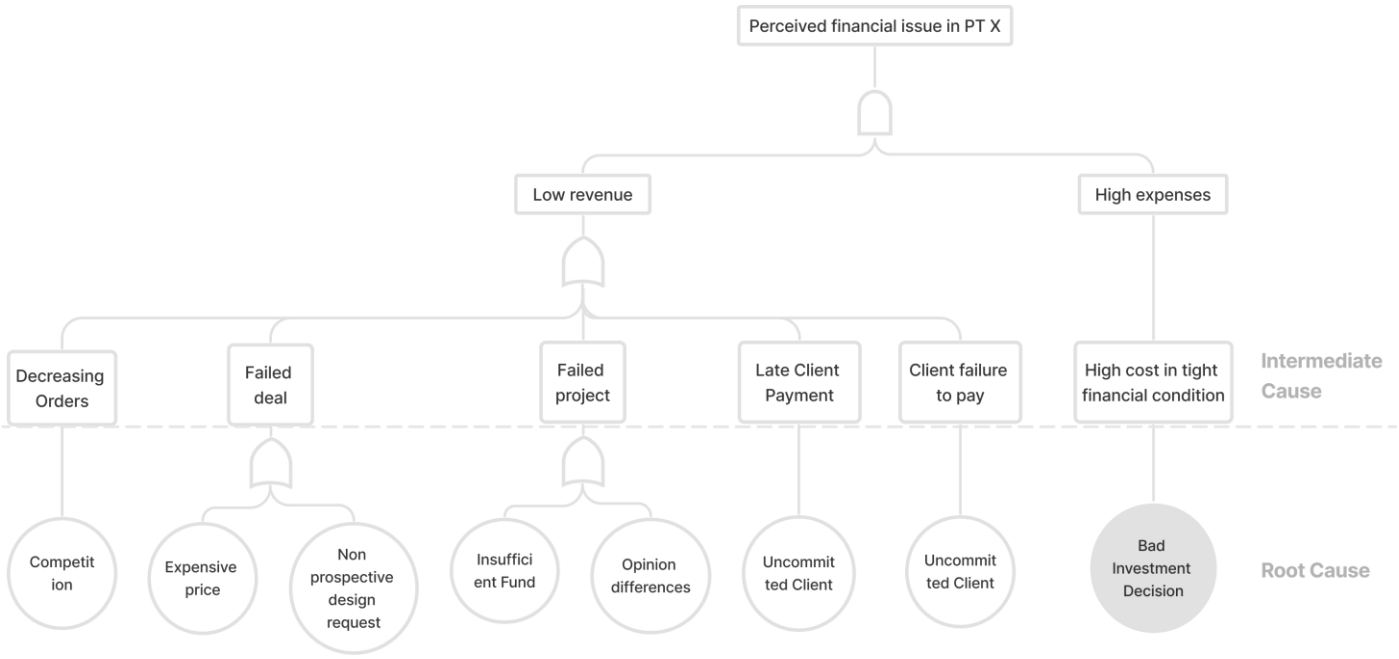

Figure 3. FTA Result

The owner valued control and simplicity. However, delegations were okay as long as to someone competent with reliable result. He wanted to make better decision supported with thorough calculations. He also wanted to retain full control and ideation on the investment ideas. Meanwhile, he did not want to do complex and detailed calculation. 3 alternative solutions derived were asking to financial consultant, hiring financial analyst, and training existing financial manager. Each has their own advantages and disadvantages.

Table 3. Alternative Solutions Comparison

Alternatives	*Description*	*Advantages*	*Disadvantages*
Alternative 1	Ask financial consultant	Reliable and fast result	Price might be expensive. Context might not be suitable. Solution is not sustainable.
Alternative 2	Hire financial analyst	Sustainable and reliable	Costly in the long run. Context might not be suitable. Need time to hire.
Alternative 3	Train existing financial manager	Cheaper, sustainable, and suitable context	Take time to develop capability. Reliability is not guaranteed.

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Table 4. Consistency Ratio

Pairwise Comparison	*Consistency Ratio*	*Note*
Criteria	0.1012	Consistent
Context Suitability	0.0061	Consistent
Sustainability	0.0109	Consistent
Time Needed	0.0061	Consistent
Cost	0.0708	Consistent

The owner set four criterions, which were suitability, sustainability, time needed, and cost. The higher the contextual sustainability and the sustainability, the more preferred it is. On the contrary, the lower the time needed for the solution result to be achieved, and the lower the cost, the more preferred it was. Five pairwise comparison matrixes were made from owner consideration. The consistency test was conducted and resulted that all pairwise comparison consistent because the consistency ratio is equal or smaller than 0.1. The pairwise comparison matrixes then translated into the scale of triangular fuzzy number (TFN).

Table 5. Pairwise Comparison Matrix for Solution Criteria

Solution Criteria	*Context Suitability*			*Sustainability*			*Time Needed*			*Cost*		
Context Suitability	1.00	1.00	1.00	2.00	3.00	4.00	4.00	5.00	6.00	8.00	9.00	10.00
Sustainability	0.25	0.33	0.50	1.00	1.00	1.00	2.00	3.00	4.00	8.00	9.00	10.00
Time Needed	0.17	0.20	0.25	0.25	0.33	0.50	1.00	1.00	1.00	6.00	7.00	8.00
Cost	0.10	0.11	0.13	0.10	0.11	0.13	0.13	0.14	0.17	1.00	1.00	1.00

Table 6. Pairwise Comparison Matrix for Context Suitability

Context Suitability	*Alternative 1*			*Alternative 2*			*Alternative 3*		
Alternative 1	1.00	1.00	1.00	0.25	0.33	0.50	0.13	0.14	0.17
Alternative 2	2.00	3.00	4.00	1.00	1.00	1.00	0.25	0.33	0.50
Alternative 3	6.00	7.00	8.00	2.00	3.00	4.00	1.00	1.00	1.00

Table 7. Pairwise Comparison Matrix for Sustainability

Sustainability	*Alternative 1*			*Alternative 2*			*Alternative 3*		
Alternative 1	1.00	1.00	1.00	0.17	0.20	0.25	0.13	0.14	0.17
Alternative 2	4.00	5.00	6.00	1.00	1.00	1.00	1.00	1.00	1.00
Alternative 3	6.00	7.00	8.00	1.00	1.00	1.00	1.00	1.00	1.00

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Table 8. Pairwise Comparison Matrix for Time Needed

Time Needed	*Alternative 1*			*Alternative 2*			*Alternative 3*		
Alternative 1	1.00	1.00	1.00	6.00	7.00	8.00	2.00	3.00	4.00
Alternative 2	0.13	0.14	0.17	1.00	1.00	1.00	0.25	0.33	0.50
Alternative 3	0.25	0.33	0.50	2.00	3.00	4.00	1.00	1.00	1.00

Table 9. Pairwise Comparison Matrix for Cost

Cost	*Alternative 1*			*Alternative 2*			*Alternative 3*		
Alternative 1	1.00	1.00	1.00	0.10	0.11	0.13	0.25	0.33	0.50
Alternative 2	8.00	9.00	10.00	1.00	1.00	1.00	8.00	9.00	10.00
Alternative 3	2.00	3.00	4.00	0.10	0.11	0.13	1.00	1.00	1.00

Each alternative weights multiplied by each criterion weight and derived result as represented in Table 10. If ranked from the highest, middle, and smallest, the order was alternative 3, alternative 2, and alternative 1 respectively.

Table 10. Normalized Weight for Solution Criterion and Alternative Solutions

Solution Criteria	*Weights*	*Alternative 1*	*Alternative 2*	*Alternative 3*
Context Suitability	0.547	0.090	0.248	0.662
Sustainability	0.284	0.079	0.435	0.486
Time Needed	0.136	0.662	0.090	0.248
Cost	0.033	0.064	0.807	0.129

Table 11. Alternative Solutions Final Score Ranked

Alternative Solutions	*Alternative 1*	*Alternative 2*	*Alternative 3*
Final Score	0.164	0.298	0.538

CONCLUSION

After conducting a fault tree analysis (FTA), bad investment decisions were identified as the root cause among initial causes like client irresponsibility, competition, lack of orders, and others. The owner acknowledged this and alternative solutions were made that align with owner values and objectives. The most ideal solution was asking a financial consultant. Other options included recruiting experienced individuals for sustainable solutions or maximizing the current financial manager's performance through training, though each had drawbacks. Fuzzy Analytic Hierarchy Process (AHP) analysis considered criteria like contextual suitability, sustainability, time, and cost. The ranking favored training the current manager (alternative 3) as the most sustainable and contextually fitting solution, followed by hiring a financial analyst (alternative 2) and asking financial consultant (alternative 1).

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