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Article Review

Policy Guidelines for Managing Variation Orders in Philippine Water and Wastewater Projects Using Analytical Hierarchy Process

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Abstract

This study aimed to identify and analyse the impacts of variation orders on project costs in selected water and wastewater projects in the Philippines using the Analytical Hierarchy Process (AHP). Specifically, the study sought to determine and rank the most critical causes of variation orders and to propose a policy guideline to minimize their impacts on project costs. A mixed-methods approach was employed, involving surveys administered to experts directly involved in water and wastewater projects. Responses were evaluated using the AHP technique, which enabled the prioritization of the identified causes based on their relative influence. The results revealed that design changes, errors and omissions in design, and changes in project scope were the top contributing factors to variation. These causes were found to significantly affect project cost, leading to increased expenditures and potential delays. Consequently, the desire for profit and the ambiguous design from the consultant are driving variation, impacting cost as well. Through the AHP, a pairwise comparison matrix was developed, which established a consistent and structured ranking of these causes based on expert judgment. The study concluded that effective planning to finalize the scope, enhanced stakeholder coordination, and improved design review processes are essential to mitigate the adverse impacts of variation orders on the project cost. A policy guideline was developed to assist agencies in managing and reducing variation-related issues in future projects.

Keywords: *Variation Order, Project Cost, Water and Wastewater Projects*

INTRODUCTION

Variations are common in building projects of all kinds. Ghimire et al. (2023) stress that it is common in construction projects to have variation orders, and these are a helpful indicator or instrument for project success and efficiency. Project Management Institute defines variation orders as the document that covers any increase or decrease in quantities affecting the original contract cost of a specific project due to reasons such as change of plans, change due to alignment in site conditions, and others that are issued by any concerned agency. These alterations cause disagreements between the stakeholders, which impacts the whole project.

Water is essential to all, and with water scarcity due to the evident repercussions of climate change, it is important to ensure that people efficiently handle the construction of water and wastewater projects. Thus, the a necessity to study and identify the various root causes of the changes or variation orders and their impact on public and private companies' water and wastewater projects. Moreover, it will determine the perceptions of key stakeholders towards it and identify existing mitigating practices in the industry. Therefore, guidelines for professionals (stakeholders, companies, and institutions) should be formulated to mitigate the causes of Variation Orders in water and wastewater projects in the Philippines.

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This study seeks to investigate the underlying causes of variation orders in water and wastewater projects in the Philippines, recognizing that such changes constitute a major source of cost escalation and project delays in the construction industry. Specifically, the research aims to identify and analyze the root causes of variation orders and subsequently determine the top five factors that most significantly influence project costs in this sector. To provide a structured and systematic prioritization of these factors, the study employs the Analytical Hierarchy Process (AHP), a multi-criteria decision-making tool well-suited for evaluating complex problems involving numerous interrelated variables. By ranking the most prevalent causes through AHP, the research provides an evidence-based foundation for the formulation of policy guidelines. These guidelines are intended to mitigate the adverse impacts of variation orders on project costs and enhance the overall efficiency of project implementation. The scope of the study is delimited to the cost implications of variation orders, thereby ensuring a focused analysis that directly addresses one of the most critical challenges faced in the management of water and wastewater infrastructure projects in the Philippines.

LITERATURE REVIEW

All forms of construction projects frequently involve variations. Depending on several variables, the type and occurrence of such variations may vary from case to case, depending on the project. Ghimire et al. (2023) emphasize that variation orders are usual in construction projects, and they provide a significant indication or serve as a tool for project efficiency and success. According to PD 1594, or the "Prescribing Policies, Guidelines, Rules, and Regulations for Government Infrastructure Contracts of the Philippines" (Office of the President, 1978), variation orders have many forms; one widely used is a Change Order. Change orders are defined as additional work orders that can only be issued for tasks essential to the project's completion and fall within the broad parameters of the contract as it was bid and awarded.

Awasthi (2023) studied and focused on the variations' root causes and their impacts in the building construction context by studying three hotel buildings under construction in Bharatpur. Their study identified the following major causes of variation orders are the errors and omissions in design, omission, deletion, or addition in the scope of work, client's additional requirements or alterations, and revisions in the design and drawings by the engineer or consultant, which cause delays and an increase in project cost.

Enshassi et al. (2014) discussed that any variations from the agreed scope in the contract result in delay, increased project cost, quality defects, and other unfavorable impacts. Their study found that ambiguity in the contract documents, financial instability of the client, poor coordination among project parties, and utilization of insufficient specifications are among the top ten most significant causes affecting variations in projects in the Gaza Strip.

With the rise of design as a significant cause of variation orders in many types of research, Tedja, B., & Rarasati, A. (2021) studied the impact of starting development during the early designing stage, focusing on the risk of reducing change or variation orders in building construction projects. However, there is no unique technique for properly avoiding or controlling them. To prepare for them, it is common practice to provide a percentage of the project's cost to serve as contingency in the contract budget (Alnuaimi et al., 2010).

Variation Order Management in the Philippines

In the Philippines, variation orders are governed by the Implementing Rules and Regulations of Republic Act No. 9184, generally known as the "Government Procurement Reform Act". This regulation provides a systematic framework for managing variation orders and other facets of procurement process management. The IRR states that variation orders may be granted in some circumstances, such as unforeseen circumstances, design modifications, or the requirement to adjust to fit site conditions (Republic Act No. 9184, 2003).

Recent studies show that although the IRR offers a fundamental guideline for variation orders, real-world application frequently faces difficulties. Ambiguities in the IRR might result in inconsistent application, delays, and disagreements. These ambiguities often stem from undefined key terms, such as what precisely constitutes an "unforeseen circumstance," leading to subjective interpretations and disputes over the validity of a proposed change. Furthermore, the IRR does not mandate specific timelines for each approval step, creating administrative bottlenecks that directly cause significant project delays. The lack of a standardized, detailed format for the required justification also results in inconsistent documentation, where some variation orders are rejected for insufficient data, while similarly vague proposals are approved. This ambiguity in the required supporting evidence forces implementing officers to make judgment calls, which can be later questioned by auditors, fostering a culture of hesitation and potential disagreement among project stakeholders. Ultimately, these procedural gaps collectively undermine the procurement framework's goal of efficiency, often translating into direct cost overruns and schedule extensions for public infrastructure projects.

Additionally, the Department of Public Works and Highways, or DPWH, published Department Order No. 28 in 2015, which offers instructions for handling variation orders in government infrastructure projects. The order specifies the approval procedure for variation orders according to their financial effect and divides them into two categories:

Change Orders and Extra Work Orders impose a cumulative cap on variation orders, typically not exceeding 10% of the original contract cost. They require comprehensive documentation and justification for any changes and ensure that the changes are properly documented and approved by the appropriate DPWH channels.

Challenges in Variation Order Management

Lack of accurate documentation and stakeholder communication are the most common challenges to variation orders in the Philippines. This inadequacy in the documentation may lead to a dispute if the claim is reasonable and outside the original scope and, thus, a variation order.

For a change to be justified, it must be well recorded and assessed for its impact on project costs and timelines. Without comprehensive documentation, it could be difficult for stakeholders to resolve conflicts, leading to delays and increased costs.

Another significant issue is the absence of standardized procedures for handling variation orders across numerous projects. The claim is that the absence of a defined method results in inconsistent processes for processing, authorizing, and executing variation orders. Conflicts and inefficiencies between project participants, contractors, clients, and governmental entities could arise from this disparity. A consistent strategy could shorten procedures and reduce the likelihood of disagreement.

Another important area of concern is financial management. Because extra expenses are required to accommodate changes in project scope, variation orders sometimes result in budget overruns. Nurlaelah (2022) identified that coming from the client’s standpoint, unachievement of project targets can lead to the loss of confidence of consumers and stop the construction in the context of building construction. The delay in processing variation orders worsens financial strain by interfering with cash flow and impairing project performance. Effective financial management techniques are required to lessen these problems and guarantee that projects stay within budget.

Best Practices in Addressing Variation Orders

Recent research suggests a few of the most common methods for handling and reducing the impacts of variation orders. Enhancing documentation and communication is necessary to address these problems. Various researchers assert that a robust documentation system may ensure that each modification is appropriately and logically documented. These techniques reduce conflict and encourage better decision-making by thoroughly recording every variation.

Consistent processes for managing variant orders are also advised. Industries support the creation of precise rules for granting and carrying out variation orders. This might involve establishing defined roles and duties, standardizing templates, and establishing review and approval deadlines. Standardization may improve efficiency and uniformity while lowering stakeholder disputes.

Financial management practices must also be improved. Industries believe that improved forecasting techniques and cost-control measures can help mitigate the financial effects of variation orders. Financial stability requires regular financial evaluations and revised project budgets to account for changes in scope. Projects can remain within budgetary restrictions, and budget overruns can be minimized with effective cost management.

Additionally crucial are stakeholder and project management capacity-building and training. The stress the value of continual education and professional growth to manage variation orders effectively. Workshops on financial management, regulatory updates, and best practices can be incorporated into training programs to assist stakeholders in acquiring the skills they need to manage variation orders more skillfully.

Variation orders involve consultants, contractors, and clients.

Customers are the project's owners and funders. It may be public, private, or governmental. The consultants, not the customer or owner, are responsible for the project's design, management, and oversight. The consultant's function in a project depends on the customer's demands. Contractors are often the ones carrying out a particular project. Within the time, money, and quality constraints specified in the contract, they are responsible for carrying out the design and plans as specified in the on-site scope. These three significant stakeholders influence each project's variation orders, which are essential to the project's implementation.

Over the years, several studies about variation orders have been carried out in many settings, including building construction, road construction, water and wastewater infrastructure construction, residential building construction, etc. The three parties listed—clients, consultants, and contractors—can be held responsible for various issues.

Various programs and circumstances from various nations brought about different perspectives on the underlying reasons for variations. The current study examined the causes and impacts of variation orders from clients, consultants, and contractors on the project success criteria of cost through a literature review that compared several studies by different researchers. An activity or strategy to lessen or prevent the potential impact of the risks that have been identified is known as risk mitigation. The goal of risk mitigation is to lessen the likelihood or effect of losses brought on by risk (Henni et.al, 2022).

Client-related Causes of Variation Orders

Client-related concerns are often the reason for variation orders in construction projects, which can seriously alter the project's initial design and impact its scope, schedule, and price. These issues frequently include changes to the scope of work, whether additions, deletions, or modifications. These kinds of modifications are usually brought about by changing customer goals, changes in their interests, or budgetary limitations that necessitate project modifications. Changes may also be necessary due to poor procurement planning and inefficient resource management, mainly if the original planning was insufficient.

Due to the client's financial limitations, the project may need to be modified in scope or quality. Delays and necessary adjustments may result from poor decision-making and unclear initial scope of work, which can produce misunderstandings and misalignments between the client and the project team. Poor communication between all parties involved could make these issues worse, which would call for modification orders and other difficulties. Unexpected events like inclement weather or unforeseen site issues could cause the project to be disrupted, requiring changes to the initial plan.

Conflicts and disagreements over contracts between project experts may also necessitate variation orders since addressing these problems frequently calls for changes to the project's terms or execution. Corruption among the client's team managers may result in immoral choices that take the project off course. On the other hand, a stubborn client can oppose required adjustments, resulting in further difficulties and holdups. These client-related elements make variation orders a frequent and inevitable part of building projects, significantly affecting their overall performance. (Albasyouni, W, et.al, 2024; Alsohiman, N. K, et.al, 2023; Ghimire, S, et.al, 2023; Dirgantoro, M. R. , et.al, 2024; Muhsen, H. K, et.al, 2022; Saki, R., & Yeom, C., 2022, Koirala, N., et.al, 2021; Alhadithi, W. , et.al, 2021; Mohammad, N. , et.al, 2019; Mashamba, T, et.al, 2023.)

Consultant-related Causes of Variation Orders

Variation orders in construction projects can be caused by various problems, most of which result from poor design and management. Design flaws are a frequent problem, requiring amendments throughout the building process due to inaccuracies in the original designs, which can alter the scope, cost, and timeline. Furthermore, consultants may start design modifications after the project has started for various reasons, such as client demands, missed details, or fresh insights, which call for variation orders to account for these changes.

Another factor that may contribute to variation orders is the consultant's insufficient experience or skill. Consultants who lack the requisite training or expertise may provide unworkable or defective designs, necessitating changes throughout construction. Contract document conflicts, in which several project documentation sections present conflicting information, can lead to misunderstandings and call for clarification through variation orders.

Consultants' slow replies or approvals might cause the project to stall, necessitating revisions to the timeframe and the project's scope to keep it moving forward. Design failure to adhere to building regulations and statutory requirements is another serious problem that may require significant modifications to satisfy safety and legal requirements. Insufficient collaboration amongst all project specialists may lead to misdirected endeavors and misinterpretations, resulting in design modifications and the requirement for variation orders.

Project management flaws on the consultant's part, including inadequate supervision or a failure to foresee difficulties, may force changes and inefficiencies. Construction can also be complicated by vague or ambiguous designs, inconsistencies, and insufficient working drawings from the consultant, resulting in mistakes that must be fixed through variation orders. Lastly, modifications that need formal variation orders may result from value engineering, which is modifying the project design to increase functionality or lower costs.

These consultant-related problems highlight how crucial thorough planning, effective communication, and skilled management are to reducing variation orders and guaranteeing the seamless completion of building projects. (Albasyouni, W, et.al, 2024; Ghimire, S, et.al, 2023; Dirgantoro, M. R. , et.al, 2024; Muhsen, H. K, et.al, 2022; Saki, R., & Yeom, C., 2022, Koirala, N., et.al, 2021)

Contractor-Related Causes of Variation Orders

Contractors frequently claim variation orders in their projects due to various management, supervisory, and communication-related issues. One significant problem is inadequate management of site resources when the Contractor does not correctly distribute workers, equipment, or supplies, resulting in inefficiencies and the need for adjustments. Contractors may need to make modifications that lead to variation orders when there are notable discrepancies between the authorized design and the actual site circumstances.

Poor contractor management and control can result in oversights and errors during construction, requiring revisions to the original design. Contractors occasionally try to boost earnings by proposing adjustments that would benefit them monetarily, even if these changes result in variation orders. Payment delays can impede work and necessitate adjustments to project timetables, whether they originate from clients or the Contractor's operations.

Procurement delays, in which equipment or supplies are not obtained promptly, can cause delays in the construction timeline and necessitate modifications. Additionally crucial are the Contractor's output and craftsmanship; subpar work or poor performance may necessitate repair or revisions, which may result in variation orders. The state and status of the Contractor's finances also matter since unstable finances might interfere with project execution and force adjustments to maintain project viability.

Procurement delays that result in the delayed sourcing of required equipment or supplies can disrupt the building timeline and require changes. Additionally important are the Contractor's output and craftsmanship; if they perform poorly or provide subpar work, it may be necessary to rework or modify the project, resulting in variation orders. Since financial instability can interrupt project execution and require adjustments to maintain the project's sustainability, the Contractor's financial status and position also matter.

Ineffective communication can result in misconceptions and mistakes that must be fixed between the Contractor and other stakeholders, including clients, consultants, and subcontractors. Therefore, the non-involvement of the Contractor in the design phase shall be avoided. Given that their opinions and experience were not considered during the initial design, they can then face unanticipated difficulties during construction that call for modifications.

These contractor-related concerns emphasize the need for efficient resource management, proactive oversight, transparent communication, and early engagement in the design process to reduce variation orders and guarantee project success. (Albasyouni, W, et.al, 2024; Ghimire, S, et.al, 2023; Dirgantoro, M. R. , et.al, 2024; Muhsen, H. K, et.al, 2022; Koirala, N., et.al,2021; Mashamba, T, et.al,2023.)

Contextualizing Variation Orders in Philippine Water and Wastewater Projects

The reviewed literature demonstrates that variation orders are a pervasive issue across different types of construction projects worldwide, with recurring root causes attributed to clients, consultants, and contractors. Studies from diverse contexts consistently identify design errors, scope modifications, inadequate documentation, financial instability, and weak coordination among stakeholders as major drivers of variation orders, leading to cost overruns, delays, and disputes (Enshassi et al., 2014; Awasthi, 2023; Ghimire et al., 2023). While these findings highlight universal challenges, their implications are particularly significant in the Philippine water and wastewater sector, where government infrastructure projects are strictly regulated by PD 1594, RA 9184, and subsequent DPWH orders. Despite these regulatory frameworks, gaps persist in the implementation of variation order management, including inadequate documentation, inconsistent approval processes, and a lack of standardized procedures, which mirror the challenges observed internationally.

Furthermore, water and wastewater projects often involve complex interfaces among multiple stakeholders, clients, consultants, and contractors, making them especially prone to scope changes, design revisions, and site-specific adjustments that necessitate variation orders. The literature thus underscores that the Philippines is not exempt from these global challenges, but the compounded issues of regulatory ambiguities, financial constraints, and technical complexities in the local setting heighten the risks of cost escalation. This synthesis confirms the relevance of examining variation order causes in Philippine water and wastewater projects and highlights the need for structured prioritization methods, such as the Analytical Hierarchy Process (AHP), to rank the most critical factors and inform evidence-based policy guidelines tailored to the Philippine construction industry.

Analytical Hierarchy Process

Saaty T.L. (1970) created the Analytical Hierarchy Process (AHP) as a framework for decision-making. It is well known for its capacity to tackle complex decision-making issues organized and methodical manner. Because it allows complicated issues to be broken down into manageable hierarchies and offers a quantitative way to assess qualitative judgments, the Analytic Hierarchy Process is especially helpful when decision-making involves several criteria, options, and stakeholders (Saaty, 1980). AHP is fundamentally based on pairwise comparisons, in which decision-makers assess criteria and options about one another.

These comparisons usually have three primary levels: the aim at the top, the criteria at the center, and the alternatives at the bottom. The decision-making process is reflected in this hierarchical structure, which begins with general goals and then focuses on particular options, similar to what Amora et.al (2021) and Pedron et.al (2025) have conducted in the context of building construction and road construction, respectively, utilizing the AHP as their statistical tool. Given a particular goal and a set of constraints, some of which might not be immediately expressible as linear inequalities, the AHP is applied (Nugraha S. et al. 2022). AHP is especially appreciated for balancing quantitative data and qualitative insights and for integrating objective and subjective factors into decision-making (Wind & Saaty, 2008).

Although the Analytical Hierarchy Process (AHP) provides a systematic framework for decision-making, it inherently relies on expert judgments in pairwise comparisons, which introduces a degree of subjectivity. To mitigate this limitation, the method incorporates a consistency ratio (CR) test that evaluates the logical coherence of expert inputs, thereby enhancing the validity of the results (Saaty, 1980). A CR value of 0.10 or lower is generally considered acceptable, ensuring that the comparisons are not random but instead reflect rational decision-making. Furthermore, reliability can be strengthened by involving a sufficiently diverse pool of experts, conducting iterative rounds of evaluation, and applying statistical aggregation techniques to minimize individual biases. Together, these mechanisms provide greater confidence in the robustness of the AHP outcomes, balancing its reliance on expert opinion with safeguards for objectivity and methodological rigor.

RESEARCH METHOD

This research will employ a systematic literature review to understand the various root causes of variation orders in construction. This research will gather the common causes in the context of construction. It is then summarized into variations caused or triggered by clients, consultants, and contractors, as collected from the literature review. A panel of experts with more than ten years of experience in the field of water and wastewater projects has prioritized the list. Next, the prioritized list was classified and standardized into a questionnaire, which was answered by the respondents. The respondents were asked to assess the impact of all causes of variation orders relative to the project cost. After that, the responses were analyzed using the Analytical Hierarchy Process, which provides the top causes from the three categories. A policy framework proposal was crafted to address these top causes.

To process the responses, the following steps were conducted:

1. Data Collection and Transformation. The survey responses were collected using a Likert scale, where respondents rated the impact of each variation order cause on project cost using five levels: Very Low Impact (1); Low Impact (2); Moderate Impact (3); High Impact (4); Very High Impact (5).
2. To convert the qualitative survey data into numerical values for AHP processing, each response was assigned a corresponding numerical score. The ratings given by all respondents were then aggregated by averaging the assigned numerical values for each variation order cause:

$$X_i = \frac{\sum R_{ij}}{n}$$

Where:

$$X_i = \text{ is the aggregated score for variation order cause}$$
$$R_{ij} = \text{is the rating given by respondent to cause}$$
$$n = \text{is the total number of respondents}$$

1. Pairwise Comparisons. The foundation of AHP is pairwise comparison, which allows decision-makers to measure the relative significance of each criterion and sub-criterion. To ascertain each set of criteria's relative importance to the study's objective, the researcher will compare them in this stage. Expert responders, including engineers and project managers, offer feedback using a Likert scale according to their project experience and area of expertise. For instance, a higher number (such as 4 or 5) is given to the source of variation if it is thought to have a substantially more significant impact than delays. This phase makes a further understanding of the effects of variation orders possible, guaranteeing that subjective assessments are methodically quantified. To construct the pairwise comparison matrix, the geometric mean of the expert responses was used to aggregate the individual judgments, ensuring a consistent and robust comparison. The resulting matrix was then normalized to obtain the priority weights for each criterion.

$$A = a_{ij}$$

Where:

a_{ij} = *represent how much the other cause is prefered than the other cause*

If $i = j$, *then the value is equal to* 1 *thus the diagonal is expected to be* 1

Table 1. Matrix for Pairwise calculation

Pairwise	C1	C2	C3	C4	C5
C1	C1/C1	C1/C2	C1/C3	C1/C4	C1/C5
C2	C2/C1	C2/C2	C2/C3	C2/C4	C2/C5
C3	C3/C1	C3/C2	C3/C3	C3/C4	C3/C5

Pairwise	C1	C2	C3	C4	C5
C4	C4/C1	C4/C2	C4/C3	C4/C4	C4/C5
C5	C5/C1	C5/C2	C5/C3	C5/C4	C5/C5

2. Synthesizing Priorities. The relative weights of each criterion and sub-criterion are determined when the pairwise comparisons are finished. This procedure derives a priority vector from the comparison matrices, usually by computing the eigenvalues. For example, "C1" would have the highest weight if variation order were considered the most important element. Consistency and comparability between components are ensured by normalizing the weights, representing each criterion's proportional relevance, and adding up to 1. This synthesized data establishes the basis for ranking the effects of variation orders. To achieve this,

$$N_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

$Where$:

$N_{ij} = \ normalized\ value$

$\sum_{i=1}^{n} a_{ij} = sum\ of\ each\ column$

After this, to compute the priority vector or weights,

$$W_i = \frac{\sum_{i=1}^{n} a_{ij}}{n}$$

$Where$:

$W_i = weight\ of\ the\ cause\ i$

$n = is\ the\ number\ of\ causes$

3. Consistency Check. Ensuring that the conclusions drawn from pairwise comparisons are consistent is a crucial component of AHP. The Consistency Ratio or CR is calculated to evaluate the dependability of the comparisons. The judgments are deemed to be acceptably consistent if the CR is less than 0.1. The comparisons must be examined and modified if they are 0.1 or greater. This stage is crucial to preserving the analysis's credibility and reducing biases or mistakes in stakeholder input. It strengthens the methodological soundness of the research utilizing AHP. To do this, derive the weighted sum vector to be multiplied by the original pairwise matrix by the priority vector:

$$AW = A\ x\ W$$

Next, computing the Eigenvalue

$$\lambda_{max}$$

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n}\frac{AW_i}{W_i}$$

Compute the Consistency Index,

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Compute the Consistency Ratio,

$$CR = \frac{CI}{RI}$$

Random Consistency Index depends on the value of n,

Table 2. Random Consistency Index Values

n	1	2	3	4	5
RI	0	0	0.58	0.9	1.12

If CR $<$ 0.10 the matrix is consistent. If CR $>$ 0.10Adjustments are needed.

Using the above data from the actual survey conducted, the following CR values were determined: 0.023, 0.028, and 0.031 from the client-caused, consultant-caused, and contractor-caused variation order, respectively.

4. Aggregating Results. A weighted sum model is used to aggregate the contributions of each criterion and sub-criterion to the overall objective after their weights have been established. This entails multiplying each criterion's weight by the alternative (impacts) scores that go along with it. For instance, if approval process delays are a sub-criterion under "schedule impacts," the overall impact is determined by multiplying the weight by the relevant score. This stage helps stakeholders determine which elements are most important in causing project cost variations by clearly ranking the effects of variation orders.

5. Reliability Check using Cronbach's Alpha Equation. Cronbach's Alpha is crucial to this study since it gauges the survey instrument's internal consistency or dependability, which is utilized to determine how variation order causes affect project costs. Because Likert-scale responses were used to collect the data, it is important to make sure that the items (i.e., the causes of variance ordering that were discovered) reflect the same underlying concept—project cost impact—collectively. The reliability of the survey instrument is suggested by a high Cronbach's Alpha value, which is usually above 0.7 and shows that respondents' assessments for various causes are consistent. By verifying that the input data used to evaluate the causes is consistent and reliable, this lends credibility to the Analytical Hierarchy Process (AHP) outcomes.

$$\propto = \frac{k}{k-1}\left(1 - \frac{\sum \sigma^2 item}{\sigma^2 total}\right)$$

Where:

$k = number\ of\ items$

$\sigma^2 = variance\ for\ each\ column$

$\sigma^2 total = variance\ of\ the\ total\ score\ per\ respondent$

The number of items in the questionnaire is 15. Computing the variance for each column and the variance of the total score per respondent derived is 14.05 and 72.61, respectively. Utilizing the equation above using the derived data from the actual survey conducted, the Cronbach's alpha is 0.86. Interpreting the value from Table 1, the data is good in terms of consistency.

Table 3. Cronbach's Alpha Value Interpretation

Alpha Value	Interpretation
≥ 0.9	Excellent internal consistency
0.8–0.89	Good
0.7–0.79	Acceptable
0.6–0.69	Questionable
< 0.6	Poor

FINDINGS AND DISCUSSION

Through a thorough examination of the literature, the study identified and categorized the underlying causes of variation orders within water and wastewater infrastructure projects in the Philippines. These root causes were classified into three main groups: client-related, consultant-related, and contractor-related factors. Client-related causes included poor procurement planning, financial constraints, delayed decision-making, unanticipated weather conditions, and scope modifications (addition, omission, or alteration). Consultant-related factors encompassed design errors, inconsistencies in contract documents, delayed responses or approvals, non-compliance with regulatory standards, and inadequate interdisciplinary coordination. Contractor-related issues involved weak project supervision, procurement delays, conflicts arising from profit-motivated changes, delayed payments, and insufficient early contractor involvement. These findings were synthesized from more than fifty relevant studies, confirming the recurrent nature of similar causative patterns in prior research. This alignment reinforces that variations are a persistent phenomenon across developing countries, where fragmented project delivery systems and limited integration among stakeholders amplify cost and schedule risks.

To refine and contextualize the literature-based findings, the study employed an expert validation process based on a consensus-ranking matrix similar to a modified Delphi technique. Five industry experts with over ten years of experience in water and wastewater infrastructure projects evaluated the initially derived list of causes, ranking them by their estimated influence on project cost and time impacts. The validation led to a convergence of expert opinions, narrowing the extensive list into five dominant causes per category. This iterative consultation enhanced the robustness of results and ensured that the final rankings reflected current industry realities rather than purely theoretical assertions.

The analysis revealed that, among client-related causes, scope changes, through additions, omissions, or alterations, were the most influential, consistent with findings by Koirala et al. (2021) and Alnuaimi et al. (2010), who observed that such variations stem from evolving client objectives and insufficient project definition. Other frequently cited client-side drivers included inadequate procurement planning and delayed decision-making, both leading to time and cost overruns, as similarly evidenced in studies by Alhilli and Rezoqi (2021). Consultant-related variations, led by delayed responses or approvals and ambiguous design documents, mirror findings in Gaza and Iraq, where insufficient coordination and design clarity were ranked among the top five contributors to variation orders (Enshassi et al., 2010; Alhilli & Rezoqi, 2021). Contractor-related causes such as weak supervision, procurement delays, and profit-motivated change requests were consistent with international trends, though profit-oriented modifications appeared more prevalent in the Philippine context, reflecting contractual opportunism under competitive bidding conditions.

From a management perspective, these findings imply that greater emphasis should be placed on early stakeholder alignment and design coordination to minimize scope creep and rework. Comparative insights suggest that implementing formal change control mechanisms and promoting early contractor involvement can significantly mitigate the recurrence of costly variation orders, echoing recommendations by Alhilli and Rezoqi (2021).

To minimize the effects of variation orders on project cost, this study proposes a strategic approach centered on three key interventions: implementing a formal Change Management Process (CMP), adopting Building Information Modeling (BIM), and applying Lean Construction principles. The CMP should emphasize structured change approval protocols and proactive scope management to control client-initiated variations. BIM, as supported by Alaryan et al. (2020), enhances coordination and reduces design-related inconsistencies. Meanwhile, Lean Construction tools, particularly the Last Planner System (LPS), can address workflow predictability and contractor-side inefficiencies. Integrating these approaches within the Philippine context can bridge the observed gap between policy frameworks and field implementation, strengthening cost governance and ensuring that preventive measures align with globally recognized best practices.

Table 4. Proposed Policy Guidelines to Mitigate Impacts of Variation Orders on Cost of Water and Wastewater Projects in the Philippines

Variation Order Cause to Mitigate	Proposed Measure	KRA and Objective	Activities	Metrics
Variation of the scope of work through "addition", "omission", or "alteration."	Institutionalized Change Management	Structured and Accountable Change Control To reduce the frequency, cost, and delay of variation orders through a	• Establish a Change Control Framework: Implement a formal Change Management Plan (CMP) with clear, time-bound steps for request	• % of variation orders processed through formal CMP • Average duration to approve/reject a variation request

Variation Order Cause to Mitigate	Proposed Measure	KRA and Objective	Activities	Metrics
		formalized, proactive, and transparent Change Management Process (CMP).	initiation, technical and financial evaluation, and approval involving a Change Control Board (CCB), with defined authority limits for different change cost thresholds. • Mandatory Stakeholder Scope Alignment Workshops: Conduct mandatory alignment workshops during project inception to define and freeze scope, minimizing client-driven changes; document final consensus via a signed Scope Charter that serves as the project baseline. • Standardized Variation Order Templates: Mandate the use of standardized digital templates for all change requests, requiring	• Number of variation orders reduced due to early scope alignment • % of stakeholders trained on CMP procedures

Variation Order Cause to Mitigate	Proposed Measure	KRA and Objective	Activities	Metrics
			completed fields for technical justification, detailed cost and schedule impact analysis, and mandatory stakeholder approval signatures. • Training and Awareness Campaigns: Provide mandatory, role-specific CMP training to all project managers, contractors, and consultants, supplemented by awareness campaigns on the financial and schedule impacts of poor change control.	
Ambiguous design, discrepancy, and inadequate working drawings from the consultant	BIM-Enabled Design Coordination and Integration	Minimized Design Conflicts through Digital Collaboration To reduce design-related variation orders by integrating Building Information Modeling to detect conflicts early and	• Mandatory Use of BIM for All Projects Over Defined Thresholds: Require BIM application integrated with AI-based design validation and digital twin technology for clash detection and construction	• Number of design-related variation orders per project • % of clashes resolved pre-construction through BIM • Time saved through coordinated design reviews

Variation Order Cause to Mitigate	Proposed Measure	KRA and Objective	Activities	Metrics
		enhance stakeholder collaboration.	sequencing, using geospatial and site data for all projects over a threshold. • Conduct Clash Detection Reviews: Utilize BIM and AI algorithms to perform automated clash detection and constructability simulations, ensuring all inter-disciplinary conflicts are resolved before construction begins. • Develop a BIM Execution Plan (BEP): Each project must submit a detailed BEP outlining modeling protocols, Level of Development (LOD), stakeholder responsibilities, data exchange standards, and file coordination methods. • Facilitate BIM-Based Design Sign-Offs:	• Stakeholder satisfaction index with BIM deliverables

Variation Order Cause to Mitigate	Proposed Measure	KRA and Objective	Activities	Metrics
			All stakeholders must review and formally approve the federated 3D models and associated data sets in a coordinated digital review before procurement and construction commence.	
Desire for profit	Lean Construction Implementation for Workflow Efficiency	Improved Planning Reliability and Execution Predictability To minimize construction-phase variation orders by adopting Lean Construction practices that improve scheduling accuracy and resource utilization.	• Adopt the Last Planner System (LPS): Implement a full LPS cycle, including pull planning sessions, weekly look-ahead planning to identify constraints, and daily coordination meetings across all project teams. • Track Percent Plan Complete (PPC): Consistently monitor PPC metrics to quantitatively evaluate planning reliability, identify recurring workflow issues, and trigger root	• Weekly and monthly PPC improvement rate • Number of variation orders due to poor scheduling or sequencing • Frequency of missed tasks and top 3 root causes • Time saved from reduced rework or workflow clashes

Variation Order Cause to Mitigate	Proposed Measure	KRA and Objective	Activities	Metrics
			cause analysis for any performance deviations. • Root Cause Analysis of Missed Tasks: Conduct regular weekly reflection meetings specifically dedicated to analyzing the root causes of missed tasks and implementing immediate, actionable corrective measures. • Continuous Improvement via Lean Cycles: Apply iterative Plan-Do-Check-Act (PDCA) cycles based on PPC data and reflection meeting outputs for the constant refinement of all planning and execution processes.	

CONCLUSION

Factors related to the client or owner, consultants, and main contractors are the primary sources of variation orders in water and wastewater projects in the Philippines. The most common problem that interferes with project planning, procurement, and execution is the scope of work fluctuation. This finding underscores the systemic challenge of maintaining scope discipline within multi-stakeholder public projects, where evolving client priorities and administrative bottlenecks often disrupt planned workflows. Understanding these interrelationships provides a foundation for improving institutional project governance and aligning technical decisions with fiscal accountability.

Expert validation determined that the top five causes were poor procurement planning, delayed consultant approvals, inadequate project supervision, client budgetary constraints, and work scope variations. These factors create a cascading effect, where delays in approvals stall progress, while scope changes and budgetary issues directly necessitate contractual modifications and financial reassessments. These elements were graded according to how they affected project costs. The pattern reflects not only operational inefficiencies but also gaps in decision coordination across implementing agencies, suggesting the need for stronger integration of planning and design functions to prevent reactive cost adjustments during construction.

According to an analytical hierarchy process (AHP) analysis, variation in the scope of work through omission or addition is the most common reason for variation orders. Other major culprits include delays in consultant approvals, inadequate contractor oversight, budgetary limitations, and inadequate procurement planning. This AHP-based ranking provides a clear, evidence-based hierarchy of the most critical areas requiring management intervention to control cost escalation. The quantitative hierarchy reinforces the qualitative expert insights, highlighting that most root causes are preventable through improved front-end definition and decision-making efficiency. In this context, the AHP results serve as an empirical guide for prioritizing resource allocation and policy attention toward areas with the highest impact potential.

A policy framework was created to emphasize early scope definition, better financial and procurement planning, and expedited consultant approvals to reduce the adverse effects of variation orders. Improved project supervision and early contractor participation in design can also help reduce delays and cost overruns. Each of these measures directly stems from the AHP-derived priority areas: scope definition addresses client-initiated variations; strengthened procurement and financial planning mitigate cost and cash flow risks; and faster consultant approvals respond to design-related delays. Meanwhile, enhanced supervision and early contractor involvement operationalize solutions for contractor-related inefficiencies. This alignment ensures that the proposed framework is both data-driven and practically grounded in the study’s analytical outcomes.

Overall, the findings contribute to strengthening the project management discipline in Philippine water and wastewater infrastructure by offering a structured decision-support model for variation order control. Beyond their immediate application, these insights can inform national infrastructure policies, institutional training, and procurement reforms aimed at enhancing project predictability. Future studies may build on this framework by integrating digital tools such as BIM-enabled change management systems to further improve transparency, accountability, and cost performance in public sector construction.

LIMITATIONS AND FURTHER RESEARCH

Although this study provides valuable insights into the predominant causes and impacts of variation orders in water and wastewater projects, it is not without limitations. The analysis was constrained by the sample size of industry experts and the focus on selected case studies within the Philippine context, which may limit the generalizability of the findings to other infrastructure sectors or geographic regions. Additionally, the study relied primarily on expert judgment and literature-based synthesis; hence, potential biases in perception and data interpretation could influence the prioritization outcomes. Future research should address these limitations by incorporating larger datasets, multi-sectoral perspectives, and longitudinal project data to validate and expand the analytical results.

To create more focused mitigation techniques, further investigation into the underlying causes of variation orders should be deepened within the water and wastewater sector. This specialized expertise can then serve as a model to be expanded and applied to other infrastructure industries. Likewise, future research should explore the effects of early contractor involvement in the design phase of water and wastewater systems to identify best practices that can be adapted for other complex government-funded infrastructure projects.

Moreover, examining how well current financial management and procurement planning procedures are suited to reducing variation orders could offer a framework for improving resource allocation and cost control across the public sector.

In parallel, future studies should assess how digital technologies such as artificial intelligence (AI), Building Information Modeling (BIM), and digital twins may help mitigate design inconsistencies and document conflicts, enhancing interdisciplinary collaboration and reducing the frequency of variation orders. Collectively, these directions can advance the theoretical understanding and practical management of variation orders while reinforcing the applicability of this study's framework beyond the water and wastewater domain.

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