

Benchmarking Construction Quality in Cagayan De Oro City: Maturity Assessment and Overcoming Barriers to Adoption

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Abstract

Benchmarking is a recognized driver of continuous improvement in construction project performance. This study evaluated project management maturity and benchmarking readiness of public-sector agencies in Cagayan de Oro City, Philippines through a structured survey of engineers and architects from local government institutions. Data were validated in IBM SPSS Statistics using KMO, Bartlett's Test, and Cronbach's alpha. Maturity was assessed across nine PMBOK knowledge areas, while stakeholders' perceptions of benchmarking were quantified using Likert-scale ratings. Expert judgments were processed through pairwise comparison and the Fuzzy Analytic Hierarchy Process (FAHP) to account for uncertainty in final rankings. Results indicate moderately high maturity in project and quality management, with 55%-66% of practices rated at Level 4-5. Scope, cost, integration, and quality management showed the highest maturity, while risk and time management were comparatively lower. Stakeholders also expressed a favorable perception of benchmarking, with Relative Importance Index values ranging from 0.788-0.817 across key performance indicators. Despite this positive outlook, benchmarking remains weakly institutionalized as a standard practice. FAHP identified technological and systemic constraints as the most critical barriers, led by the high cost of digital tools (0.276), lack of real-time data systems (0.210), and absence of standardized performance measures across agencies (0.127). The top strategies emphasize strong leadership commitment (0.240), capacity-building initiatives (0.197), and technical training in digital benchmarking systems (0.129). Future studies may include private-sector projects and integrate longitudinal data and digital performance analytics to strengthen implementation readiness and track changes across multiple project cycles.

Keywords: Benchmarking, Construction Quality Management, Project Management Maturity

1. INTRODUCTION

The local government of Cagayan de Oro City is committed to enhancing infrastructure to support community development and improve the quality of life for its residents. Each year, millions of pesos are allocated for infrastructure projects. However, with the rising cost of service delivery and increasing expectations from government funding models, there is a pressing need to establish an effective framework to meet the growing demand for improved public services and infrastructure [1]. While established quality

management frameworks like Total Quality Management (TQM) have significantly transformed industries in developed countries, adapting these models to emerging markets poses unique challenges. In many cases, local councils prioritize regulatory compliance over performance, which often leads to issues in project planning and implementation such as budget overruns, quality defects, scheduling delays, and operational inefficiencies.

One powerful yet underutilized tool in this context is benchmarking, which enables organizations to assess their performance against industry standards and identify areas for improvement [2, 3]. Despite its potential, the practice has not been fully embraced within the local construction sector. To understand and advance quality practices, this study incorporates the Project Management Maturity Model (PMMM) and Key Performance Indicators (KPIs) as central evaluation tools. The PMMM provides a structured framework for assessing the maturity level of project management processes across key knowledge areas, helping determine how systematically quality practices are applied in local government construction projects [15, 18].

Meanwhile, KPIs serve as quantifiable metrics such as cost predictability, defect rates, schedule adherence, and client satisfaction that allow for performance tracking and benchmarking comparisons [4, 5]. Together, these tools offer a data driven approach to identifying performance gaps, evaluating stakeholder perceptions, and crafting practical strategies to institutionalize benchmarking. This study seeks to investigate the barriers to fostering a quality culture through benchmarking and to recommend strategic interventions for enhancing performance in the Cagayan de Oro City construction sector. By applying maturity modeling and performance indicators, the research aims to offer evidence-based solutions that support a more efficient, accountable, and quality driven future for local infrastructure development [1].

Benchmarking is an established strategy for enhancing quality management by identifying best practices and promoting continuous improvement [2, 7]. In the construction sector, it allows firms to evaluate their performance against industry standards and adopt strategies that boost efficiency, reduce waste, and improve overall quality. Research shows that construction companies that implement benchmarking frameworks tend to achieve better project delivery, increased cost efficiency, and higher client satisfaction. However, successful benchmarking requires a supportive organizational culture, effective data collection mechanisms, and strong management commitment. Unfortunately, these elements are often lacking in many developing economies [6, 1].

Despite its global adoption, benchmarking in Cagayan de Oro City faces several limitations. A primary challenge is the lack of awareness and understanding of benchmarking principles among construction professionals. Many firms regard benchmarking as a complex and resource-intensive process that requires extensive data collection and analysis, which leads to reluctance in adopting it. Additionally, the absence of standardized performance metrics in the local construction industry makes it difficult to establish meaningful comparisons with industry leaders [8, 5]. Furthermore, the lack of technical expertise and limited access to training further impede the effective utilization of benchmarking tools [9].

Resistance to change within construction organizations poses a significant challenge. Many firms in Cagayan de Oro City operate under traditional management structures that prioritize cost and time over quality. As a result, the prevailing mindset among contractors and project managers often emphasizes immediate project completion rather than long term quality improvement. This resistance is further reinforced by the competitive nature of the industry, where firms are hesitant to share performance data due to concerns over confidentiality and maintaining a competitive edge. Without a collaborative approach

to benchmarking, individual firms find it difficult to fully realize the benefits [3, 7].

Financial constraints significantly hinder the implementation of benchmarking in the construction industry. Many small and medium-sized construction firms do not have the financial resources to invest in benchmarking initiatives, such as hiring consultants, adopting digital tools, or conducting thorough performance assessments [6]. The costs related to data collection, training, and system upgrades often lead these firms to prioritize other operational expenses over benchmarking [10]. Additionally, the absence of government incentives and regulatory support for benchmarking further discourages firms from investing in quality improvement measures.

The lack of regulatory enforcement and standardized quality management practices in Cagayan de Oro City hinders the adoption of benchmarking. Although existing regulations focus on construction safety and compliance, they do not prioritize continuous improvement through benchmarking. In contrast to developed economies, where government agencies and industry associations actively promote benchmarking initiatives, the local construction sector lacks structured programs to encourage firms to implement best practices. This regulatory gap leads to inconsistencies in quality management approaches among different firms, making it challenging to establish a unified benchmarking framework [11, 1].

To address these challenges, a strategic approach is required to integrate benchmarking into the quality management systems of the local construction industry. One effective strategy is to improve awareness and training programs focused on the principles and applications of benchmarking. Industry associations, academic institutions, and government agencies can play a key role in educating construction professionals about the benefits of benchmarking and offering practical guidance for its implementation [9]. By fostering a culture of continuous learning, firms can build the expertise necessary to adopt and maintain effective benchmarking practices.

Collaboration among construction firms is essential for effective benchmarking implementation. Establishing industry-wide benchmarking networks can facilitate data sharing, allow for performance comparisons, and promote the dissemination of best practices. Creating a centralized benchmarking database, managed by industry stakeholders, can help firms' access relevant data while maintaining competitive integrity [3, 8]. Additionally, partnering with international benchmarking organizations can provide local firms with insights into global best practices and innovative quality management strategies [2].

Financial support and policy interventions can effectively promote the adoption of benchmarking. Government initiatives, such as tax incentives, subsidies, and grants for companies that implement benchmarking, can help alleviate costs. Regulatory bodies can also require quality performance reporting and participation in benchmarking as part of construction licensing requirements [1, 3]. By incorporating benchmarking into regulatory frameworks, policymakers can establish quality management as a standard practice throughout the industry.

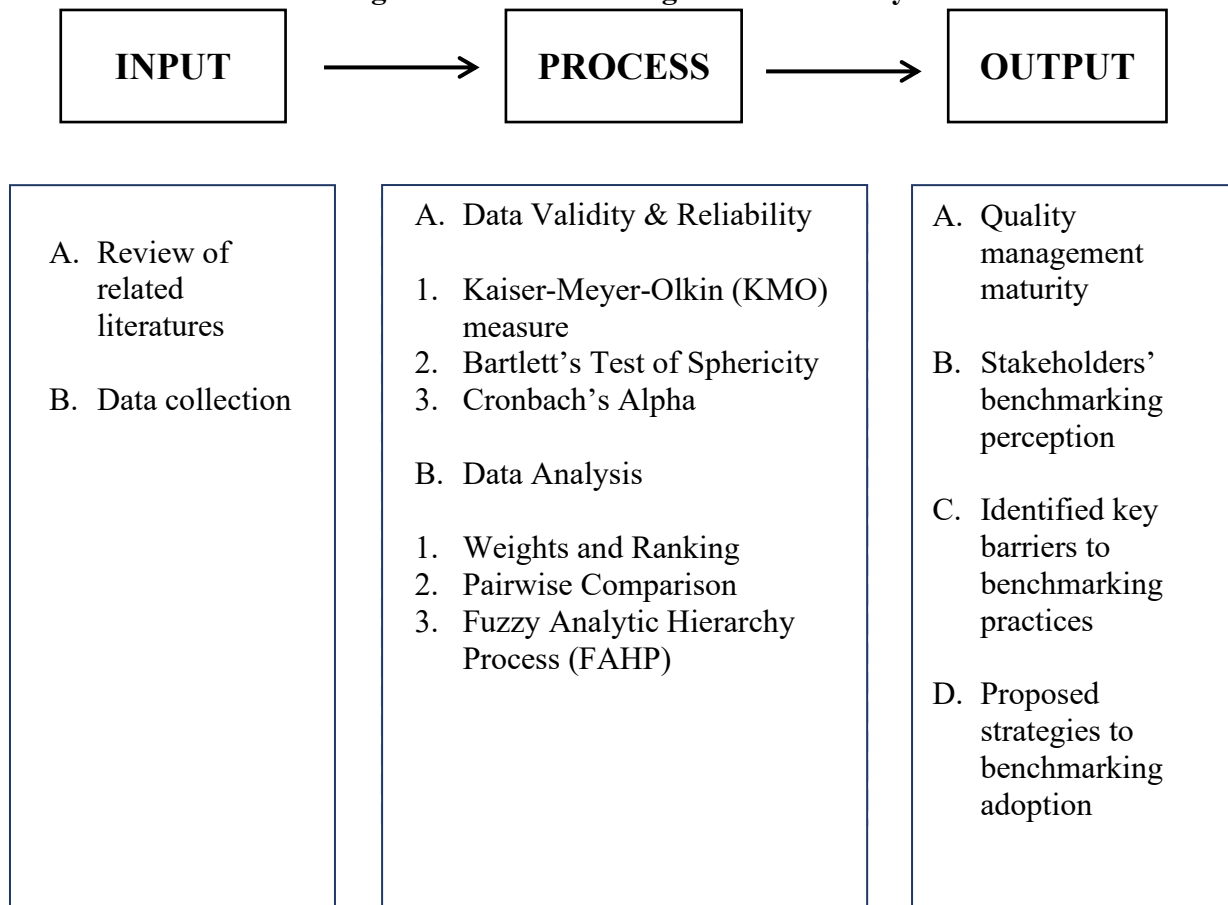
In conclusion, benchmarking presents a valuable opportunity to improve the quality management of construction in Cagayan de Oro City. However, several barriers must be overcome for successful implementation. By raising awareness, promoting collaboration, and offering financial and regulatory support, stakeholders can create an environment that fosters the adoption of benchmarking [7, 1]. The purpose of this study is to assess the current quality management maturity of the Local Government, particularly in the City of Cagayan de Oro, and to identify their perception of benchmarking, its barriers and strategies in adopting best practices. Data was collected and analyzed in the context of the local government.

1.1 Conceptual Framework

This study examines the current maturity of quality management in the local construction industry, adoption barriers and strategies to its integration that is involved in implementing benchmarking, using the Input-Process-Output (IPO) Model. In the input phase, we review literatures related to the research study. Particularly, studies based on Project Management Maturity Model and Key Performance Indicators (KPIs) was used in the formation of the survey questionnaire. Data collection was conducted through a structured survey distributed to government stakeholders. Respondents assessed the current level of quality management maturity in their organization based on predefined criteria.

The process phase employs a quantitative research approach to measure maturity levels using the Project Management Maturity Model (PMMM) and involves analyzing the survey results. Finally, the output phase presents the construction quality management maturity level, identifies key barriers and industry specific challenges, and offers practical strategies to improve benchmarking implementation.

Figure 1 Schematic Diagram of the Study



1.2 Statement of the Problem

The construction industry in Cagayan de Oro City faces significant challenges in fostering a strong culture of construction quality, primarily due to the limited adoption of benchmarking practices. While benchmarking is recognized globally as an effective tool for improving quality management, its implementation at the local level remains minimal. This is largely attributed to the lack of research studies contextualizing benchmarking within the Philippine setting, particularly in Cagayan de Oro City. Compounding this issue is the absence of a prescribed benchmarking framework mandated by the National

Government for adoption at the Local Government level, leaving local stakeholders without clear guidance or standards [2, 7].

Benchmarking is a strategic approach used by organizations to compare their processes and performance metrics to industry best practices, with the aim of identifying gaps and improving overall efficiency and quality [3]. In the context of construction, benchmarking enables firms and agencies to assess performance against recognized standards, learn from leading practices, and drive continuous improvement in areas such as project delivery, cost control, safety, and customer satisfaction [7, 12]. Despite its potential benefits, the adoption of benchmarking in the Philippine public sector, especially in local government units, remains underdeveloped. The absence of standardized performance metrics and minimal industry wide collaboration continue to restrict the potential of benchmarking to support continuous improvement. Additionally, the crucial role of governance is often overlooked, despite its importance in ensuring effective service delivery and accountability in government supported construction efforts [20, 1]. Without benchmarking, local construction projects risk inefficiencies, cost overruns, delays, and quality shortcomings.

This study aims to explore the implications of these gaps in benchmarking practices and governance, and to identify strategies for integrating benchmarking more effectively into local quality management systems. It assessed the impact of the absence of structured frameworks and propose actionable solutions for fostering a culture of quality within the Cagayan de Oro City construction industry. Through this research, the study contributed to improving construction quality, operational efficiency, and long-term sustainability in the local context, while also offering a foundation for the development of localized benchmarking frameworks relevant to other Philippine cities.

1.3 Research Questions

Despite the potential benefits of benchmarking for improving construction quality and efficiency, its integration into the government-led construction sector of Cagayan de Oro City has encountered several challenges. These challenges include a lack of standardized practices, limited awareness, and institutional resistance. This study aims to examine the current state of benchmarking the construction industry in the city, identifying the barriers to its adoption. Additionally, it investigated strategies to facilitate the integration of benchmarking into quality management processes, optimizing project outcomes and resource utilization.

1. What is the current maturity of benchmarking quality management of construction industry in Cagayan de Oro City using PMBOK4?
2. What is the extent of government stakeholders' perception in Cagayan de Oro City on benchmarking quality management within their organization?
3. What are the ten (10) key barriers to implementing benchmarking in the government sector of Cagayan de Oro City construction industry?
4. What strategies can be devised to address the barriers and incorporate benchmarking into government sector construction projects in Cagayan de Oro City?

1.4 Research Objectives

This study aims to evaluate the maturity level of benchmarking implementation in quality management within the Cagayan de Oro City's construction industry. The research identified key barriers to the adoption of benchmarking and analyze government stakeholders' perceptions of its value and feasibility.

Based on these findings, the study proposed strategies to overcome these barriers and enhance the integration of benchmarking, ultimately optimizing project outcomes and resource

1. To assess the current maturity level of benchmarking in quality management within the construction industry of Cagayan de Oro City using PMBOK4.
2. To evaluate the extent of government stakeholders' perception regarding the integration of benchmarking into their organizational practices related to construction quality management in Cagayan de Oro City using Likert Scale rating.
3. To identify ten (10) key barriers to implementing benchmarking practices in the government sector of the construction industry in Cagayan de Oro City using fuzzy analytic hierarchy process.
4. To propose strategies for overcoming the challenges and successfully incorporating benchmarking practices into government sector construction projects in Cagayan de Oro City using fuzzy analytic hierarchy process.

1.5 Definition of Terms

Benchmarking - The process of comparing an organization's performance, processes, and practices against industry leaders or best practices to identify areas for improvement and enhance competitiveness.

Building Information Modeling (BIM) - A digital representation of a construction project's physical and functional characteristics, used to enhance collaboration, improve decision making, and optimize project performance throughout its lifecycle.

Government Stakeholders - Public sector entities, including regulatory bodies, policymakers, and government agencies, that influence, oversee, or implement policies and regulations affecting construction quality and benchmarking initiatives.

ISO 9001 - An internationally recognized standard for quality management systems (QMS) that provides a framework for organizations to ensure consistent quality, customer satisfaction, and regulatory compliance.

Key Performance Indicators (KPIs) - Measurable values used to assess the efficiency and effectiveness of an organization's performance in achieving specific objectives. In construction, KPIs often include defect rates, project completion times, and safety compliance.

Maturity Level - Represents an organization's readiness and effectiveness in achieving its quality related goals. A maturity model helps assess current levels and identify strategies for improvement.

Project Management Maturity Model (PMMM) - A framework used to assess and improve the maturity of an organization's project management practices. It consists of progressive levels that guide organizations from basic, unstructured project management to optimized, standardized processes.

Quality Management Systems (QMS) - A structured framework of policies, procedures, and processes designed to ensure consistent quality and compliance with industry standards. QMS helps organizations manage and improve their quality performance effectively.

Small and Medium Enterprises (SMEs) - Businesses that fall within a certain size category based on revenue, assets, or employee count.

Total Quality Management (TQM) - A management approach focused on long-term success through customer satisfaction, continuous improvement, and employee involvement. TQM emphasizes the integration of quality principles into all business operations.

1.6 Significance of the Study

This study is significant as it addresses a critical gap in the construction industry of Cagayan de Oro City, particularly the limited application of benchmarking practices in quality management within government construction projects. The lack of localized research, structured benchmarking frameworks, and institutional support has limited its adoption among government agencies in the city. The primary beneficiaries of this research are government agencies in Cagayan de Oro City that are involved in planning, implementing, and supervising public infrastructure projects. By examining the current level of benchmarking maturity and its integration into public sector construction, the study provides valuable insights that can support these agencies in improving project quality, performance monitoring, and decision-making processes.

Benchmarking, when applied effectively, serves as a tool for continuous improvement by enabling organizations to assess performance, adopt best practices, and establish measurable standards. This study contributes to both academic and professional knowledge by situating benchmarking practices within the Philippine public construction context, thereby addressing a long-standing knowledge gap.

Beyond its academic contribution, the study offers practical benefits for local government agencies, policymakers, and public sector practitioners in Cagayan de Oro City. By identifying barriers to benchmarking adoption and proposing actionable strategies, the research provides a basis for developing policies and management approaches that promote higher construction quality, efficiency, and accountability in government projects. It emphasizes the role of governance in strengthening transparency, leadership, and accountability in public infrastructure delivery.

The findings may serve as a reference for government offices seeking to institutionalize benchmarking as part of their quality management systems, leading to more sustainable, cost effective, and timely project outcomes. Overall, the study aims to foster a stronger culture of quality and performance excellence among government agencies in Cagayan de Oro City through structured benchmarking practices.

1.7 Scope and Delimitation of the Study

This study focused exclusively on government stakeholders in Cagayan de Oro City, examining construction projects implemented by key public institutions, namely the Department of Public Works and Highways (DPWH) in the region, the City Engineer's Office representing the local government units (LGUs), and the University of Science and Technology of Southern Philippines (USTP), which represents government academic institutions involved in construction project planning and implementation. The research assessed benchmarking practices in construction quality management within these government led projects.

Data collection relied primarily on survey instruments and statistical analysis to generate quantitative insights into the maturity of benchmarking practices, as well as the barriers and strategies associated with their adoption. Stratified random sampling was employed to ensure proportional representation across different organizational levels. To enhance the reliability and credibility of the data, respondents were required to have a minimum of five (5) years of experience. A minimum sample size of 100 participants were targeted. In addition, the Delphi method was integrated into the research design to obtain structured expert input while maintaining respondent anonymity, to minimize bias and ensuring independent judgment, particularly in validating benchmarking maturity expectations.

Survey questions were systematically structured around the PMBOK 4th Edition Knowledge Areas and relevant Key Performance Indicators (KPIs) in construction quality management to ensure clarity,

consistency, and alignment with established project management standards. The questionnaire assessed respondents' awareness of benchmarking, the extent of its application, perceived barriers to adoption, and potential strategies for integration within their organizations. To reduce respondent burden and improve response rates, the survey was limited to fewer than 50 questions.

Despite its methodological strengths, the study is limited to government-initiated construction projects and does not include private sector participants. Participation in the survey was voluntary, and the researcher had limited control over respondent selection, which may affect the completeness and representativeness of the dataset. Furthermore, the findings were context specific to Cagayan de Oro City and may not be fully generalizable to other geographic or institutional settings.

2. Review of Related Literature

Benchmarking has become an essential tool for improving quality management practices across various industries. It provides a systematic process for organizations to compare their performance with industry leaders and identify areas for improvement [3, 2]. This process is vital for fostering continuous improvement, enhancing efficiency, and promoting competitiveness. In the construction sector, which involves multiple stakeholders and complex operations, benchmarking offers a structured approach to addressing inefficiencies and optimizing outcomes [7, 5].

The construction industry is highly dynamic, with numerous external and internal factors influencing project performance. Factors such as regulatory policies, workforce competency, and technological advancements impact the culture of construction quality [6, 7]. Benchmarking allows companies to analyze best practices from leading firms and integrate them into their operational framework [13, 9]. This is especially relevant in developing economies, where construction standards and quality management systems can vary significantly across regions [1, 3].

However, implementing benchmarking is not without its challenges. Many construction firms encounter barriers such as limited awareness, resistance to change, and insufficient availability of data. Despite these obstacles, research indicates that structured benchmarking practices can lead to improvements in productivity, cost management, and safety performance. Numerous studies emphasize the importance of collaboration between government and industry in facilitating the adoption of benchmarking through policy support and training initiatives.

This review examines existing literature to understand the barriers to and strategies for implementing benchmarking, focusing specifically on its potential application in the construction industry of Cagayan de Oro City. By exploring both international and local studies, this section aims to provide insights into how benchmarking can enhance the construction quality culture in the region. The following sections discuss construction quality culture in the Philippines, the competencies of government stakeholders, benchmarking construction quality culture, the barriers to benchmarking, and strategies for enhancing the adoption of benchmarking.

2.1 Construction Quality Management in the Philippines

Construction quality management in the Philippines is crucial to national development but is hindered by inconsistent standards, limited technology use, and uneven workforce skills. Disparities between large urban projects and smaller regional ones reflect gaps in quality control and adherence to best practices. At the same time, government agencies responsible for oversight face challenges in technical capacity, coordination, and enforcement. Addressing these issues requires strengthening industry practices and

improving the competencies of regulatory bodies to ensure reliable and consistent construction outcomes across the country.

2.1.1 Quality Management

The Philippine construction industry is a significant driver of economic growth, contributing to infrastructure development, job creation, and urban expansion. However, challenges persist in maintaining high quality standards due to inconsistent quality control measures, inefficient project management systems, and regulatory gaps. Variations in adherence to best practices and a lack of standardized procedures across regions contribute to delays, budget overruns, and substandard outcomes. To address these issues, industry stakeholders such as contractors, project managers, and policymakers recognize the need for systematic quality improvement strategies like benchmarking [2, 7].

The construction quality management in the Philippines is influenced by workforce skills, technology adoption, and regulatory frameworks. A major challenge is the widespread shortage of skilled labor, as many workers lack formal training in quality assurance methodologies. Additionally, Philippine-based studies note that BIM and related digital tools are still at an early stage of adoption in the local AEC industry, with low awareness and limited organizational readiness in many firms [21]. While large scale projects in metropolitan areas implement advanced quality management techniques, smaller firms in provincial areas like Cagayan de Oro face resource constraints that hinder quality focused practices. [10, 14]

Government intervention is crucial in shaping the construction quality culture. Various agencies enforce quality standards and safety regulations, but inconsistent implementation and weak enforcement mechanisms create compliance gaps. Corruption and bureaucratic inefficiencies further impede strict adherence to quality guidelines. To combat these issues, the government has introduced reforms such as enhanced contractor accreditation, stricter project monitoring, and third party quality audits to improve transparency, accountability, and construction quality.

Advancing the construction quality management requires collaboration among industry stakeholders, government agencies, and educational institutions. Public and private partnerships (PPPs) can facilitate knowledge exchange, training programs, and capacity building initiatives. Firms should invest in continuous professional development and compliance with international standards. By fostering a culture of quality excellence, accountability, and innovation, the Philippine construction industry can achieve long term sustainability and growth. Benchmarking offers a structured approach to quality enhancement, ensuring industry wide improvements [22].

2.1.2 Competencies of Government Stakeholders

Government stakeholders play a vital role in ensuring construction quality through regulatory oversight, policy formulation, and benchmarking practices. However, gaps in technical expertise, resource allocation, and strategic planning hinder their effectiveness. Kärnä and Junnonen (2016) emphasize that government agencies need to enhance both technical knowledge and soft skills, including leadership, stakeholder collaboration, and communication.

A major challenge in government led construction projects is the inconsistent oversight and quality assurance mechanisms. Many agencies lack standardized monitoring protocols, leading to varied enforcement across regions. Limited funding and bureaucratic inefficiencies further delay quality control implementation, resulting in poor workmanship, delays, and cost overruns. Capacity building programs that train government officials in modern construction management techniques and digital tools are essential for improving regulatory efficiency. The slow adoption of emerging technologies restricts

government benchmarking efforts. Kärnä and Junnonen (2016) argue that without technological proficiency, agencies struggle to effectively enforce and evaluate construction standards. Therefore, investments in digital infrastructure, data collection systems, and performance analytics are crucial for enhancing quality benchmarking and regulatory oversight [10,14].

Effective leadership and interagency collaboration are critical to improving government competencies in benchmarking construction quality. Many policies require coordination between national and local agencies, industry stakeholders, and private contractors. However, fragmented governance structures lead to communication gaps and overlapping responsibilities, reducing the efficiency of quality management programs. By fostering cross sector partnerships, enhancing policy coherence, and implementing transparent accountability mechanisms, government agencies can promote benchmarking initiatives and ensure consistent quality standards. Addressing competency gaps in project oversight and quality assurance is essential for fostering a culture of benchmarking and continuous improvement in government led projects [2, 7].

2.2 Maturity Level of Quality Management

The Project Management Maturity Model (PMMM) was adapted in this study to assess the maturity of project management practices within the local government sector. While the PMMM is commonly applied through standardized criteria and self-assessment approaches, which makes it suitable for adaptation to broader survey-based assessment when consistent scoring is required [15, 18]. Local government project environments frequently vary in the formality and consistency of project management systems, which can limit opportunities to optimize delivery performance and institutional learning [23]. To address these challenges, this study employed an internationally recognized project management frameworks, specifically the PMMM and the PMBOK Guide Fourth Edition Knowledge Areas, to develop structured questionnaires for benchmarking current practices.

Table 1: Nine (9) PMBOK Knowledge Area

	Knowledge Area
1	Project integration
2	Project scoping
3	Project time management
4	Project cost management
5	Project quality management
6	Project human resourcing
7	Project communications management
8	Project risk management
9	Project procurement management

The nine PMBOK Fourth Edition Knowledge Areas presented in Table 1 are Integration, Scope, Time, Cost, Quality, Human Resources, Communications, Risk, and Procurement Management, provide a comprehensive yet accessible structure for evaluating maturity across core project functions (PMI, 2008). Although later editions of the PMBOK Guide are available, PMBOK4 remains a practical choice for benchmarking due to its concise structure, with fewer Knowledge Areas and 42 core processes (in contrast to the Fifth Edition’s expanded scope and 47 processes), making it less demanding for participants [16, 17].

The PMBOK Guide also emphasizes the importance of governance, requiring project managers to align with broader organizational objectives and ensure compliance throughout the project lifecycle [17]. To operationalize the PMMM in this study, the researcher developed a questionnaire in which each PMBOK Knowledge Area is represented by variables arranged in a column, and the five maturity levels such as Initial, Structured, Organizational Standards, Managed, and Optimizing, were arranged in a row [19, 18]. This structure allows respondents to self-assess their organization's maturity within each PMBOK Knowledge Area, enabling the identification of sector wide strengths and weaknesses. Maturity levels are treated as cumulative, meaning higher performance presumes that foundational practices are already in place. For instance, achieving Level 3 in Project Quality Management requires evidence of standardized quality assurance processes, formal quality plans, and organizational support for quality at key control points. This staged progression is consistent with the logic of maturity models, where advancement reflects increasing institutionalization and managed execution rather than isolated good practices [19, 15]. The literature further indicated that maturity progression is strongly influenced by organizational leadership, workforce capability development, and the use of technologies that strengthen monitoring, control, and learning across projects.

To quantify the maturity level of project management practices across the PMBOK knowledge areas, this study adopts the computation of the Maturity Index (M_i) in Equation 1 and the Weight Index (W_i) in Equation 2 under the PMMM-based benchmarking approach. These indices allow maturity results to be expressed in a standardized numerical form that supports comparison across knowledge areas and participating organizations, consistent with the use of benchmarking methods in project management maturity research [19]. The Maturity Index (M_i) represents the weighted average maturity score for a given knowledge area, computed by multiplying the number of responses at each maturity level by the corresponding score and dividing the result by the total number of responses. This approach ensures that higher maturity levels contribute proportionally more to the overall maturity score [11].

$$M_i = \frac{\sum_{j=1}^L f_{ij} \times j}{N} \quad (1)$$

Where M_i is the maturity index for the i th knowledge area, f_{ij} is the frequency of responses at maturity level j for the i th knowledge area, j is the maturity level score (1 = Initial, 2 = Structured, 3 = Organizational Standards, 4 = Managed, 5 = Optimizing), L is the total number of maturity levels, and N is the total number of respondents [15, 18].

To allow comparison across knowledge areas and to express maturity in relative terms, the Weight Index (W_i) is computed by normalizing each maturity index against the total maturity score across all knowledge areas. This produces a proportional score (0-1) that indicates how strongly each knowledge area contributes to the overall maturity profile in the sample [19, 11].

$$W_i = \frac{M_i}{\sum_{i=1}^n M_i} \quad (2)$$

Where W_i is the weight index for the i th knowledge area, M_i is the computed maturity index, and $\sum M_i$ is the summation of the mean ratings for the knowledge areas. Values closer to 1 indicate relatively higher maturity contribution and stronger institutionalization of practices within that knowledge area [15, 18].

Recent literature suggests that maturity progression in construction organizations is not achieved by adding more procedures alone. It depends on consistent leadership, clear accountability, and policies that are enforced in practice, not only written on paper [5]. Progress also becomes easier when organizations use digital tools that support reliable data and analysis, because these tools help shift project management

from basic compliance checks toward performance-based improvement [24]. Benchmarking strengthens this shift by providing agencies a practical way to compare performance, identify gaps, and implement targeted improvements [25]. At the sector level, studies also point to the value of shared standards, third-party audits, and incentives that encourage quality certification as drivers of sustained improvement across organizations [26, 23]. By adopting the PMMM framework, supported by benchmarking and best practices, local governments can establish a foundation for continuous improvement, stronger quality culture, and enhanced project delivery outcomes across the sector [10, 14].

2.3 Key Performance Indicator (KPI)

Key Performance Indicators (KPIs) are widely used in performance measurement and management, including in construction and local government settings. KPIs serve as quantifiable metrics that allow organizations to monitor progress toward strategic objectives, evaluate operational efficiency, and assess the effectiveness of project delivery [27]. Within continuous improvement work, KPIs are commonly organized around core project outcomes, most particularly cost management, schedule adherence, quality control, and stakeholder satisfaction, often referred to as the iron triangle of project management [28]. At the same time, measurement systems can lose value when they become too crowded. Kaplan and Norton (1996) have argued for a strategic and selective approach, recommending that organizations limit their KPIs to a manageable set, typically between eight and twelve indicators, to ensure clarity, usability, and meaningful performance evaluation. Recent research has emphasized the importance of involving industry professionals, such as experienced project managers and consultants, in the KPI selection process to ensure alignment with operational realities and strategic priorities. Participatory methods, including Likert scale surveys and expert panels, have been used to rank the relevance of various KPIs and refine them for practical use in benchmarking and quality management systems [11].

In this study, the identification of ten (10) Key Performance Indicators (KPIs) has been a foundational step in developing a robust benchmarking framework for assessing project management performance within the local government sector. These KPIs were selected through an extensive review of relevant literature and industry practices to ensure their relevance, applicability, and feasibility for use in diverse local government contexts. The selected indicators shown in Table 2 cover the fundamental dimensions of cost efficiency and budget compliance, schedule performance and timeliness, quality of deliverables and standards compliance, safety and risk management, client and stakeholder satisfaction, governance and regulatory compliance, innovation and continuous improvement, productivity and operational efficiency, data integrity and decision making transparency, and human capital and capacity building. Establishing these KPIs allows for a structured and consistent assessment of quality management practices, helping to identify both strengths and areas requiring improvement. Furthermore, the prioritization of these indicators supports the study’s broader aim of enabling effective benchmarking, fostering accountability, and promoting sector wide learning and collaboration in project management practices [4].

Table 2: Ten (10) Key Performance Indicators (KPIs)

KPIs	Description
Cost Efficiency	Measures project adherence to approved budget, cost predictability, and efficient use of public funds.
Timeliness	Tracks on-time project delivery and ability to meet planned milestones.

Quality Compliance	Assesses the degree to which outputs meet defined specifications, standards, and regulatory requirements.
Safety & Risk	Evaluates safety incidents, risk mitigation effectiveness, and health standards, especially on-site.
Stakeholder Satisfaction	Gauges satisfaction from public agencies, end-users, and citizens based on service quality and communication.
Regulatory Compliance	Monitors adherence to laws, policies, procurement standards, and ethical guidelines to ensure transparent governance.
Innovation	Tracks adoption of new technologies, process innovations, and proactive quality improvements.
Productivity	Measures output versus input, workforce productivity, and resource utilization.
Data Transparency	Evaluates the availability, accuracy, and use of project data to support accountable and evidence-based decisions.
Human Capital	Assesses workforce training, qualifications, leadership quality, and ability to manage complex public projects.

While KPIs provide a valuable foundation for benchmarking and continuous improvement, their successful implementation is often hindered by several practical challenges, particularly in fragmented and resource constrained sectors like construction and local government. Studies by Costa and Formoso (2023) highlight the risks of overwhelming organizations with too many performance metrics, which can dilute focus, obscure strategic priorities, and create confusion among staff. Barriers such as inconsistent data collection practices, limited technological capacity, and a lack of leadership support further undermine the effective use of KPIs in many organizations. Research by Kärnä and Junnonen (2016) underscores the importance of leadership commitment, workforce development, and clear accountability structures in advancing maturity beyond basic compliance levels. Collaborative approaches, such as benchmarking clubs have been proposed as solutions to these challenges, enabling organizations to exchange best practices, develop solutions, and promote collective learning in a noncompetitive environment [29]. These initiatives help address knowledge gaps, facilitate data sharing, and build sector wide capacity for performance improvement, particularly when supported by digital platforms and shared benchmarking standards [10, 14].

Ultimately, the strategic use and contextual adaptation of KPIs, combined with stakeholder engagement, leadership commitment, and collaborative benchmarking practices, emerges as a critical enabler for advancing project management maturity and quality management within the local government sector. This study integrates the selected KPIs into a benchmarking framework that complements the Project Management Maturity Model (PMMM), enabling both structured self-assessment and comparative analysis across councils. By aligning KPI measurement with PMMM based maturity assessments, the research seeks to establish a baseline understanding of current practices, identify sector wide trends, and provide actionable insights for continuous improvement. The dual focus on maturity and KPI performance allows for a holistic evaluation of project management capabilities, bridging the gap between formal process frameworks and the human, organizational, and contextual factors that influence project success. Through this approach, the study aims to contribute to the development of a culture of quality, accountability, and innovation in the delivery of capital projects within the local government sector [4].

2.4 Statistical Methods

Statistical methods support research by providing systematic tools for collecting, interpreting, and presenting evidence. In the context of construction quality management, these methods provide reliable tools to measure performance, assess stakeholder perceptions, and evaluate the effectiveness of implemented strategies. Techniques such as the Kaiser-Meyer-Olkin (KMO) Measure and Bartlett’s Test of Sphericity assess data suitability for factor analysis, while Cronbach’s Alpha determines the internal consistency of survey instruments. Pairwise Comparison and Fuzzy Analytic Hierarchy Process (FAHP) further support decision making by ranking barriers and strategies based on expert judgment. By applying these statistical tools, this study ensures data validity and enhances the credibility of findings related to benchmarking practices in the construction industry of Cagayan de Oro City.

2.4.1 Kaiser-Meyer Olkin Test and Bartlett’s Test

The Kaiser-Meyer-Olkin (KMO) test is designed to evaluate the suitability of data for factor analysis by measuring the adequacy of sample size and the appropriateness of sampling for each variable [30]. Alongside this, Bartlett’s Test of Sphericity is computed to assess whether the dataset is appropriate for conducting factor analysis [31]. The KMO statistic is expressed as:

$$KMO = \frac{\sum \sum r_{ij}^2}{\sum \sum r_{ij}^2 + \sum \sum p_{ij}^2} \quad (3)$$

Where r_{ij} represents the correlation coefficients and p_{ij} represents the partial correlation coefficients between variables [31]. A KMO value close to 1 indicates that the correlation patterns are compact, suggesting that factor analysis will likely produce distinct and reliable factors. A KMO value greater than 0.50 is considered acceptable for factor analysis. Meanwhile, the Bartlett’s test statistic is calculated using the formula:

$$X^2 = - \left(n - 1 - \frac{2p + 5}{6} \right) \ln|R| \quad (4)$$

where x^2 is the chi-square test statistic, n is the sample size, p is the number of variables, and $|R|$ is the determinant of the correlation matrix. Bartlett’s Test of Sphericity is a statistical procedure developed to test whether the correlation matrix is significantly different from an identity matrix [31]. An identity matrix implies that the variables are not correlated, and therefore, unsuitable for factor analysis. Bartlett’s test evaluates the null hypothesis that the observed correlation matrix is an identity matrix. A significance level (p-value) less than 0.05 allows us to reject the null hypothesis and infer that the variables have statistically significant relationships.

Based on the sample output in Table 3, a KMO value of 0.751 indicates that the dataset has adequate shared variance for factor analysis and can yield interpretable factors [30]. The Bartlett’s Test of Sphericity is significant ($p < 0.001$), confirming that correlation matrix is not an identity matrix and that the variables are meaningfully interrelated [31]. These tests are standard preliminary checks that provide methodological support for reducing many observed indicators into defensible factor structures for benchmarking and performance assessment [32].

Table 3: KMO and Bartlett’s Test (Sample Result)

Measure	Value
Kaiser-Meyer-Olkin (KMO)	0.751
Bartlett’s Test of Sphericity	

Approx. Chi-Square	7341.784
Degrees of Freedom (df)	135
Significance (Sig.)	0.000

In the context of benchmarking, especially for quality management in industries like construction, the KMO test validates whether performance indicators such as cost, time, quality compliance, or client satisfaction are statistically interrelated. This interrelatedness is crucial when attempting to reduce multiple benchmarking criteria into key performance dimensions or indices. Bartlett’s test helps confirm that the metrics being used such as site safety ratings, rework frequency, or material usage efficiency are sufficiently interrelated to produce meaningful, combined indicators. This is fundamental in deriving best practices or benchmark scores that can be generalized across projects or firms [2,7].

In benchmarking, particularly for quality management systems in the construction industry, these statistical tests ensure that the indicators being used are not only relevant and measurable but are also statistically reliable and related. This ensures that benchmarking outcomes are based on empirical patterns rather than arbitrary metrics, making performance comparisons more credible and the resulting strategies for improvement more effective. These tests, therefore, not only facilitate data reduction but also enhance the rigor and reliability of benchmarking as a quality management tool [11].

2.4.2 Cronbach’s Alpha Test

Cronbach’s Alpha is a statistical method used to evaluate the reliability and internal consistency of tests and scales developed for a study. It estimates how closely related a set of items are as a group, helping to assess the quality of the data collected. In this context, Cronbach’s Alpha was calculated to measure the internal consistency and reliability of the survey instrument. The formula for Cronbach’s Alpha is:

$$\alpha = \frac{N\bar{c}}{\bar{v} + (N - 1)\bar{c}} \quad (5)$$

Where N is the number of items, \bar{c} is the average covariance between item pairs, and \bar{v} is the average variance [33]. This formula reflects that Alpha increases as the number of items and the average covariance increase, indicating greater shared variance among items. In survey research and benchmarking studies, calculating Cronbach’s Alpha ensures that groupings of items are measuring the same construct consistently [2, 7].

Understanding issues that affect Cronbach’s Alpha is crucial when designing and evaluating survey instruments. One important factor is the number of items, increasing the number of relevant and well aligned items generally improves Alpha, but adding too many similar items may artificially inflate it [34]. Another consideration is unidimensionality, which assumes that all items measure a single construct. If items span multiple dimensions unknowingly, Alpha can be misleading. This is why it is often recommended to conduct factor analysis alongside Cronbach’s Alpha to verify that item groupings are unidimensional [35].

2.4.3 Pairwise Comparison

The Pairwise Comparison method plays a valuable role in benchmarking because it helps decision makers identify priorities among performance indicators through a structured process of comparing indicators two at a time [36]. This approach makes the decision more focused and allows for clearer comparative analysis. In the context of construction benchmarking, this method is especially helpful when evaluating essential areas of performance such as cost efficiency, safety and risk management, stakeholder satisfaction,

timeliness, and data transparency, where direct quantitative measurement may be difficult. By analyzing these indicators in pairs using input from a sample group of construction professionals, researchers can identify consistent trends in preferences and create a structured ranking that highlights which aspects of construction quality are considered most important across the industry [37].

Table 4: Pairwise Comparison Saaty Scale

Saaty Scale	Linguistic Meaning
1	Equal Importance
2	Between Equal and Moderate
3	Moderate Importance
4	Between Moderate and Strong
5	Strong Importance
6	Between Strong and Very Strong
7	Very Strong Importance
8	Between Very Strong and Extreme
9	Extreme Importance

Pairwise comparison is a structured decision-making technique used to determine the relative importance of criteria by comparing them two at a time. This method forms the foundation of the Analytic Hierarchy Process (AHP) developed by Saaty (1980) and has been widely applied in construction management, quality assessment, and benchmarking studies.

This validation step is essential in construction related decision models to ensure reliable prioritization of quality criteria [38]. The benefit of this method is found in its ability to support both qualitative and quantitative benchmarking, making it suitable for gathering expert opinions as well as field data. For instance, when assessing infrastructure projects funded by the government, professionals such as engineers and project managers may be invited to compare pairs of quality indicators based on their knowledge and experience. A preference schedule is developed, in which respondents express their preferences for one factor over another based on their experience or observations.

These comparisons are then compiled to identify which criteria are prioritized, guiding continuous improvement efforts and benchmarking decisions. This process allows analysts to determine which indicators are considered most critical. The resulting priority list provides a foundation for improving performance, as it guides where resources, policy changes, or training efforts should be focused. In summary, the Pairwise Comparison method helps convert individual expert judgments into organized benchmarking data that supports more informed planning and quality control in the construction sector.

2.4.4 Fuzzy Analytic Hierarchy Process (Fuzzy AHP)

Fuzzy Analytic Hierarchy Process (Fuzzy AHP) is employed to rank construction quality attributes by expressing the intensity of one attribute relative to another, using fuzzy sets to capture the degree of preference. This approach is particularly useful in decision-making situations where preferences are uncertain or not clearly defined. A method based on fuzzy preference relation allows for measuring the degree of preference between fuzzy numbers with a reduced number of pairwise comparisons by comparing the fuzzy numbers to their mean. In classical AHP, expert judgments are arranged in a pairwise comparison matrix, expressed in equation 6.

$$A = [a_{ij}], \quad i, j = 1, 2, \dots, n \tag{6}$$

Where a_{ij} represents the relative importance of criterion i over criterion j , $a_{ij} > 0$, $a_{ij} = 1/a_{ji}$, and $a_{ii} = 1$. The priority weights of the criteria are obtained by solving the eigenvalue problem in equation 7.

$$Aw = \lambda_{max}w \tag{7}$$

Where w is the priority vector and λ_{max} is the maximum eigenvalue of the matrix. To verify the logical consistency of expert judgments, Saaty (1980) introduced the Consistency Index (CI) and Consistency Ratio (CR) shown in equation 8 and 9.

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{8}$$

$$CR = \frac{CI}{RI} \tag{9}$$

To ensure the reliability of the comparison data, consistency testing was conducted for all matrices. The Consistency Index (CI) and Consistency Ratio (CR) were computed to evaluate the logical coherence of stakeholder judgments. A consistency ratio of $CR \leq 0.10$ indicates acceptable judgment consistency. The consistency test results for both the dimension-level and sub-dimension matrices confirms that the judgments were sufficiently consistent for further multi-criteria analysis.

Although classical AHP provides a robust prioritization framework, it assumes that expert judgments are precise. In practice, especially in construction quality management and benchmarking, expert opinions are often uncertain, subjective, and expressed linguistically. To address this limitation, the Fuzzy Analytic Hierarchy Process (FAHP) integrates fuzzy set theory into AHP [39]. In FAHP, pairwise comparisons are represented using Triangular Fuzzy Numbers (TFNs) presented in Table 5.

Table 5: Triangular Fuzzy Numbers (TFNs)

Saaty Scale	Linguistic Meaning	TFN	Inverse TFN
1	Equal Importance	(1,1,1)	(1,1,1)
2	Between Equal and Moderate	(1,2,3)	(1/3,1/2,1)
3	Moderate Importance	(2,3,4)	(1/4,1/3,1/2)
4	Between Moderate and Strong	(3,4,5)	(1/5,1/4,1/3)
5	Strong Importance	(4,5,6)	(1/6,1/5,1/4)
6	Between Strong and Very Strong	(5,6,7)	(1/7,1/6,1/5)
7	Very Strong Importance	(6,7,8)	(1/8,1/7,1/6)
8	Between Very Strong and Extreme	(7,8,9)	(1/9,1/8,1/7)
9	Extreme Importance	(9,9,9)	(1/9,1/9,1/9)

To compute the fuzzy weights, Buckley’s (1985) fuzzy geometric mean method is applied. The average TFNs need to be converted into crisp numbers using equation 10 and will lead to crisp comparison matrix.

$$M_{crisp} = \frac{a + 4b + c}{6} \text{ for any TFN} \tag{10}$$

The priority vector or normalized principal eigen vector W , showing normalized relative weights for criteria can be derived using equation 11. It is row averaged value of a column normalized matrix. Finally, the resulting matrix shows the weighted sum criteria using equation 12.

$$w_i = \frac{\sum_j^n a_{ij}}{1 \sum_{x=1}^n a_{xi}} \tag{11}$$

$$X = AW \tag{12}$$

2.5 Benchmarking of Construction Quality Management

Benchmarking in construction quality management provides firms a practical way to compare their practices with industry standards, identify performance gaps, and implement necessary improvements. The construction sector, especially in developing regions like Cagayan de Oro, faces challenges in fostering continuous improvement. Garcia et al. (2023) emphasize that benchmarking goes beyond merely measuring performance; it promotes a mindset that prioritizes quality at every stage of a project. To effectively assess and enhance quality management, firms must integrate Key Performance Indicators (KPIs) that provide quantifiable metrics for project efficiency, defect rates, safety compliance, and client satisfaction. Companies that track KPIs such as defect frequency, rework percentage, on-time delivery, and safety adherence are better positioned to strengthen their quality management systems. However, the absence of a benchmarking culture and KPI monitoring in many firms leads to inconsistent and fragmented quality improvement efforts [40].

A key component of benchmarking construction quality management is the integration of structured Quality Management Systems (QMS) supported by well-defined KPIs. Pratama et al. (2021) argue that without a mature QMS, firms struggle to maintain consistent quality standards. Many construction firms in developing economies operate with ad hoc quality assurance mechanisms, resulting in inconsistencies and delays. Implementing benchmarking frameworks, such as ISO 9001, establishes a systematic approach to quality improvement, ensuring adherence to industry wide best practices [41]. KPIs such as defect density, material waste reduction, and subcontractor performance ratings help track the effectiveness of QMS and highlight areas for improvement. However, many companies, particularly small and medium sized enterprises (SMEs), lack the resources and training to implement these frameworks effectively [40]. Without data driven decision making supported by KPIs, firms encounter challenges in measuring and improving construction quality standards.

Leadership and organizational commitment are critical for successful benchmarking of construction quality culture. Kärnä and Junnonen (2016) highlight that for benchmarking to be effective, top management must support quality initiatives and foster a KPI driven culture of accountability. When leaders prioritize benchmarking and align project goals with quantifiable metrics, employees are more likely to adhere to standardized practices and contribute to continuous improvement. Setting KPIs such as training completion rates, corrective action resolution time, and quality audit scores ensures leadership engagement in quality enhancement. Conversely, a lack of leadership commitment results in resistance to change, minimal participation in quality programs, and inconsistent benchmarking efforts [41]. Firms that incorporate data driven quality evaluations can identify process weaknesses, implement corrective measures, and sustain long-term improvements in quality culture maturity.

Technology also enhances benchmarking through automation and real time KPI tracking. Digital tools such as Building Information Modeling (BIM), automated quality inspection systems, and data analytics dashboards improve firms ability to monitor quality metrics and make informed decisions [24]. Digital benchmarking platforms enable efficient performance comparisons, streamline data collection, and enhance stakeholder collaboration. KPI dashboards displaying metrics such as first time inspection pass rates, project cost variance, and schedule adherence provide objective quality assessments. However, technological adoption still poses a challenge in Cagayan de Oro due to cost constraints, a lack of technical expertise, and resistance to digital transformation [40]. Overcoming these challenges requires government incentives for digital adoption, industry wide training programs, and collaborative benchmarking initiatives to standardize KPI tracking.

Collaboration and knowledge sharing among firms are vital for establishing industry-wide KPI benchmarks. Albertin et al. (2021) note that firms that engage in benchmarking networks gain access to valuable insights, best practices, and innovative quality management approaches. However, in developing regions, competition and distrust can hinder collaboration [41]. Companies are often reluctant to share performance data due to concerns about confidentiality and competitive disadvantage. Encouraging open benchmarking through industry associations, government initiatives, and public-private partnerships can help overcome these barriers and promote collective growth. Standardizing KPIs, such as client satisfaction scores, defect resolution efficiency, and material utilization rates, ensures transparency and drives improvements in quality management [4].

Benchmarking the quality management in construction is a continuous process that requires commitment, investment, and collaboration. Key Performance Indicators (KPIs) are essential for measuring and improving this process. Effective benchmarking not only enhances construction quality but also supports project sustainability and drives industry growth. Garcia et al. (2023) describe benchmarking as a method for adopting best practices, closing performance gaps, and improving decision-making. Pratama et al. (2021) emphasize that maturity in quality culture is crucial for reducing construction failures; however, many firms lack the internal processes necessary for effective benchmarking. Without the establishment and tracking of KPIs, companies in Cagayan de Oro will continue to struggle with inconsistent quality management. To raise quality standards and remain competitive in the global market, firms should integrate structured Quality Management Systems (QMS), foster leadership commitment, leverage technology, and promote collaboration within the industry [10, 14].

2.6 Barriers to Benchmarking Construction Quality Management

Benchmarking construction quality management is crucial for enhancing industry standards, yet it faces numerous barriers that impede widespread adoption, particularly in developing regions like Cagayan de Oro. A significant challenge is the lack of awareness and understanding among local construction firms, especially small and medium-sized enterprises (SMEs), which often have limited exposure to benchmarking principles and struggle to recognize long-term benefits. Garcia et al. (2023) point out that firms in Chile are hesitant to share sensitive data, limiting their engagement in benchmarking. This issue is mirrored in Cagayan de Oro, where companies operate in isolation and lack access to industry-wide performance data.

To assess these barriers, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test can evaluate sampling adequacy and the statistical validity of analyzing firms' readiness for benchmarking [41]. A low KMO value indicates fragmented industry practices and inconsistent data collection, underscoring the need for structured benchmarking frameworks. Furthermore, Cronbach's Alpha measures the reliability of benchmarking assessment tools, ensuring consistent data collection regarding firms' challenges [40].

Another significant challenge is firms' reluctance to share performance data due to concerns about confidentiality and potential competitive disadvantages. Albertin et al. (2021) emphasize that effective benchmarking requires comprehensive data collection; however, many firms are hesitant to disclose operational details, fearing that competitors may gain insights into their processes. This reluctance limits collaboration and hampers the development of standardized benchmarking frameworks. A Pairwise Comparison approach can quantify firms' concerns and rank the significant barriers based on expert input [40]. This method prioritizes factors such as a lack of transparency, fears of competition, and financial constraints for targeted interventions. Fuzzy AHP extends the conventional AHP by expressing pairwise comparison judgments using triangular fuzzy numbers and deriving priority weights through extent

analysis to address imprecision in expert evaluations [42]. Financial constraints also obstruct the adoption of benchmarking. Many firms, particularly in developing regions, operate on tight budgets and prioritize cost reduction over quality initiatives.

Pratama et al. (2021) argue that achieving quality culture maturity is essential for reducing construction failures; however, many firms remain in the early stages of Quality Management System (QMS) development. The lack of standardization complicates benchmarking, as quality metrics tend to be inconsistent [41]. FPR-based computations of weights and rankings can identify cost-effective strategies, enabling firms to allocate resources more efficiently. By ranking barriers by severity using fuzzy preference models, policymakers can determine which firms require financial support, training, or regulatory intervention [40].

2.7 Strategies to Benchmarking Construction Quality Management

To overcome existing barriers, a variety of strategies can be implemented through structured assessments, digital tools, and policy driven initiatives. One key approach is the utilization of digital platforms to streamline data collection and provide real time performance feedback. Bonilla and Castillo (2020) highlight the benefits of online benchmarking systems that allow firms to anonymously compare their performance with industry peers. These platforms address concerns over data confidentiality while offering reliable benchmarks to identify areas for improvement. The reliability of data collected through digital benchmarking tools can be statistically validated using KMO and Bartlett's Test [41].

Another crucial strategy involves phased benchmarking implementation through structured assessments and targeted training programs. Garcia et al. (2023) support the use of semi structured interviews and scoring systems to evaluate management practices, making benchmarking more accessible for smaller firms. A gradual approach, starting with internal performance reviews and then expanding to industry wide comparisons, helps build confidence and supports integration into quality improvement initiatives. Additionally, financial incentives such as certification programs, tax credits for quality investments, and public recognition for leaders in benchmarking can encourage greater industry participation [42].

Cultivating strong quality management within organizations is also vital for the successful implementation of benchmarking. Pratama et al. (2021) recommend adopting a Quality Culture Maturity Model (QCMM) that emphasizes leadership commitment, stakeholder engagement, and continuous improvement [41]. By institutionalizing Key Performance Indicators (KPIs) related to defect rates, project efficiency, and quality standards, firms can better integrate benchmarking into their management frameworks [4].

Finally, external support and governmental involvement are crucial in fostering a strong benchmarking management. Public and private partnerships can drive knowledge sharing initiatives, provide financial incentives, and introduce policies that integrate benchmarking into construction project assessments. Ackah and Amponsah (2024) emphasize the effectiveness of policy driven benchmarking in improving project outcomes. Aligning local regulations with global best practices and promoting industry wide collaboration can enhance the competitiveness of Cagayan de Oro's construction sector.

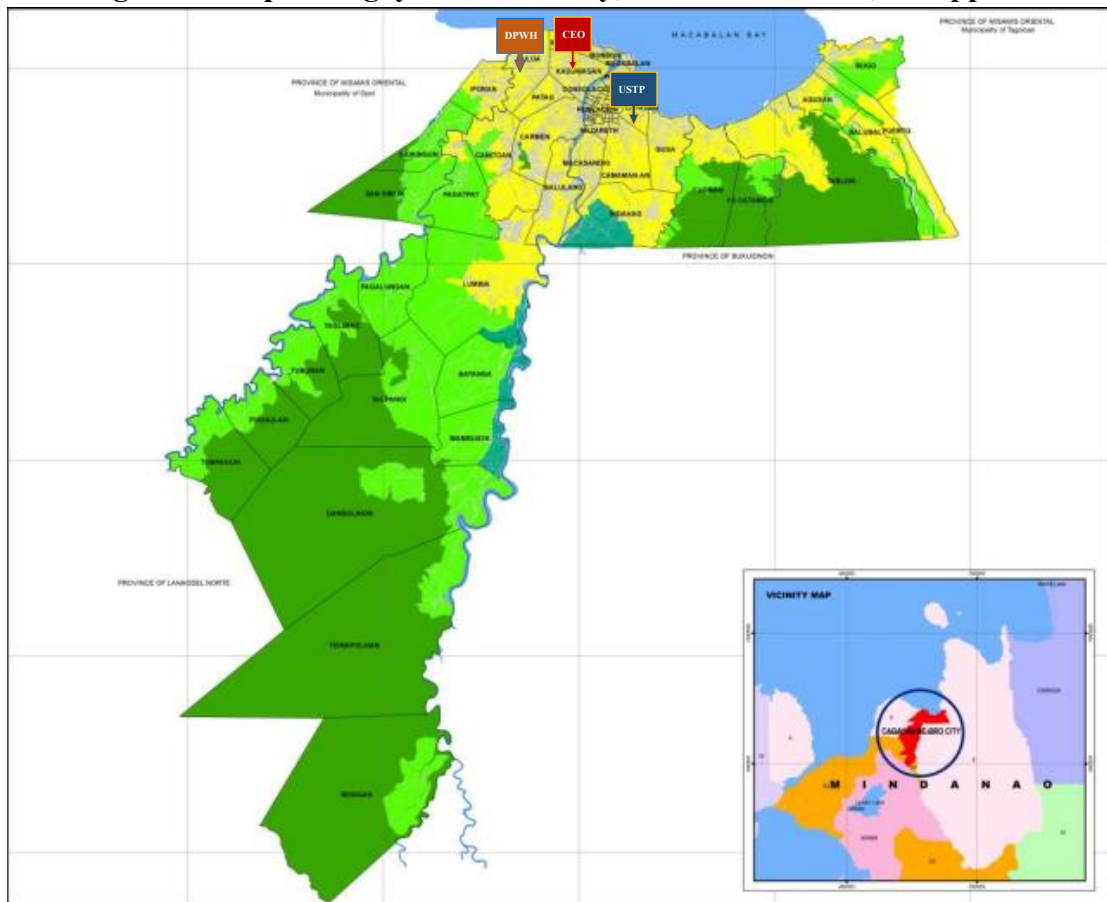
Additionally, structured benchmarking strategies including the integration of digital platforms, phased implementation, leadership driven key performance indicators (KPIs), and regulatory support, can promote data driven decision making and accelerate the maturity of quality culture across the construction sector [40]. By applying these methodologies, the construction industry in Cagayan de Oro can systematically identify gaps, implement targeted benchmarking strategies, and establish a long term framework for quality excellence and global competitiveness.

3. Methodology

This chapter outlines the methodology employed in this study, detailing the steps undertaken to achieve its objectives. The primary goal is to evaluate the construction quality management maturity of the local government, as well as identify the barriers to and strategies for adopting benchmarking in quality management within the local construction industry. Additionally, the study aims to assess the current maturity level of benchmarking practices in construction quality management in Cagayan de Oro, as well as evaluate the extent of government stakeholders’ perceptions regarding its value and implementation.

3.1 Research Locale

Figure 2: Map of Cagayan de Oro City, Misamis Oriental, Philippines

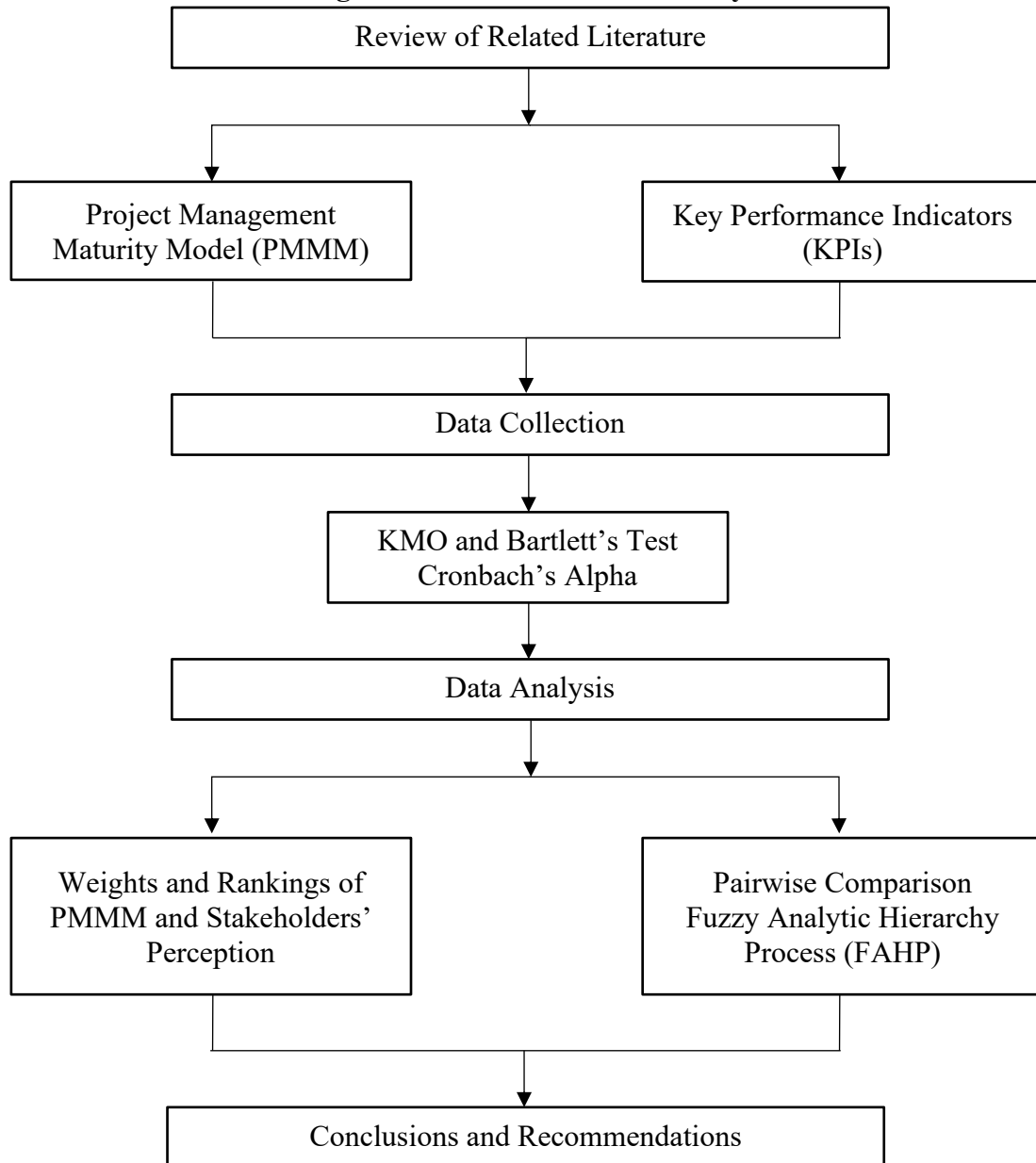


The study took place in Cagayan de Oro City, Misamis Oriental, Philippines (Latitude: 8° 28' 37.9812" N, Longitude: 124° 38' 45.3120" E). The selected respondents are from the offices of the Department of Public Works and Highways Region 10, the Office of the City Engineer and the University of Science and Technology of Southern Philippines. The respondents were engineers and architects involved in the construction planning and execution, both on the high and low management level.

The study aims to gather insights on current construction practices, project management techniques, and challenges encountered in infrastructure development within the region. The geographical focus on Cagayan de Oro City allows for a contextualized understanding of local engineering practices and regional infrastructure demands. Collaboration with local institutions was also sought to enhance the study’s relevance and applicability to ongoing and future projects.

3.2 Research Flow

Figure 3: Flow Chart of the Study



The study begins by applying the Project Management Maturity Model (PMMM) to establish the present maturity level of benchmarking practice of local government agencies. It also identifies the top ten (10) key performance indicators (KPIs) used as a basis for examining the barriers that limit benchmarking adopting and strategies that can address them. This phase emphasizes the importance of integrating benchmarking into the quality management systems of the local construction industry. To ensure the data collected is both representative and reliable, the sample size for the survey questionnaire was determined using stratified random sampling.

Furthermore, several established analytical techniques were applied to verify the soundness of the dataset, particularly its validity, reliability and internal consistency. These included the Project Management Maturity Model (PMMM), the Kaiser-Meyer-Olkin (KMO) Measure and Bartlett's Test of Sphericity, Cronbach's Alpha, Pairwise Comparison, and Fuzzy Analytic Hierarchy Process (Fuzzy AHP). These methodologies are selected to uphold rigorous research standards and to ensure the credibility of the

findings, which can serve as a foundation for future studies. The results of this phase supported the development of a practical framework for enhancing benchmarking practices in public infrastructure projects. Figure 3 presents a schematic diagram illustrating the study's workflow, offering a visual overview that enhances comprehension of the research structure and overall process.

3.3 Research Design

This study adopts a quantitative research design to examine patterns and relationships among variables using numerical data. Data were gathered through structured survey questionnaires to obtain standardized, measurable responses. A Delphi approach was used, consisting of two rounds of questionnaires distributed to selected respondents. This iterative method supports the collection of expert judgment while maintaining anonymity and using feedback to refine the instrument. The first round gathered assessments of project management maturity and the extent of benchmarking integration in their organizations, while the second round was developed based on the results of the initial responses to improve clarity and merging of expert opinion.

The first section of the first round of survey instruments were established on the Project Management Maturity Model (PMMM) to assess maturity in quality management practices within construction organizations. In developing the questionnaire, the researcher was guided by generally accepted professional standards, including those from the Project Management Institute (PMI), to strengthen content validity and ensure a consistent structure. Key Performance Indicators (KPIs) are also integrated into the questionnaire to quantify performance outcomes and provide measurable benchmarks for evaluating the effectiveness of quality management systems. The study utilized both the PMMM and the Likert Scale for rating.

Data analysis used a combination of statistical procedures and multi-criteria decision making techniques to support robust interpretation. The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity were applied to evaluate sampling adequacy and suitability of the dataset for further analysis. Cronbach's Alpha was calculated to test the internal consistency of the survey scales. For prioritization and ranking, weights were computed using pairwise comparison and fuzzy analytic hierarchy process (FAHP) to accommodate judgments under certainty. The primary purpose of the implementation phase is to project a plan into action, coordinate resources, and manage activities to achieve the research objectives.

3.4 Research Procedure

The research procedure began with the development and initial validation of the structured survey questionnaire based on the PMMM framework and selected KPIs. Preliminary checking was conducted to confirm validity, relevance and reliability, after which the instrument refined and finalized for administration. Once finished, the questionnaire was then distributed using stratified random sampling across three strata: the Department of Public Works and Highways Region 10, the Cagayan de Oro City Engineer's Office, and the University of Science and Technology of Southern Philippines. Data collection was conducted within the designated period through a combination of printed and online distribution to improve accessibility and response rates.

After retrieval, responses were screened for completeness and consistency, and the dataset was cleaned prior to analysis. The validated dataset was processed using descriptive statistics, factor analysis, reliability testing, and the selected multi-criteria techniques. All stages were documented to support transparency and to ensure compliance with academic research standards.

3.4.1 Sample of the Study

For this research, sample size decisions were informed by prior studies. For instance, the Project Management Maturity Model (PMMM) study selected sixty (60) professionals based on their expertise and industry experience. Furthermore, selecting twelve (12) to eighteen (18) carefully chosen respondents can yield valuable insights, especially when participants come from various functional areas interacting with project managers. It is also important to include individuals from different organizational levels to capture diverse perspectives.

Additionally, to meet the requirements for the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test for Exploratory Factor Analysis (EFA), a minimum of one-hundred (100) responses were targeted. For the Cronbach's Alpha reliability test, previous studies suggest that a sample size sufficient to achieve a coefficient of 0.7 or higher is generally adequate. Since the population for this study is heterogeneous, stratified random sampling was deemed the most appropriate method. This technique involves dividing the population into homogeneous subgroups, or strata, based on shared characteristics, and then randomly selecting participants from each stratum.

3.4.1.1 Sampling Techniques

Stratified random sampling is particularly useful when the population is composed of clearly defined categories. In this research, the target population comprises the government construction sector in Cagayan de Oro City. The sampling frame is divided into three distinct strata: the Department of Public Works and Highways (DPWH) Region 10, the Cagayan de Oro City Engineer's Office, and the University of Science and Technology of Southern Philippines (USTP). Random samples were drawn from each stratum to ensure all subgroups are well represented, thus enhancing the accuracy and reliability of the estimates. Table 6 presents the proportional distribution of the sample across the three strata.

3.4.1.2 Sampling Size

A total of one hundred and ten (110) questionnaires were distributed among the three stratum to avoid insufficient data during analysis. The total number of participants in the study are ninety-nine (99), both Engineers and Architects working in the government construction sector. Out of the fifty-seven (57) participants expected in DPWH-Region 10, only fifty-four (54) respondents submitted their responses. The Cagayan de Oro City Engineer's office submitted twenty-two (22) responses, which is six (6) more than the sample size. Lastly, twenty-three (23) personnel from USTP participated in the survey out of the twenty-seven (27) given.

Table 6: Stratified Random Sampling Size

Strata	Population Size	Sample Size	Sample Collected
DPWH - R10	384	57	54
CDO - CEO	100	16	22
USTP	177	27	23
Total	661	100	99

This proportional allocation ensures that each stratum is fairly represented in the sample, thereby preserving the population's structure and improving the accuracy and reliability of the findings. Ensuring an adequate sample size is essential for generating valid statistical results. In stratified sampling, this often means calculating separate sample sizes for each subgroup. A larger sample generally increases the precision of parameter estimates and enhances the study's statistical power. Adequate sample size is particularly important in cases where the study may not reveal statistically significant differences. The

demographic profile of field experts are detailed in Table 7. The participants should have at least a minimum of five (5) years industry experience.

Table 7: Field Experts Profile

Characteristics	No. of Participants	Percentage
Sex		
F	28	28.28
M	42	42.42
No Response	29	29.30
Age Bracket		
25-34	80	80.81
35-44	11	11.11
45-54	6	6.06
55-64	2	2.02
65 Over	0	0
Industry Experience		
5	45	45.46
6-10	40	40.40
11-15	7	7.07
16-20	2	2.02
Over 20	5	5.05
Profession		
Civil Engineer	71	71.72
Architect	22	22.22
No Response	6	6.06

3.4.2 Research Instruments

The study used a structured survey questionnaire to assess (1) project management maturity and (2) organizational readiness for benchmarking within the government construction sector in Cagayan de Oro City. Data collection followed a two-round Delphi format. The first round of survey gathered the personal profiles of respondents and baseline assessments, while results of first round were used to refine and finalize the second-round instrument for the feedback process.

The first-round questionnaire consisted of three parts: (a) respondent profile (e.g., age, gender, length of experience, position, and time in current position), (b) assessment of maturity in quality management practices, and (c) perceived value and current implementation of benchmarking. The second round questionnaire retained the profile section for document consistency, then focused on (b) barriers to benchmarking adoption and (c) strategies that may improve implementation within agencies.

3.4.2.1 Development of Survey Questionnaire

The maturity assessment items were developed using the Project Management Maturity Model (PMMM) and organized around the nine PMBOK knowledge areas. Indicators were arranged in a matrix structure, with maturity descriptors presented across increasing levels of practice development. Respondents rated

each indicator using a five-point maturity scale ranging from ad hoc to optimized practice. Variables and indicators were derived from the review of related literature and examined by external construction experts to support content relevance. The resulting PMMM variables are summarized in Table 8.

Table 8: PMMM Research Variables

	Knowledge Area	Indicators
1	Integration Management	Project Brief
		Project Plans
		Lesson Learned
2	Scope Management	Project Scope
		Structured Approach
		Scope Changes
3	Time Management	Tasks Arrangement
		Project Schedule Tracking
		Updating Project Schedule
4	Cost Management	Standardized Cost Estimate
		Project Expenditures
		Cost Performance
5	Quality Management	Quality Standards
		Quality Checks
		Quality Documentation
6	Human Resource Management	Roles & Responsibilities
		Team Performance
		Human Resource Planning
7	Communications Management	Communication Plans
		Stakeholder Information Needs
		Stakeholder Updates
8	Risk Management	Potential Project Risks
		Risk Response Plans
		Risk Management Outcomes
9	Procurement Management	Procurement Needs Identification
		Contractor Performance Evaluation

For each indicator, a corresponding item was provided with five response options aligned with the maturity levels. Responses were aggregated to determine maturity levels across knowledge areas for each participating agency. To evaluate stakeholder perception of benchmarking, a KPI-based set of items was included to collect performance dimensions relevant to construction quality culture and benchmarking readiness. The indicators covered cost efficiency, timeliness, quality compliance, safety and risk, stakeholder satisfaction, regulatory compliance, innovation, productivity, data transparency, and human capital. The stakeholder perception items are presented in Table 9.

Table 9: Stakeholders' Perception Research Indicators

Indicator	Questions
------------------	------------------

1	Cost Efficiency	Does benchmarking help identify areas where project costs can be reduced without affecting quality?
		Are project cost variances regularly reviewed and compared through benchmarking data?
2	Timeliness	Does benchmarking support better planning and control of project timelines?
		Are project delays analyzed and used as part of benchmarking reviews for improvement?
3	Quality Compliance	Does benchmarking lead to the delivery of higher quality outcomes in capital works?
		Are post-project quality metrics benchmarked against other projects to drive improvement?
4	Safety and Risk	Does benchmarking improve awareness and compliance with health and safety standards in projects?
		Are safety incident rates tracked and benchmarked to identify areas needing improvement?
5	Stakeholder Satisfaction	Does benchmarking help increase responsiveness and communication with clients?
		Is client feedback regularly collected and used for performance comparison?
6	Regulatory Compliance	Does benchmarking help minimize negative environmental impacts of projects?
		Are environmental performance indicators incorporated into project benchmarking processes?
7	Innovation	Does benchmarking help set clearer goals and improve team communication?
		Are team dynamics and conflict resolution practices evaluated and compared in benchmarking?
8	Productivity	Does benchmarking highlight the impact of leadership skills on project outcomes?
		Are leadership practices and technical skills assessed and benchmarked for improvement?
9	Data Transparency	Does benchmarking reveal ways to improve labor and machine productivity?
		Are productivity metrics (e.g., materials use, equipment maintenance) tracked for benchmarking?
10	Human Capital	Does benchmarking support better planning for skilled manpower needs?
		Are staff qualifications and training effectiveness reviewed and benchmarked regularly?

Table 10 consolidates the major constraints that hinder benchmarking adoption in government construction projects, organized across five broad areas: limited and inconsistent KPI integration, weak quality management system (QMS) structure, leadership and workforce readiness issues, gaps in digital capability, and low collaboration and data-sharing between agencies. The indicators reflect recurring operational problems collectively limiting the availability and credibility of benchmarking inputs.

Table 10: Key Barriers Research Variables

	Key Barriers
BSD1.1	Government construction projects lack sufficient use of Key Performance Indicators (KPIs) to measure performance.
BSD1.2	Time-related KPIs (e.g., meeting deadlines, project completion time) are often neglected in benchmarking practices.
BSD1.3	Quality-related KPIs (e.g., compliance with specifications, workmanship quality) are difficult to monitor in government projects.
BSD1.4	Cost-related KPIs (e.g., budget adherence, cost variance) are poorly tracked in government benchmarking efforts.
BSD1.5	Different projects use different measures, making comparisons unfair
BSD2.1	The absence of a structured Quality Management System (QMS) limits systematic benchmarking implementation.
BSD2.2	Quality checks are often done informally and inconsistently.
BSD2.3	The lack of ISO-based frameworks (e.g., ISO 9001) hinders adoption of standardized benchmarking practices.
BSD2.4	Weak integration of quality management systems reduces the reliability of benchmarking data.
BSD2.5	There are no regular quality reviews or audits in many projects.
BSD3.1	Some leaders do not fully support benchmarking in projects.
BSD3.2	Employees resist change when benchmarking systems are introduced.
BSD3.3	Limited leadership focus on a KPI-driven culture weakens benchmarking success.
BSD3.4	Leaders rarely promote continuous improvement using KPIs.
BSD3.5	Lack of accountability reduces staff participation in benchmarking initiatives.
BSD3.6	Excessive workloads hinder employee involvement in benchmarking-related activities.
BSD4.1	Government projects face challenges in adopting digital tools (e.g., BIM, dashboards) for benchmarking.
BSD4.2	High costs of digital technologies limit widespread implementation of benchmarking systems.
BSD4.3	Skill gaps among personnel hinder effective use of digital benchmarking platforms.
BSD4.4	Resistance to digital transformation prevents efficient KPI monitoring.
BSD4.5	Absence of real-time data systems reduces accuracy and timeliness of benchmarking outputs.
BSD5.1	Government agencies hesitate to share benchmarking data due to confidentiality concerns.
BSD5.2	Inter-agency competition and distrust reduce collaboration in benchmarking activities.
BSD5.3	Government units lack networks or partnerships for benchmarking exchange.
BSD5.4	Different agencies use different measures, making it hard to standardize benchmarking practices.
BSD5.5	Short project timelines discourage collaboration on benchmarking initiatives.

Table 11 presents the corresponding strategies designed to address the barriers in Table 10 by strengthening KPI standardization, embedding quality systems, improving leadership support, enabling digital transformation, and promoting collaboration. The strategies also highlight practical enablers for

modernization to improve data timeliness and monitoring accuracy.

Table 11: Proposed Strategies Research Variables

	Proposed Strategies
PSD1.1	Comparing and ranking KPIs can help find the most important ones to use.
PSD1.2	Analytical tools such as pairwise comparison and fuzzy analytic hierarchy process enhance KPI selection and decision-making.
PSD1.3	Ranking KPIs in order of importance helps focus on what matters most.
PSD1.4	Prioritizing quality-related KPIs, such as defect rates and efficiency, strengthens benchmarking accuracy.
PSD1.5	Using the same KPIs for all projects makes results fair and consistent.
PSD2.1	Promoting a “culture of quality” helps improve benchmarking practices.
PSD2.2	Introducing quality systems step by step makes them easier to apply.
PSD2.3	Conducting regular quality audits strengthens benchmarking reliability.
PSD2.4	Incorporating quality-related KPIs (e.g., defect rates, process efficiency) enhances quality monitoring.
PSD2.5	Leadership-driven quality assessments reinforce benchmarking accountability and compliance.
PSD3.1	Strong leadership commitment enhances benchmarking integration in projects.
PSD3.2	Capacity-building and training programs improve employee readiness for benchmarking practices.
PSD3.3	Leaders who track performance encourage a culture of improvement.
PSD3.4	Clear assignment of benchmarking responsibilities enhances participation and accountability.
PSD3.5	Gradual implementation of benchmarking practices encourages organizational acceptance and reduces resistance.
PSD4.1	Adoption of digital platforms streamlines benchmarking processes and data collection.
PSD4.2	Financial support or incentives can help agencies adopt digital systems.
PSD4.3	Technical training builds staff competencies in digital benchmarking systems.
PSD4.4	Public-private partnerships enhance technology integration in government projects.
PSD4.5	Real-time dashboards improve accuracy and speed in monitoring projects.
PSD5.1	Secure data-sharing platforms address confidentiality concerns in benchmarking.
PSD5.2	Policy-driven frameworks foster trust and collaboration between agencies.
PSD5.3	Industry-wide cooperation helps keep benchmarking sustainable.
PSD5.4	Alignment of local benchmarking practices with global standards enhances competitiveness.
PSD5.5	Partnerships with private groups can support benchmarking even with tight schedules.

3.4.2.2 Validity and Reliability of Survey Questionnaire

Validity and reliability checks were performed in IBM SPSS Statistics to confirm that the dataset was adequate for factor-based assessment and that the measurement scales were internally consistent. Sampling adequacy was evaluated using Kaiser-Meyer-Olkin (KMO) measure and Bartlett’s Test of

Sphericity. The KMO value ranges from 0 to 1, the higher values indicating that correlations among variables are sufficiently compact for factor analysis. Values below 0.50 are generally considered inadequate, while values from 0.50 upward indicate progressively better adequacy. Table 12 summarizes the interpretation guide used in this study. Bartlett’s test was used to determine whether the correlation matrix significantly differs from an identity matrix. A statistically significant result ($p < 0.05$) indicates that the variables are correlated at a level appropriate for factor analysis.

Table 12: KMO Criteria

KMO Value Range	Criteria
$KMO \geq 0.90$	Marvelous
$0.80 \leq KMO < 0.90$	Meritorious
$0.70 \leq KMO < 0.80$	Middling
$0.60 \leq KMO < 0.70$	Mediocre
$0.50 \leq KMO < 0.60$	Miserable
$KMO < 0.50$	Unacceptable

Reliability was assessed using Cronbach’s alpha to determine the internal consistency of the questionnaire scales. Table 13 presents the rule-of-thumb interpretation adopted in this study. Alpha values are interpreted using commonly applied thresholds, where an Alpha value of 0.70 or higher is considered acceptable, while higher values like 0.80 and 0.90 indicate good and excellent reliability, while low values suggest weak inter-item consistency and may indicate that items are not measuring the same underlying construct.

Table 13: Cronbach’s Alpha Criteria

Cronbach’s Alpha (α)	Reliability Level
$\alpha \geq 0.90$	Excellent
$0.90 > \alpha \geq 0.80$	Good
$0.80 > \alpha \geq 0.70$	Acceptable
$0.70 > \alpha \geq 0.60$	Questionable
$0.60 > \alpha \geq 0.50$	Poor
$\alpha < 0.50$	Unacceptable

3.5.3 Data Collection

Data collection for this study followed a structured and ethical process designed to obtain reliable responses from government construction stakeholders in Cagayan de Oro City. The survey approach was implemented in two stages, beginning with coordination and formal approval from participating agencies, followed by the distribution and retrieval of the questionnaires through institution-appropriate channels. To ensure that participation was properly authorized and that respondents were protected, the process emphasized official communication, confidentiality assurances, and adherence to the established research procedure. The first round survey gathered baseline inputs, and second round survey was subsequently administered after incorporating revisions from the initial results to improve clarity and strengthen the quality responses, consistent with the feedback-oriented nature of Delphi method.

3.5.3.1 Permission to Conduct the Survey

The researcher provided a formal letter to each agencies seeking permission to conduct and distribute the survey questionnaires to the engineers and architects employed under the institution (*See Appendix-A*). The letter outlined the purpose and objectives of the study, and the benefit of the study to the local industry. The request emphasized the significance of the study in its contribution of valuable insights to the project management of government sectors handling construction projects. In addition, the researcher provided assurance to the respondents with regards to the confidentiality and ethical considerations related to the study. This letter served as an official and formal means to as for authorization to proceed with the survey. After gaining approval to distribute the survey questionnaires, the next step involved following the research procedure and data gathering.

3.5.3.2 Distribution of Survey Questionnaire

Prior to data collection, a formal letter was sent to the target institutions requesting permission to conduct the survey. This letter included an attached form to be filled out with the email addresses of designated respondents. Once permission was granted and the form completed, the survey was distributed in either printed or electronic format, depending on the institution's accessibility and preference. Hard copies were provided to the Department of Public Works and Highways (DPWH), the City Engineer's Office received the survey through Google Forms, while the University of Science and Technology of Southern Philippines (USTP) was given both printed and online versions. This mixed distribution approach ensured convenience, inclusivity, and efficient data collection while maintaining confidentiality throughout the process.

The industry experts completed the first set of questionnaire in the span of one (1) week. Whereas, the second set of questionnaire was finished in the span of one (1) month due to the renewal process of some respondents in the Department of Public Works and Highways Region 10. Based on the result of the first survey, necessary revisions were made to the second set of questionnaire. This process involves adjusting content and refining phrases to be clearer to the respondents, to ensure better responses that aligned with the learning objectives.

3.5.4 Data Analysis

The survey questionnaire allowed both quantitative analysis and strategic interpretation, ultimately serving as a diagnostic and developmental tool for enhancing construction quality culture within the public sector. The questionnaire that was used in this study employs two measurement approaches based on the specific objectives of the study. Objective 1, which assesses the maturity of project management practices across the nine PMBOK® knowledge areas, uses the five level Project Management Maturity Model (PMMM) adapted from Crawford (2006). The Likert scale specifically addressed Objectives 2, 3, and 4.

Objective 2 aims to measure the perceived value of benchmarking, exploring whether respondents believe it contributes to improved efficiency, cost effectiveness, adherence to quality standards, and enhanced stakeholder satisfaction in project delivery. Objective 3 focuses on the actual implementation of benchmarking practices, evaluating whether local councils systematically collect and compare data, apply insights gained from benchmarking, and engage in ongoing improvement efforts.

Objective 4 examines the level of understanding and application of Key Performance Indicators (KPIs) as tools for measuring performance in critical areas such as cost, time, quality, safety, and environmental impact. By using a five point Likert scale to gather responses across these objectives, the study captures a broad range of subjective perspectives, allowing for comparative analysis of attitudes and the extent to

which benchmarking practices are embedded across different organizations. The combination of the Likert scale to assess individual perceptions and the Project Management Maturity Model (PMMM) to evaluate process maturity provides a well-rounded view of project management capabilities and challenges within the local government sector, supporting the development of targeted strategies for improvement.

To ensure analytical rigor and representativeness, Data analysis was conducted using a stratified approach, with respondents grouped into three institutional strata: the Department of Public Works and Highways Region X (DPWH), the Cagayan de Oro City Engineer’s Office (CEO), and the University of Science and Technology of Southern Philippines (USTP). The stratification allows maturity levels to be analyzed within the organizational context of each agency, recognizing differences in mandate, project scale, governance structure, and operational capacity.

3.5.4.1 Project Management Maturity Model

The Project Management Maturity Model (PMMM) served as the main analytical framework for determining the maturity of quality management and benchmarking-oriented practices among government construction agencies in Cagayan de Oro City. The model was used to assess how consistently project management processes are established, applied, monitored, and improved within each institution. In line with the first research objective, the PMMM provided a quantitative basis for measuring maturity using the nine (9) PMBOK 4th Edition knowledge areas as assessment dimensions.

Table 14: Project Management Maturity Model Rating Scale

Level	Definition
1	Initial Process
2	Structured Process and Standards
3	Organizational Standards and Institutionalized Processes
4	Managed Process
5	Optimizing Process

Each knowledge area was operationalized through predefined indicators, allowing respondents to rate the extent to which specific practices are evident in their agency. Responses were collected using the five-level PMMM rating scale in Table 14: Level 1 (Initial Process), Level 2 (Structured Process and Standards), Level 3 (Organizational Standards and Institutional Processes), Level 4 (Managed Process), and Level 5 (Optimizing Process). These levels reflect increasing degrees of formalization and integration, where higher maturity implies that foundational practices are not only present but also standardized, measured, and continuously refined.

Table 15: DPWH PMMM Result

	Knowledge Area	Variables	Level 5	Level 4	Level 3	Level 2	Level 1
1	Integration Management	Project Brief	9	28	14	2	1
		Approved Project Plans	11	29	11	2	1
		Lessons Learned	7	25	18	3	1
2	Scope Management	Defined Project Scope	11	25	16	1	1
		Structured Approach	9	30	13	1	1
		Scope Changes	11	26	14	3	0

3	Time Management	Tasks Arrangement	12	19	19	4	0
		Project Schedules Tracking	12	22	17	3	0
		Updating Project Schedules	9	17	23	4	1
4	Cost Management	Standardized Cost Estimate	9	28	15	2	0
		Project Expenditures	7	32	13	1	1
		Cost Performance	11	25	16	1	1
5	Quality Management	Quality Standards	8	23	19	4	0
		Quality Checks	9	24	17	3	1
		Quality Documentation	8	25	20	0	1
6	Human Resource Management	Project Roles & Responsibilities	12	26	15	0	1
		Team Performance	7	25	18	4	0
		Human resource planning	9	17	24	4	0
7	Communications Management	Communication Plans	6	23	22	1	2
		Stakeholder Information Needs	6	28	17	1	1
		Stakeholder Updates	7	27	16	2	2
8	Risk Management	Potential Project Risks	7	25	17	5	0
		Risk Response Plans	5	26	18	2	1
		Risk Management Outcomes	5	28	15	6	0
9	Procurement Management	Procurement Needs Identification	8	25	20	1	0
		Contractor Performance Evaluation	6	22	21	5	0

Figure 4: DPWH PMMM Chart

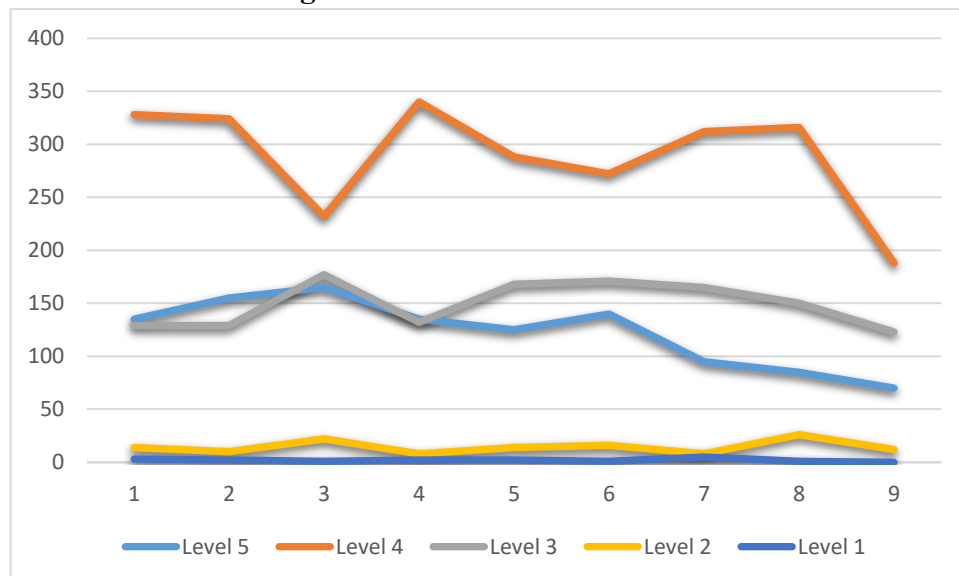


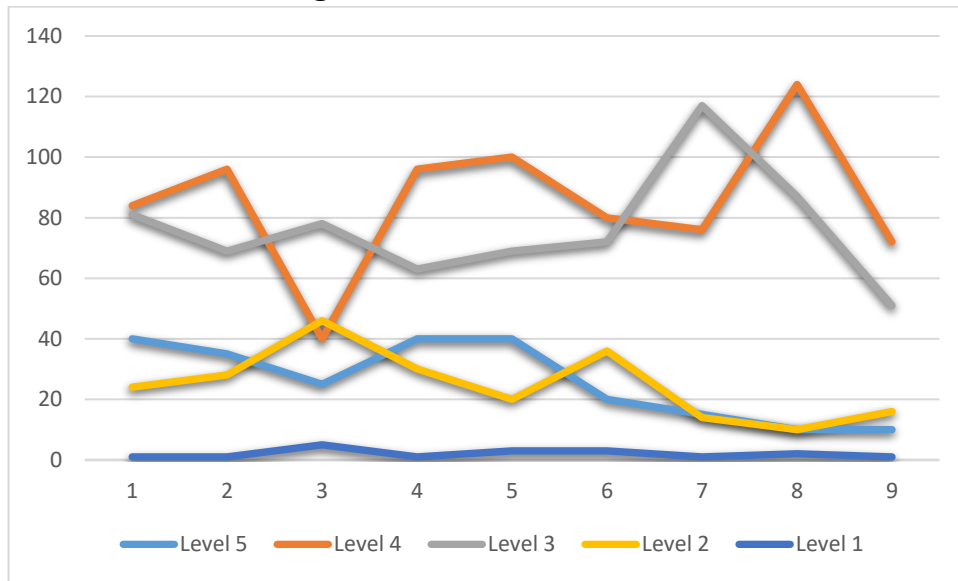
Figure 4 visually confirms the maturity distribution summarized in Table 15. Across the nine PMBOK knowledge areas, the Level 4 line consistently remains the highest, indicating the DPWH practices are generally implemented through established procedures and are routinely monitored. The Level 3 line forms the second largest cluster, showing that many processes are already standardized but not yet fully optimized across all areas. In contrast, Level 2 and Level 1 remain minimal throughout the chart, suggesting limited reliance on inconsistent practices. The Level 5 line is present across knowledge areas

but declines noticeably toward the later dimensions, reflecting that continuous improvement is evident but not uniformly embedded. This pattern is most pronounced where integration, scope, and cost related practices show stronger upper-level concentrations, while time management trends relatively more toward Level 3, implying uneven standardization in schedule control.

Table 16: CEO PMMM Result

	Knowledge Area	Variables	Level 5	Level 4	Level 3	Level 2	Level 1
1	Integration Management	Project Brief	2	8	9	4	0
		Approved Project Plans	3	8	8	3	1
		Lessons Learned	3	5	10	5	0
2	Scope Management	Defined Project Scope	3	8	7	5	0
		Structured Approach	3	7	9	3	1
		Scope Changes	1	9	7	6	0
3	Time Management	Tasks Arrangement	2	3	11	6	1
		Project Schedules Tracking	3	1	9	8	2
		Updating Project Schedules	0	6	6	9	2
4	Cost Management	Standardized Cost Estimate	2	10	6	4	1
		Project Expenditures	2	7	10	4	0
		Cost Performance	4	7	5	7	0
5	Quality Management	Quality Standards	2	8	9	3	1
		Quality Checks	3	9	7	3	1
		Quality Documentation	3	8	7	4	1
6	Human Resource Management	Project Roles & Responsibilities	2	7	10	3	1
		Team Performance	1	8	7	6	1
		Human resource planning	1	5	7	9	1
7	Communications Management	Communication Plans	1	8	11	3	0
		Stakeholder Information Needs	1	4	15	2	1
		Stakeholder Updates	1	7	13	2	0
8	Risk Management	Potential Project Risks	1	11	9	1	1
		Risk Response Plans	1	8	11	2	1
		Risk Management Outcomes	0	12	9	2	0
9	Procurement Management	Procurement Needs Identification	1	11	6	4	1
		Contractor Performance Evaluation	1	7	11	4	0

Figure 5: CEO PMMM Chart



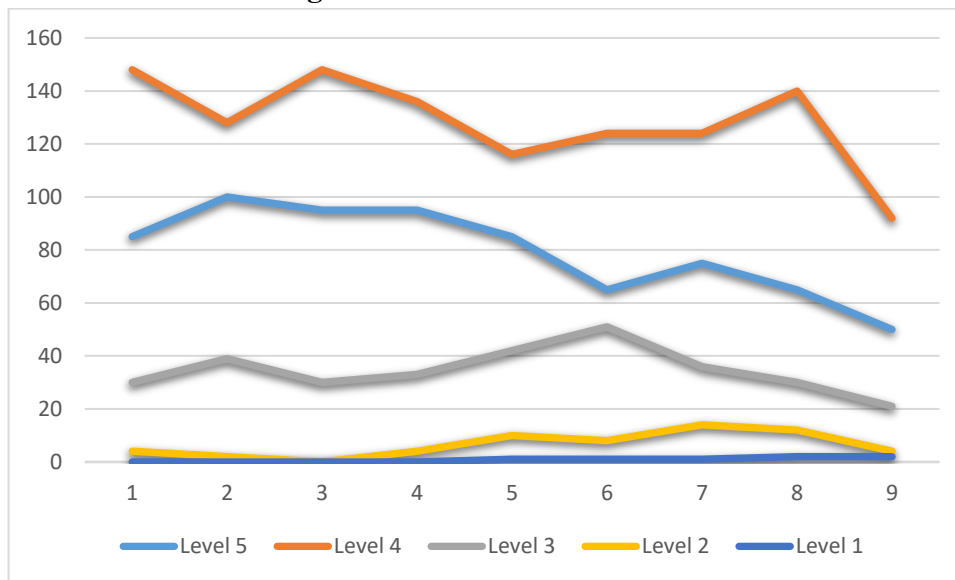
In the case of the City Engineer’s Office (CEO), PMMM data analysis accounts for the localized and community oriented nature of city level construction projects. Table 16 reflect how the project management maturity is concentrated mainly at Level 3 and Level 4. This is evident in Figure 5 where the Level 3 and Level 4 lines dominate most knowledge areas, indicating that key procedures are generally defines and implemented, although optimization remains limited. Level 5 responses are present but relatively small across indicators, which suggests that continuous improvement practices are not yet consistently embedded into daily project delivery.

Table 17: USTP PMMM Result

	Knowledge Area	Variables	Level 5	Level 4	Level 3	Level 2	Level 1
1	Integration Management	Project Brief	5	15	2	0	0
		Approved Project Plans	6	10	4	2	0
		Lessons Learned	6	12	4	0	0
2	Scope Management	Defined Project Scope	7	11	4	0	0
		Structured Approach	6	9	7	0	0
		Scope Changes	7	12	2	1	0
3	Time Management	Tasks Arrangement	7	11	4	0	0
		Project Schedules Tracking	6	14	2	0	0
		Updating Project Schedules	6	12	4	0	0
4	Cost Management	Standardized Cost Estimate	6	11	4	1	0
		Project Expenditures	6	12	3	1	0
		Cost Performance	7	11	4	0	0
5	Quality Management	Quality Standards	6	9	5	1	1
		Quality Checks	5	10	4	3	0
		Quality Documentation	6	10	5	1	0
6	Human Resource Management	Project Roles & Responsibilities	5	12	4	1	0
		Team Performance	5	9	7	1	0

		Human resource planning	3	10	6	2	1
7	Communications Management	Communication Plans	5	12	3	2	0
		Stakeholder Information Needs	5	10	3	3	1
		Stakeholder Updates	5	9	6	2	0
8	Risk Management	Potential Project Risks	6	10	3	3	0
		Risk Response Plans	3	12	4	2	1
		Risk Management Outcomes	4	13	3	1	1
9	Procurement Management	Procurement Needs Identification	6	11	3	1	1
		Contractor Performance Evaluation	4	12	4	1	1

Figure 6: USTP PMMM Chart



For the USTP, Table 17 show a maturity pattern that is strongly weighted toward the upper levels of the PMMM scale. Across all nine knowledge areas, Level 4 consistently records the highest frequencies, while Level 5 appears as the next most common rating. This is reflected in Figure 6 where the Level 4 line remains dominant across Areas 1-8, indicating that USTP’s project management processes are generally implemented with formal controls, oversight, and routine monitoring.

The distribution also highlights where maturity becomes less uniform. Quality Management and Human Resource Management show a noticeable rise in Level 3 and Level 2 counts, implying that these functions are established and repeatable but may not always be managed through consistent performance measurement across all projects. A similar pattern is visible in Communications where Level 2 and Level 1 responses become more visible than in earlier areas, indicating variability in how stakeholder information routines and risk response practices are executed across units. USTP demonstrates a managed to optimizing maturity profile, characterized by strong documentation and planning rigor, with improvement opportunities most evident in procurement strengthening and the consistent management of HR, communications, risk and selected quality routines.

Overall, the PMMM based data analysis provides a structured and comparable assessment of project management maturity across DPWH, CEO, and USTP. The maturity outputs generated in this section provide the empirical basis for reporting and discussing the comparative maturity levels in the preceding

chapter. By incorporating stratified tables and figures within this analytical framework, the study ensures transparency, replicability, and contextual relevance. The results derived from this analysis serve as the foundation for the presentation and interpretation of maturity levels in Chapter 4, while maintaining a clear methodological boundary between analysis and discussion.

3.5.4.2 Extent of Stakeholders Perception using Likert Rating Scale

The Likert rating scale is an ordinal measurement method used to record how respondents agree or disagree with a statement. In this study, it uses five options ranging from 1 (Strongly Agree) to 5 (Strongly Disagree), as shown in Table 18. Each response is collected as a category choice, making the results suitable for frequency counting and comparison. Because categories are ordered, higher ratings indicate stronger agreement, but the data are interpreted primarily through distributions than assuming equal values.

Table 18: Likert Rating Scale

Scale	Definition
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

In this research, the Likert scale was applied to quantify government stakeholders perceptions of benchmarking in construction quality management. Respondents rated attributes categorized into ten key performance indicators such as cost efficiency, timeliness, quality compliance, safety and risk, stakeholder satisfaction, regulatory compliance, innovation, productivity, data transparency, and human capital. Results from DPWH, CEO, and USTP were stratified, with each KPI summarized by the number of responses in each rating category. This structure enables direct comparison of how perceptions are distributed across agencies with different roles and operational context.

For the DPWH, Table 19 indicate generally higher levels of agreement regarding the usefulness of benchmarking in improving cost efficiency, schedule control, and regulatory compliance. The table corresponding to DPWH show a concentration of responses within the Agree and Strongly Agree categories, reflecting respondents familiarity with performance monitoring systems and standardized reporting requirements. These results suggest that DPWH stakeholders largely recognize benchmarking as a practical tool for enhancing project control and accountability, although variations remain in perception related to innovation and data transparency.

Table 19: Extent of DPWH Experts Perception

	Key Performance Indicator	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	1 Strongly Disagree	No Response
1	Cost Efficiency	11	30	13	0	0	0
		11	31	11	1	0	0
2	Timeliness	12	33	9	0	0	0

		7	34	13	0	0	0
3	Quality Compliance	10	35	8	1	0	0
		8	30	16	0	0	0
4	Safety and Risk	8	35	10	1	0	0
		12	29	12	1	0	0
5	Stakeholder Satisfaction	10	36	8	0	0	0
		4	31	17	1	1	0
6	Regulatory Compliance	11	31	11	1	0	0
		5	40	9	0	0	0
7	Innovation	13	33	8	0	0	0
		4	35	15	0	0	0
8	Productivity	9	37	7	1	0	0
		8	32	12	1	0	1
9	Data Transparency	9	36	7	1	0	1
		9	28	16	0	0	1
10	Human Capital	16	30	6	1	0	1
		12	30	10	1	0	1

In contrast, the City Engineer’s Office (CEO) exhibits more moderate perception levels, as reflected in Table 20. Responses are predominantly clustered between Neutral and Agree, particularly for indicators related to benchmarking role in productivity improvement and data driven decision making. The table show relatively stronger agreement in areas such as stakeholder satisfaction and communication, which aligns with the CEO’s localized project coordination role. However, lower agreement levels are observed for indicators associated with advanced benchmarking practices, such as systematic KPI comparison and post-project performance reviews.

Table 20: Extent of CEO Experts Perception

	Key Performance Indicator	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	1 Strongly Disagree	No Response
1	Cost Efficiency	10	11	1	0	1	0
		11	10	1	0	1	0
2	Timeliness	7	12	3	0	1	0
		10	11	1	0	1	0
3	Quality Compliance	8	12	2	0	1	0
		6	11	4	1	1	0
4	Safety and Risk	7	15	0	0	1	0
		9	10	2	1	1	0
5	Stakeholder Satisfaction	5	13	4	0	1	0
		4	12	5	1	1	0
6	Regulatory Compliance	6	11	4	1	1	0
		6	11	3	2	1	0
7	Innovation	7	14	1	0	1	0
		8	12	1	1	1	0
8	Productivity	7	13	2	1	0	0
		7	13	1	2	0	0
9	Data Transparency	9	14	0	0	0	0
		8	9	5	1	0	0
10	Human Capital	7	13	2	0	1	0
		5	12	4	1	1	0

For the USTP, Table 21 reveal a distinct perception pattern. The tables indicate higher agreement levels for indicators related to planning, documentation, and analytical evaluation, as illustrated in the corresponding figures. Respondents generally acknowledge the conceptual value of benchmarking in improving quality compliance and human capital development. However, the figures also show a higher frequency of Neutral responses for indicators related to procurement efficiency, timeliness, and operational benchmarking, reflecting USTP’s limited involvement in direct construction implementation.

Table 21: Extent of USTP Experts Perception

	Key Performance Indicator	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	1 Strongly Disagree	No Response
1	Cost Efficiency	7	13	2	0	0	0
		7	12	2	1	0	0
2	Timeliness	7	11	3	1	0	0
		10	8	4	0	0	0
3	Quality Compliance	10	8	3	1	0	0
		4	17	0	1	0	0
4	Safety and Risk	11	9	1	1	0	0
		10	10	1	1	0	0
5	Stakeholder Satisfaction	10	9	3	0	0	0
		8	11	3	0	0	0
6	Regulatory Compliance	12	7	3	0	0	0
		7	8	6	1	0	0
7	Innovation	8	12	2	0	0	0
		8	11	3	0	0	0
8	Productivity	9	10	3	0	0	0
		8	7	5	2	0	0

9	Data Transparency	8	11	3	0	0	0
		10	8	3	1	0	0
10	Human Capital	9	9	3	1	0	0
		8	9	4	1	0	0

Across all three strata, the consolidated tables demonstrate that stakeholders generally perceive benchmarking as beneficial, particularly in enhancing quality awareness, accountability, and performance evaluation. However, the extent of agreement varies by agency, with DPWH showing the strongest positive perception, followed by CEO and USTP. These variations highlight the influence of organizational role, exposure to formal performance systems, and project execution responsibility on stakeholders’ perception of benchmarking implementation.

Overall, the Likert scale results presented in the tables and figures provide empirical evidence of stakeholders’ readiness and receptiveness toward benchmarking in government construction projects. These findings establish an important perceptual baseline that supports the subsequent identification of barriers and prioritization of strategies using pairwise comparison and fuzzy analytic hierarchy process in later sections of the analysis.

3.5.4.3 Pairwise Comparison

Pairwise comparison analysis was used to support the prioritization requirements of Research Objectives 3 and 4 by recording stakeholder judgment into a structured set of relative preferences. Since multiple barriers and strategies were assessed, the analysis followed a two-level judgment structure to keep comparisons systematic and reduce inaccurate judgment. This approach enabled the study to convert qualitative expert opinions into comparable numerical priorities, ensuring that the most practical strategies could be ranked objectively.

Table 22: Compiled Pairwise Comparison of the Barriers Dimensions

	KPI Integration	Quality Management Systems	Leadership Commitment	Technological Adoption	Collaboration
KPI integration	1	1/3	1/2	1/5	1/4
Quality Management Systems	3	1	2	1/4	1/3
Leadership commitment	2	1/2	1	1/4	1/3
Technological adoption	5	4	4	1	2
Collaboration	4	3	3	1/2	1

The first level of judgment involved the comparison of the main dimensions influencing benchmarking implementation. These dimensions represent higher level groupings of related factors derived from the research framework, such as governance and policy related issues, quality management system limitations,

leadership and organizational factors, technological readiness, and collaboration related constraints. Stakeholders compared these dimensions pairwise to determine their relative importance in affecting benchmarking adoption. The resulting judgments were organized into a dimension level pairwise comparison matrix, which forms the basis for computing the relative weights of each dimension. The compiled comparison data for the key barriers main dimensions are presented in Table 22, whereas Table 23 presents the compiled comparison data for the proposed strategies.

Table 23: Compiled Pairwise Comparison of the Strategies Dimensions

	Digital tools	Training	Leadership	Prioritization of KPIs	External support
Digital tools	1	1/4	1/5	1/4	1/3
Training	4	1	1/3	1	3
Leadership	5	3	1	3	4
Prioritization of KPIs	4	1	1/3	1	3
External support	3	1/3	1/4	1/3	1

The second level of judgment focused on the comparison of sub-dimensions within each main dimension. These sub-dimensions correspond to the specific benchmarking barriers and proposed strategies identified in Table 10 and Table 11. Separate pairwise comparison matrices were constructed for each set of sub-dimension to ensure that comparisons were made only among conceptually related factors. This level of analysis captures finer distinctions among individual barriers and strategies while remaining consistent with the broader priorities established at the dimension level. The pairwise comparison data for the sub-dimensions of the key barriers and proposed strategies are presented in Appendix.

Following matrix construction at both levels, normalization was performed to compute the relative weights of the dimensions and sub-dimensions. Dimension-level weights obtained from the first level of judgment were combined with the local weights of sub-dimensions derived from the second level to calculate overall priority values. This aggregation process ensures that the final prioritization reflects both the strategic importance of each dimension and the specific influence of individual barriers and strategies.

The outputs of this two-level pairwise comparison analysis served as validated inputs for the subsequent Fuzzy Analytic Hierarchy Process (FAHP). By structuring the analysis hierarchically, the study ensures that the identification of key barriers and the prioritization of strategies are based on a rigorous, transparent, and reproducible analytical process appropriate for complex decision-making in government construction benchmarking.

3.5.4.4 Fuzzy Analytic Hierarchy Process

The Fuzzy Analytic Hierarchy Process (FAHP) was applied to further analyze the results obtained from the pairwise comparison for Research Objective 3 and 4. FAHP was employed to address the inherent uncertainty, subjectivity, and vagueness in human judgment when evaluating complex decision criteria related to benchmarking implementation in government construction projects.

The FAHP analysis builds directly upon the validated pairwise comparison matrices derived in the previous section. Instead of using crisp numerical judgments, each linguistic judgment (e.g., equal importance, moderate importance, strong importance) is represented by a lower, middle, and upper bound, allowing preferences to be expressed as ranges rather than fixed values. This transformation ensures uniform interpretation of stakeholder judgments across all criteria. The linguistic scale and corresponding

TFNs used in this study are presented in Table 4. This table defines the fuzzy numerical ranges associated with Saaty’s scale and serves as the basis for converting pairwise comparison judgments into fuzzy form.

Table 24: Transformed Fuzzy Comparison Matrix of the Barriers Dimensions

	KPI Integration			Quality Management Systems			Leadership Commitment			Technological Adoption			Collaboration		
KPI integration	1	1	1	1/4	1/3	1/2	1/3	1/2	1	1/6	1/5	1/4	1/5	1/4	1/3
Quality Management Systems	2	3	4	1	1	1	2	3	4	1/6	1/5	1/4	1/4	1/3	1/2
Leadership commitment	1	2	3	1/4	1/3	1/2	1	1	1	1/5	1/4	1/3	1/4	1/3	1/2
Technological adoption	4	5	6	4	5	6	3	4	5	1	1	1	3	4	5
Collaboration	3	4	5	2	3	4	2	3	4	1/5	1/4	1/3	1	1	1

Table 25: Transformed Fuzzy Comparison Matrix of the Strategies Dimensions

	Digital tools			Training			Leadership			Prioritization of KPIs			External support		
Digital tools	1	1	1	1/5	1/4	1/3	1/6	1/5	1/4	1/5	1/4	1/3	1/4	1/3	1/2
Training	3	4	5	1	1	1	1/4	1/3	1/2	1	1	1	2	3	4
Leadership	4	5	6	2	3	4	1	1	1	2	3	4	3	4	5
Prioritization of KPIs	3	4	5	1	1	1	1/4	1/3	1/2	1	1	1	2	3	4
External support	2	3	4	1/4	1/3	1/2	1/5	1/4	1/3	1/4	1/3	1/2	1	1	1

For both the barriers and strategies, the crisp pairwise comparison matrices were first transformed into fuzzy pairwise comparison matrices, shown in Table 24 and Table 25, using the TFNs defined in Table 5. Each comparison value was replaced with its corresponding triangular fuzzy number, resulting in a fuzzy reciprocal matrix. Separate fuzzy matrices were constructed for the main dimensions and for the sub-criteria, consistent with the two-level judgment structure established in the pairwise comparison analysis.

Table 26: Crisp Comparison Matrix of the Barriers Dimensions

	KPI Integration	Quality Management Systems	Leadership Commitment	Technological Adoption	Collaboration
KPI integration	1.00	0.35	0.42	0.20	0.26
Quality Management Systems	3.00	1.00	1.04	0.24	0.39
Leadership commitment	2.67	1.52	1.00	0.26	0.42

Technological adoption	5.00	4.33	4.00	1.00	2.67
Collaboration	4.00	3.00	2.67	0.42	1.00

Table 27: Crisp Comparison Matrix of the Strategies Main Dimensions

	Digital tools	Training	Leadership	Prioritization of KPIs	External support
Digital tools	1.00	0.26	0.20	0.26	0.35
Training	4.00	1.00	0.35	1.00	3.00
Leadership	5.00	3.00	1.00	3.00	4.00
Prioritization of KPIs	4.00	1.00	0.35	1.00	3.00
External support	3.00	0.35	0.26	0.35	1.00

Following matrix construction, the fuzzy synthetic extent values were computed using Buckley’s FAHP method. This process involves aggregating the fuzzy comparison values across each row of the matrix and normalizing them to obtain fuzzy weights for each criterion. The mathematical formulation used to compute the fuzzy weights is defined in Equation 7, which converts the fuzzy comparison data into comparable fuzzy priority values. Table 26 and 27 shows the crisp comparison matrices for the barriers and proposed strategies main dimension.

Table 28: Resulting Matrix of the Barriers Dimensions

Dimensions	Normalization					Priority Vector (W)	X=AW	AW= λ W
KPI integration	0.064	0.034	0.046	0.120	0.054	0.063	0.324	5.102
Quality Management Systems	0.191	0.098	0.114	0.140	0.082	0.125	0.665	5.321
Leadership Commitment	0.170	0.149	0.110	0.151	0.088	0.134	0.720	5.394
Technological Adoption	0.319	0.425	0.439	0.590	0.564	0.467	2.553	5.464
Collaboration	0.255	0.294	0.292	0.246	0.212	0.260	1.439	5.540

Table 29: Resulting Matrix of the Strategies Dimensions

Dimensions	Normalization					Priority Vector (W)	X=AW	AW= λ W
Digital tools	0.059	0.046	0.094	0.046	0.031	0.055	0.283	5.144
Training	0.235	0.178	0.161	0.178	0.264	0.204	1.083	5.319
Leadership	0.294	0.535	0.465	0.535	0.353	0.436	2.339	5.359
Prioritization of KPIs	0.235	0.178	0.161	0.178	0.264	0.204	1.083	5.319
External support	0.176	0.062	0.119	0.062	0.088	0.101	0.519	5.118

To facilitate ranking and further analysis, the fuzzy weights were subsequently transformed into crisp values through a defuzzification process. The defuzzification method applied in this study uses the geometric mean approach, which calculates a single representative value for each triangular fuzzy number. The defuzzification formula is presented in Equation 10, allowing the fuzzy weights to be converted into

crisp priority scores suitable for normalization and ranking. Finally, the resulting matrix in Table 28 and Table 29 shows the weighted sum criteria using equation 12.

Table 30: Resulting Crisp Weights of the Barriers Dimensions

Dimensions	RI(Fuzzy Matrix)			GM			WI (Fuzzy Weights)			Defuzzy wi (CoA)	Normalized wi
KPI integration	0.297	0.365	0.488	0.035	0.055	0.098	0.063	0.057			
Quality Management Systems	0.559	0.760	1.045	0.066	0.115	0.209	0.130	0.119			
Leadership commitment	0.591	0.828	1.137	0.070	0.126	0.228	0.141	0.129			
Technological adoption	2.316	2.970	3.578	0.275	0.451	0.717	0.481	0.440			
Collaboration	1.227	1.656	2.177	0.146	0.252	0.436	0.278	0.254			
RI Inverse	0.119	0.152	0.200			Total	1.094	1			

Table 31: Resulting Crisp Weights of the Strategies Dimensions

Dimensions	RI(Fuzzy Matrix)			GM			WI (Fuzzy Weights)			Defuzzy wi (CoA)	Normalized wi
KPI integration	0.278	0.334	0.425	0.036	0.052	0.083	0.057	0.054			
Quality Management Systems	1.084	1.320	1.585	0.138	0.206	0.311	0.218	0.206			
Leadership commitment	2.169	2.825	3.438	0.277	0.441	0.675	0.464	0.437			
Technological adoption	1.084	1.320	1.585	0.138	0.206	0.311	0.218	0.206			
Collaboration	0.478	0.608	0.803	0.061	0.095	0.158	0.105	0.098			
RI Inverse	0.128	0.156	0.196			Total	1.063	1			

Once defuzzied, the resulting crisp weights were normalized to ensure that the sum of all criteria weights equals one, as shown in Table 30 and Table 31. This normalization process produces the final priority weights for the key barriers and proposed strategies, representing the relative importance of each barrier and the relative effectiveness of each strategy under fuzzy conditions, and ensures comparability of results across all evaluated criteria.

The FAHP analysis concludes by validating the coherence of the fuzzy judgments through consistency verification inherited from the initial pairwise comparison stage. Since the fuzzy matrices are derived from consistency-validated crisp matrices, the resulting fuzzy priorities maintain logical reliability while offering improved representation of stakeholder uncertainty.

Overall, the application of FAHP enhances the strength of the multi-criteria decision-making process by integrating human judgment uncertainty into the prioritization of benchmarking barriers and strategies, serving as the final analytical input for identifying the most critical challenges and the most effective interventions related to benchmarking implementation discussed in Chapter 4.

4. Results and Discussion

This chapter presents and discusses the study findings derived from government stakeholders involved in construction projects in Cagayan de Oro City. The findings are organized by research objectives and provide an overview of the current state of benchmarking in construction quality management within the local government sector, highlighting operational setting and constraints that form current practice. It

begins with the presentation of validity and reliability results to confirm the adequacy and consistency of the survey instrument used in the study. This step is necessary because the succeeding analyses depend on stakeholder assessments that will be used to determine maturity levels, perception ratings, and priority judgments across institutions.

Subsequent sections present the PMMM maturity assessment and the Likert-based perception results, addressing the first and second research objectives. The results are discussed at both an overall level and by institutional group, namely the Department of Public Works and Highways (DPWH), the City Engineer’s Office (CEO), and the University of Science and Technology of Southern Philippines (USTP), to reflect differences in organizational roles and responsibilities. The chapter concludes with the outcomes of the pairwise comparison and Fuzzy Analytic Hierarchy Process (FAHP) procedures, which identify key barriers to benchmarking adoption and prioritize the most suitable strategies, providing the basis for the conclusions and recommendations in Chapter 5.

4.1 Validity and Reliability Tests

Prior to the analysis and interpretation of the main results, validity and reliability tests were conducted using SPSS. These tests are essential in confirming that the constructs measured in the study accurately represent the intended variables and that the responses are reliable for further analysis. The results of these tests provide assurance that subsequent findings related to maturity assessment, stakeholder perception, and prioritization of barriers and strategies are based on robust and credible data.

4.1.1 Kaiser–Meyer–Olkin (KMO) Measure and Bartlett’s Test of Sphericity

The Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy and Bartlett’s Test of Sphericity were applied using SPSS, to assess the suitability of the dataset. The KMO value obtained indicates that the sample size and the pattern of correlations among variables are adequate for further statistical analysis. Meanwhile, Bartlett’s Test of Sphericity yielded a statistically significant result, confirming that the correlation matrix is not an identity matrix and that meaningful relationships exist among the variables.

Table 32: KMO and Bartlett’s Test of Sphericity Results

	KMO Value	Bartlett’s Test χ^2	Degrees of Freedom (df)	Sig. (p-value)	Interpretation
Project Management Maturity Model	0.915	2265.605	325	<.001	Marvelous
Stakeholders’ Perception	0.895	1522.279	190	<.001	Meritorious
Barriers & Strategies	0.764	4047.810	1275	<.001	Middling

4.1.2 Cronbach’s Alpha Reliability Test

Cronbach’s Alpha was computed using SPSS, to evaluate the internal consistency and reliability of the survey instrument. The resulting alpha coefficients indicate acceptable to high levels of reliability across the measured constructs, suggesting that the questionnaire items consistently measure the same underlying concepts. This level of internal consistency confirms that the survey instrument is reliable for assessing project management maturity, stakeholders’ perception, and benchmarking-related factors.

Table 33: Cronbach’s Alpha Reliability Results

	No. of Items	Cronbach’s Alpha	Interpretation
Project Management Maturity Model	26	0.964	Excellent

Stakeholders' Perception	20	0.956	Excellent
Barriers & Strategies	51	0.948	Excellent

The Cronbach's Alpha reliability test results are summarized in Table 33. These tables present the internal consistency of the PMMM indicators, stakeholders' perception items, and the barriers and strategies variables. The reported coefficients demonstrate that the survey instruments used in this study exhibit high levels of reliability. The excellent reliability results provide confidence that the responses are stable and dependable, thereby strengthening the credibility of the findings presented in the succeeding sections of this chapter.

4.2 Project Management Maturity (PMMM) Level

This section presents the results of the PMMM assessment conducted to address Research Objective 1, which aims to determine the maturity level of project management and quality management practices in government agencies. The results are derived from the PMMM rating scale applied across the PMBOK knowledge areas and are presented using summary and stratified tables to facilitate comparison and interpretation. The findings provide an overview of the current state of maturity and serve as a basis for understanding benchmarking readiness within the government construction sector.

4.2.1 Overall PMMM Maturity Level

The overall PMMM results indicate that the agencies predominantly operate at the mature level of project management practice, as evidenced by the high proportion of responses classified under the mature category across all PMBOK knowledge areas. As shown in Table 34, the percentage of respondents indicating mature practices ranges from 55% to 66%, demonstrating that structured and standardized project management processes are generally established within the agencies.

Table 34: Overall PMMM Maturity Result

Knowledge Area	Poor (Level 1-2)	Medium (Level 3)	Mature (Level 4-5)
Integration Management	8%	27%	65%
Scope Management	8%	27%	66%
Time Management	13%	32%	55%
Cost Management	8%	26%	66%
Quality Management	9%	31%	59%
Human Resource Management	12%	33%	55%
Communications Management	8%	36%	56%
Risk Management	10%	30%	60%
Procurement Management	10%	33%	58%

Among the knowledge areas, Cost Management and Scope Management exhibit the highest levels of maturity, with 66% and 65% of responses, respectively, classified as mature. These results suggest strong capability in managing project scope and financial resources, which are critical areas in government construction projects due to regulatory oversight and budgetary constraints. Integration Management and Time Management also show a high proportion of mature responses at 65%, indicating effective coordination of project components and adherence to project schedules.

Relatively lower maturity levels are observed in Human Resource Management, Communications Management, and Procurement Management, where mature responses range from 55% to 58%. Although these areas still reflect a majority of mature practices, the higher proportions of medium and poor ratings

suggest that people and coordination-related processes are less consistently institutionalized. Risk Management and Quality Management display moderate maturity levels, with 60% and 59% mature responses, indicating that while these practices are present, opportunities remain to further strengthen proactive risk handling and quality assurance mechanisms.

Overall, the distribution of maturity levels across knowledge areas suggests that the agencies have largely moved beyond ad hoc project management practices and have established formal systems. However, the variation in maturity percentages highlights the need to further enhance consistency and integration across all knowledge areas to support higher levels of project management maturity and benchmarking readiness.

4.2.2 Overall PMMM Weights and Rankings

An examination of the PMMM results using the Maturity Index (Mi), Weight Index (Wi), and ranking provides a clearer comparison of maturity levels across the PMBOK knowledge areas. As presented in Table 35, all knowledge areas posted Mi values exceeding 3.50, suggesting that project management practices are generally implemented at a mature level across the participating agencies. However, variations in the corresponding Wi values and rankings reveal differences in the relative emphasis and strength of specific knowledge areas. These variations highlight uneven development in project management capabilities and point to areas where focused improvement efforts may be required.

Table 35: Overall PMMM Ranking

Knowledge Area	Mi	Wi	Rank
Scope Management	3.76	0.115	1
Cost Management	3.75	0.114	2
Integration Management	3.72	0.114	3
Quality Management	3.65	0.111	4
Procurement Management	3.60	0.110	5
Risk Management	3.59	0.109	6
Time Management	3.58	0.109	7
Communications Management	3.58	0.109	8
Human Resource Management	3.57	0.109	9

Scope Management ranked first, recording the highest Mi value of 3.76 and the weight index ($W_i = 0.115$). This indicates that scope definition, control, and change management are strongly emphasized, which is expected in public construction projects where uncontrolled scope adjustments can cause cost escalation, schedule disruption, and compliance issues.

Cost Management and Integration Management followed closely in second and third, with Mi values of 3.75 and 3.72, respectively. Their high rankings suggest that the government entities place strong priority on financial accountability and on coordinating project components to maintain alignment with objectives, requirements, and implementation processes. These results reflect a management environment that values control, coordination, and documentation.

Mid-ranked areas include Quality Management (rank 4) and Procurement Management (rank 5), with Mi values of 3.65 and 3.60. While both remain within the mature range, the lower ratings imply that quality assurance and procurement processes may be more compliance driven than performance optimized. This indicates potential for further enhancement through systematic benchmarking and continuous improvement initiatives.

The lowest ranked knowledge areas are Risk Management, Time Management, Communications Management, and Human Resource Management, which ranked sixth, seventh, eighth, and ninth, respectively. Although their Mi values still fall within mature category, their lower weight indices ($W_i = 0.109$) indicate comparatively weaker institutionalization. This suggest that proactive risk practices, schedule planning and control, structured communication, and workforce development may receive less emphasis, highlighting areas where targeted actions may be necessary to support higher maturity and benchmarking readiness.

Overall, the PMMM profile demonstrate stronger maturity in technically regulated and control oriented domains, while people centered and adaptive management areas exhibit comparatively lower maturity. This pattern provides a useful direction for benchmarking initiatives that aim to strengthen maturity in a more balanced and sustainable manner.

4.2.3 PMMM Results by Institutional Strata

This subsection presents the PMMM results by institutional strata to determine variations in maturity levels among the participating government entities. The analysis focuses on three institutions involved in government construction projects, namely the Department of Public Works and Highways (DPWH), the City Engineer’s Office (CEO), and the University of Science and Technology of Southern Philippines (USTP). Disaggregating the results allows maturity patterns to be interpreted in relation to each institution’s mandate, project environment, and operational context where strengths are concentrated and gaps remain. The results are presented using institution specific tables to support comparative interpretation.

4.2.3.1 PMMM Results by DPWH

The PMMM results for the Department of Public Works and Highways (DPWH) reflect consistently mature performance across all PMBOK knowledge areas, with Maturity Index (Mi) values ranging from 3.57 to 3.83, as shown in Table 36. This indicates that DPWH has largely institutionalized formal project management practices, likely supported by standardized systems and regulatory requirements governing national infrastructure delivery. The relatively low proportions of poor ratings across all knowledge areas further supports consistency in the application of established management processes.

Table 36: DPWH PMMM Maturity Result

Knowledge Area	Poor	Medium	Mature	Mi	Wi	Rank
Scope Management	2%	14%	37%	3.83	0.115	1
Cost Management	2%	15%	37%	3.81	0.114	2
Integration Management	3%	14%	36%	3.76	0.113	3
Human Resource Management	3%	19%	32%	3.70	0.111	4
Time Management	4%	20%	30%	3.69	0.111	5
Quality Management	3%	19%	32%	3.69	0.111	5
Procurement Management	3%	21%	31%	3.64	0.109	6
Communications Management	3%	18%	32%	3.61	0.108	7
Risk Management	5%	17%	32%	3.57	0.107	8

Among the knowledge areas, Scope Management achieved the highest maturity level, ranking first with a Mi value of 3.83 and a Weight Index (W_i) of 0.115. This shows DPWH’s strong capability in defining, controlling, and managing project scope, which is essential in large scale projects where scope changes

can significantly affect both cost and time performance. Cost Management and Integration Management also demonstrate high maturity, ranking second and third, reinforcing DPWH’s emphasis on budgetary control and coordination of project components.

Time Management, Quality Management, and Human Resource Management have Mi values ranging from 3.69 to 3.81. While these areas fall within the mature category, their comparatively lower rankings suggest that opportunities exist to further enhance schedule optimization, quality assurance systems, and workforce management practices. These findings imply that although DPWH maintains strong technical and control oriented capabilities, some supporting management functions may benefit from further refinement.

The lowest rankings were observed in Communications Management, Risk Management, and Procurement Management, with Mi values of 3.61, 3.57, and 3.64. Although still within the mature range, the lower ranks indicate that structured communication planning, proactive risk management, and procurement efficiency may be less emphasized relative to scope and cost control. Overall, the DPWH demonstrates a maturity profile characterized by standardized control mechanisms, with opportunities to strengthen adaptive and risk response functions to support continuous improvement and benchmarking.

4.2.3.2 PMMM Results by CEO

The PMMM results for the City Engineer’s Office (CEO) indicate a moderate to mature level of project management practice across the PMBOK knowledge areas, with Maturity Index (Mi) values ranging from 3.06 to 3.38, as shown in Table 37. Compared to national agencies, the maturity profile of the CEO reflects the localized and operational nature of city-level construction projects, where project management practices are applied within more constrained institutional and resource environments. The distribution of poor, medium, and mature ratings suggests that while formal practices are present, their application is less consistently institutionalized.

Table 37: CEO PMMM Maturity Result

Knowledge Area	Poor	Medium	Mature	Mi	Wi	Rank
Risk Management	2%	10%	11%	3.38	0.116	1
Quality Management	4%	8%	11%	3.36	0.116	2
Cost Management	5%	7%	11%	3.33	0.115	3
Integration Management	4%	9%	10%	3.33	0.115	3
Scope Management	5%	8%	10%	3.32	0.114	4
Procurement Management	5%	9%	10%	3.26	0.112	5
Communications Management	3%	13%	7%	3.23	0.111	6
Human Resource Management	7%	8%	8%	3.06	0.105	7
Time Management	9%	9%	5%	2.81	0.097	8

Among the knowledge areas, Risk Management achieved the highest maturity ranking, with a Mi value of 3.38 and a Weight Index (Wi) of 0.116, ranking first overall. This suggests that the CEO places relatively strong emphasis on identifying and managing uncertainties, likely due to the direct exposure of local government projects to environmental, community, and operational constraints. Quality Management followed closely, indicating attention to compliance standards and inspection requirements, while Cost and Integration Management suggest financial control and active coordination, though not uniformly applied.

Procurement Management, and Communications Management, with Mi values ranging from 3.23 to 3.36 ranked in the middle. These results indicate that procurement and communication practices are generally present, but may vary across projects. The presence of medium and poor ratings in these areas suggests that standardized procedures are not uniformly applied, potentially influenced by project scale differences and administrative constraints.

Ranking lastly are knowledge areas Time Management and Human Resource Management, with Mi values of 3.06 and 2.81. The notably lower Mi for time management indicates that schedule planning, tracking, and corrective control are more challenging within the CEO, while the HR ranking suggests constraints in workforce planning, assignment stability, and capability development. Overall, the PMMM results reflect developing institutional systems with particular strengths in risk and quality, alongside improvement needs in schedule management and human resource reinforcement.

4.2.3.3 PMMM Results by USTP

The University of Science and Technology of Southern Philippines (USTP) recorded the highest maturity levels among the three strata, with Maturity Index (Mi) values ranging from 3.77 to 4.14, as shown in Table 38. The very low proportions of poor and medium ratings suggest that management processes are not only present but consistently applied, indicating strong institutional reinforcement of project management practices, particularly in planning oriented areas.

Table 38: USTP PMMM Maturity Result

Knowledge Area	Poor	Medium	Mature	Mi	Wi	Rank
Time Management	0%	3%	19%	4.14	0.117	1
Scope Management	0%	4%	17%	4.08	0.115	2
Cost Management	1%	4%	18%	4.06	0.115	3
Integration Management	1%	3%	18%	4.05	0.114	4
Quality Management	2%	5%	15%	3.85	0.109	5
Procurement Management	2%	4%	17%	3.84	0.109	6
Communications Management	3%	4%	15%	3.79	0.107	7
Risk Management	3%	3%	16%	3.77	0.107	8
Human Resource Management	2%	6%	15%	3.77	0.107	8

Time Management ranked first, with a Mi value of 4.14 and a Wi of 0.117, emphasizing high capability in planning, scheduling, and timeline monitoring. This aligned with USTP’s structured planning environment and academic project oversight. Scope Management and Cost Management also demonstrate high maturity levels, ranking second and third, indicating effective control over project scope and financial resources.

Integration Management and Quality Management also demonstrate strong maturity with Mi values of 4.05 and 3.85, reflecting coordination among project components and adheres to quality standards, although these practices may be more formalized in planning and evaluation stages rather than in execution activities. Procurement Management also exhibits mature practices, suggesting adequate compliance with institutional requirements.

The lowest rankings were observed in Human Resource Management, Communications Management, and Risk Management, with Mi values of 3.77 to 3.79. While these areas still fall within the mature category, their lower rankings indicate comparatively less emphasis on workforce deployment, communication

planning, and proactive risk management. Overall, USTP shows a maturity profile centered in planning and analytical control, with opportunities to further strengthen people oriented and risk based practices to support comprehensive benchmarking.

4.2.4 Discussion of PMMM Findings

The PMMM results reveal that while all participating institutions demonstrate mature levels of project management practice, the degree and nature of maturity vary across organizational contexts. The comparative analysis across DPWH, CEO, and USTP indicates that project management maturity is strongly influenced by institutional mandate, project scale, and functional role within government construction delivery. Rather than reflecting a uniform maturity profile, the results highlight differentiated strengths and limitations aligned with each institution's operational environment.

DPWH exhibits a maturity profile characterized by strong performance in control centered knowledge areas such as scope, cost, and integration management. This reflects the agency's national mandate, standardized systems, and strict regulatory oversight, which emphasize compliance, coordination, and financial accountability. In contrast, the City Engineer's Office demonstrates moderate maturity levels with greater variability across knowledge areas, suggesting that while formal project management practices are present, their consistent institutionalization is constrained by localized project conditions, limited resources, and administrative demands. USTP records the highest overall maturity levels, particularly in planning and analysis driven areas such as time, scope, and cost management, which aligned with an environment where planning and evaluation processes are strongly structured.

Across all strata, comparatively lower maturity levels are observed in people centered and adaptive knowledge areas, particularly human resource management, communications management, and risk management. This pattern suggests a broader tendency in government construction delivery to prioritize technically regulated and compliance driven functions, while management area that support coordination, organizational learning, workforce development, and proactive uncertainty management receive less sustained institutional reinforcement. Addressing weaker domains through targeted benchmarking can support a more balanced maturity profile and improve long-term performance outcomes.

4.3 Stakeholders' Perception on Benchmarking Implementation

This section presents the Likert scale results used to address Research Objective 2 by examining how government stakeholders perceive benchmarking in construction quality management. Perceptions were assessed across key performance indicators (KPIs) covering cost, time, quality, safety, compliance, innovation, productivity, data transparency, and human capital. Results are summarized using the Relative Importance Index (RII) to determine which indicators stakeholders associate most strongly with benchmarking benefits, providing an overall view of how benchmarking is valued in local government construction projects.

4.3.1 Overall Stakeholders Perception

The overall results indicate that stakeholders generally hold a positive perception of benchmarking implementation in construction quality management, as reflected by consistently high Relative Importance Index (RII) values across all key performance indicators (KPIs). As shown in Table 39, the RII values range from 0.788 to 0.817, suggesting broad agreement among respondents on the relevance of benchmarking to project performance in government construction projects.

Table 39: Overall Stakeholders Perception Rating

KPI	SA*5	A*4	Ne*3	D*2	SD*1	Total (W)	A*N*Q	RII	Rank
Cost Efficiency	285	428	90	4	2	809	990	0.817	1
Safety and Risk	285	432	78	10	2	807	990	0.815	2
Timeliness	265	436	99	2	2	804	990	0.812	3
Innovation	240	468	90	2	2	802	990	0.810	4
Data Transparency	265	424	102	6	0	797	990	0.805	5
Human Capital	285	412	87	10	2	796	990	0.804	6
Productivity	240	448	90	14	0	792	990	0.800	7
Quality Compliance	230	452	99	8	2	791	990	0.799	8
Regulatory Compliance	235	432	108	10	2	787	990	0.795	9
Stakeholder Satisfaction	205	448	120	4	3	780	990	0.788	10

Among the indicators, Cost Efficiency ranked first with the highest RII value (0.817), highlighting stakeholders’ strong association of benchmarking with improved cost control and financial accountability. This aligns with the public-sector expectation that project delivery should demonstrate efficient use of government funds. Safety and Risk and Timeliness also ranked highly, indicating that benchmarking is perceived as contributing to safer project execution and better adherence to schedules.

A middle cluster of indicators include Innovation, Productivity, Human Capital, and Data Transparency, with RII values clustered around 0.800 to 0.810. These results imply that stakeholders recognize the role of benchmarking in supporting performance improvement and organizational capability, these benefits are perceived as less pronounced than those related to cost and safety. The lowest ranked indicators are Stakeholder Satisfaction and Regulatory Compliance. Despite reflecting positive perception, it still viewed as areas where the impact of benchmarking is more indirect. Overall, the results indicate that stakeholders primarily perceive benchmarking as a tool for performance monitoring and control rather than for broader organizational development.

4.3.2 Stakeholders Perception by Institutional Strata

This subsection presents the stakeholders’ perception of benchmarking implementation by institutional strata to examine differences in perception across government entities involved in construction projects. The analysis focuses on the Department of Public Works and Highways (DPWH), the City Engineer’s Office (CEO), and the University of Science and Technology of Southern Philippines (USTP). By comparing perception results across these institutions, this stratified analysis provides insight into variations in awareness, application, and perceived effectiveness of benchmarking within different organizational settings.

4.3.2.1 Stakeholders Perception by DPWH

The perception results for the Department of Public Works and Highways (DPWH) indicate a generally favorable assessment of benchmarking implementation across the evaluated key performance indicators, as reflected by Relative Importance Index (RII) values ranging from 0.770 to 0.800, as presented in Table 40. These results suggest that DPWH stakeholders recognize benchmarking as a relevant component of project management practice within national infrastructure projects.

Table 40: DPWH Stakeholders Perception Rating

KPI	SA*5	A*4	Ne*3	D*2	SD*1	Total (W)	A*N*Q	RII	Rank
Human Capital	140	240	48	4	0	432	540	0.800	1
Timeliness	95	268	66	0	0	429	540	0.794	2
Cost Efficiency	110	244	72	2	0	428	540	0.793	3
Safety and Risk	100	256	66	4	0	426	540	0.789	4
Regulatory Compliance	80	284	60	2	0	426	540	0.789	4
Innovation	85	272	69	0	0	426	540	0.789	4
Quality Compliance	90	260	72	2	0	424	540	0.785	5
Productivity	85	276	57	4	0	422	540	0.781	6
Data Transparency	90	256	69	2	0	417	540	0.772	7
Stakeholder Satisfaction	70	268	75	2	1	416	540	0.770	8

Among the evaluated dimensions, Human Capital and Capacity Building obtained the highest RII value (0.800), indicating that benchmarking is associated with workforce development, skills enhancement, and institutional capacity strengthening within DPWH. This suggests that stakeholders perceive benchmarking as contributing to internal capability improvement alongside project performance objectives. Schedule Performance and Timeliness and Cost Efficiency and Budget Compliance also ranked highly, reflecting the agency’s emphasis on timely delivery and financial accountability.

Several indicators, including Safety and Risk Management Performance, Governance and Regulatory Compliance, and Innovation and Continuous Improvement, recorded similar mid-range RII values (0.789). These results indicate that benchmarking is perceived as supporting compliance and improvement related practices, although the extent of its perceived influence varies across operational areas. The relatively close clustering of these indicators suggests a consistent but differentiated application of benchmarking across performance dimensions.

Lower ranked indicators include Stakeholder Satisfaction, Data Transparency, and Productivity, with RII values between 0.770 and 0.781. While still positive, these results suggests that benchmarking is seen as less directly connected to external satisfaction outcomes, transparency processes, and daily operational efficiency. This may also suggest that improvements in these area depend not only on benchmarking itself, but also on supporting systems.

4.3.2.2 Stakeholders Perception by CEO

The perception results for the City Engineer’s Office (CEO) expressed positive view of benchmarking, with Relative Importance Index (RII) values ranging from 0.765 to 0.857, as shown in Table 41. These results suggest that CEO stakeholders recognize the relevance of benchmarking in supporting project performance and governance within city level construction projects.

Table 41: CEO Stakeholders Perception Rating

KPI	SA*5	A*4	Ne*3	D*2	SD*1	Total (W)	A*N*Q	RII	Rank
Cost Efficiency	105	84	6	0	2	197	230	0.857	1
Timeliness	85	92	12	0	2	191	230	0.830	3
Quality Compliance	70	92	18	2	2	184	230	0.800	6
Safety and Risk	80	100	6	2	2	190	230	0.826	4

Stakeholder Satisfaction	45	100	27	2	2	176	230	0.765	9
Regulatory Compliance	60	88	21	6	2	177	230	0.770	8
Innovation	75	104	6	2	2	189	230	0.822	5
Productivity	70	104	9	6	0	189	230	0.822	5
Data Transparency	85	92	15	2	0	194	230	0.843	2
Human Capital	60	100	18	2	2	182	230	0.791	7

Cost Efficiency ranked first with the highest RII value (0.857), reflecting the strong emphasis placed on financial control and efficient utilization of public funds at the local government level. Data Transparency and Timeliness also ranked highly, with RII values of 0.843 and 0.830. These findings indicate that benchmarking is perceived as particularly valuable in enhancing transparency, supporting informed decision making, and improving adherence to project schedules.

Mid-ranked indicators include Innovation, Productivity, and Quality Compliance, with RII values ranging from 0.800 to 0.822. These results suggest that while benchmarking is associated with performance improvement and quality assurance, its perceived impact in these areas is moderate and may vary depending on project context and implementation practices.

The lowest rated indicators for the CEO include Safety and Risk, Stakeholder Satisfaction, Human Capital, and Regulatory Compliance, with RII values between 0.770 and 0.826. This demonstrates that stakeholders perceive benchmarking as having a less direct influence on safety management, satisfaction outcomes, workforce development, and regulatory processes.

4.3.2.3 Stakeholders Perception by USTP

The perception results for the University of Science and Technology of Southern Philippines (USTP) recorded Relative Importance Index (RII) values ranging from 0.823 to 0.868, as presented in Table 42. These results suggest that USTP stakeholders view benchmarking as a relevant and effective mechanism for supporting project performance, governance, and institutional development within the context of government academic construction projects.

Table 42: USTP Stakeholders Perception Rating

KPI	SA*5	A*4	Ne*3	D*2	SD*1	Total (W)	A*N*Q	RII	Rank
Safety and Risk	105	76	6	4	0	191	220	0.868	1
Stakeholder Satisfaction	90	80	18	0	0	188	220	0.855	2
Innovation	80	92	15	0	0	187	220	0.850	3
Data Transparency	90	76	18	2	0	186	220	0.845	4
Cost Efficiency	70	100	12	2	0	184	220	0.836	5
Timeliness	85	76	21	2	0	184	220	0.836	5
Regulatory Compliance	95	60	27	2	0	184	220	0.836	5
Quality Compliance	70	100	9	4	0	183	220	0.832	6
Human Capital	85	72	21	4	0	182	220	0.827	7
Productivity	85	68	24	4	0	181	220	0.823	8

Among the indicators, Safety and Risk Performance ranked first with the highest RII value (0.868), indicating that benchmarking is associated with promoting safe project execution and effective risk management practices within USTP managed projects. Stakeholder Satisfaction and Innovation also ranked highly, with RII values of 0.855 and 0.850. These findings suggest that stakeholders perceive

benchmarking as contributing to improved stakeholder engagement and fostering a culture of continuous improvement and innovation.

Data Transparency, Cost, Timeliness, and Regulatory Compliance related indicators clustered at RII values clustered around 0.836 to 0.845. These results indicate that benchmarking is perceived as moderately effective in supporting efficient operations, regulatory adherence, and financial management. The relatively close ranking of these indicators suggests a balanced perception of benchmarking across operational and compliance related dimensions.

Lower-ranked indicators for USTP include Quality Compliance, Human Capital, and Productivity, with RII values ranging from 0.823 to 0.832. Although these values still reflect agreement, they indicate that the perceived benchmarking influence is comparatively weaker in efficiency metrics and workforce related outcomes than in safety improvement areas.

4.3.3 Discussion of Perception Result

The results of the stakeholders' perception analysis show that benchmarking is widely regarded as relevant and beneficial in management of construction quality within government institutions. At the same time, the findings suggest that stakeholders do not view benchmarking in a uniform way across all performance areas. Instead, perceptions tend to reflect how closely benchmarking activities align with existing management systems, reporting requirements, and institutional responsibilities.

Across the different performance dimensions, benchmarking is most associated with areas such as cost efficiency, schedule performance, safety, and regulatory compliance. These aspects of project management are already supported by established procedures and measurable indicators, making the application of benchmarking more visible and easier to integrate into routine project oversight. As a result, stakeholders are more likely to perceive benchmarking as effective in supporting control, monitoring, and compliance related functions.

Perceptions are comparatively moderate in areas related to innovation, productivity, data transparency, and human capital development. These dimensions often require stronger analytical capacity, reliable data systems, and sustained organizational learning, which may not be consistently available across agencies. While stakeholders acknowledge the potential value of benchmarking in these areas, the results suggest that its application remains uneven and, in some cases, indirect.

Differences in perception are also evident when the results are viewed by institutional context. Implementing agencies tend to associate benchmarking more closely with performance control and accountability, reflecting their operational focus and regulatory environment. In contrast, institutions with planning, oversight, or academic roles place greater emphasis on safety, innovation, and stakeholder related outcomes. These variations indicate that stakeholders' views on benchmarking are shaped by how it fits within their specific organizational roles and project environments.

Overall, the findings suggest that benchmarking in government construction projects is currently perceived primarily as a tool for monitoring performance and ensuring compliance, rather than as a comprehensive mechanism for continuous improvement and organizational development. Expanding the role of benchmarking beyond its traditional control oriented functions will likely depend on improvements in data management, analytical capability, and knowledge sharing practices. These perception patterns provide important context for understanding the barriers to benchmarking implementation and the strategies proposed in the succeeding sections.

4.4 Identification of Key Barriers to Benchmarking Implementation

This section presents the results used to identify and prioritize the barriers to benchmarking implementation in government construction projects in support of Research Objective 3. Guided by the findings of maturity and perception assessment, the barriers were evaluated through pairwise comparison and refined using the Fuzzy Analytic Hierarchy Process (FAHP), as described in Chapter 3. These methods convert expert judgments into priority weights while allowing for uncertainty in evaluation, producing an evidence based ranking of the most constraining factors. The results are presented sequentially, beginning with the FAHP results, followed by ranking and concluding with a discussion of the most critical barriers, providing an analytical basis for understanding the challenges to benchmarking implementation and informing the development of appropriate strategies in the succeeding section.

4.4.1 Fuzzy Pairwise Comparison Results for Key Barriers

This subsection reports the transformed fuzzy pairwise comparison results used to estimate the relative influence of the barriers affecting benchmarking implementation. Expert judgments from the Department of Public Works and Highways (DPWH), the City Engineer’s Office (CEO), and the University of Science and Technology of Southern Philippines (USTP) focuses on comparing both the main barrier dimensions and their corresponding research indicators. The resulting normalized weights provide an initial priority structure that is later integrated and refined through Fuzzy Analytic Hierarchy Process (FAHP) to obtain final global rankings.

4.4.1.1 Fuzzy Pairwise Comparison Results for Key Barriers Dimensions

The fuzzy pairwise comparison results for the major benchmarking barrier dimensions indicate clear differences in their relative importance, as reflected by the normalized weights derived from expert judgments. As shown in Table 43, technological adoption emerged as the most dominant barrier dimension, obtaining the highest weight ($W = 0.486$). This result indicates that limitations related to technology readiness, digital systems, and technical capability are perceived as the most influential constraints affecting benchmarking implementation in government construction projects.

Table 43: Transformed Fuzzy Pairwise Comparison Matrix for Key Barriers Dimensions

	Experts	BD1			BD2			BD3			BD4			BD5			
BD1	DPWH	1	1	1	1/4	1/3	1/2	1/3	1/2	1	1/6	1/5	1/4	1/5	1/4	1/3	0.061
	CEO	1	1	1	1/4	1/3	1/2	1/4	1/3	1/2	1/6	1/5	1/4	1/5	1/4	1/3	
	USTP	1	1	1	1/4	1/3	1/2	1/4	1/3	1/2	1/6	1/5	1/4	1/5	1/4	1/3	
BD2	DPWH	2	3	4	1	1	1	1	2	3	1/5	1/4	1/3	1/4	1/3	1/2	0.136
	CEO	2	3	4	1	1	1	1/3	1/2	1	1/5	1/4	1/3	1/3	1/2	1	
	USTP	2	3	4	1	1	1	1/3	1/2	1	1/6	1/5	1/4	1/5	1/4	1/3	
BD3	DPWH	1	2	3	1/3	1/2	1	1	1	1	1/5	1/4	1/3	1/4	1/3	1/2	0.086
	CEO	2	3	4	1	2	3	1	1	1	1/5	1/4	1/3	1/3	1/2	1	
	USTP	2	3	4	1	2	3	1	1	1	1/5	1/4	1/3	1/4	1/3	1/2	
BD4	DPWH	4	5	6	3	4	5	3	4	5	1	1	1	1	2	3	0.486
	CEO	4	5	6	3	4	5	3	4	5	1	1	1	2	3	4	
	USTP	4	5	6	4	5	6	3	4	5	1	1	1	2	3	4	
BD5	DPWH	3	4	5	2	3	4	2	3	4	1/3	1/2	1	1	1	1	0.231
	CEO	3	4	5	1	2	3	1	2	3	1/4	1/3	1/2	1	1	1	

	USTP	3	4	5	3	4	5	2	3	4	1/4	1/3	1/2	1	1	1	
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The collaboration dimension ranked second with a weight of 0.231, suggesting that inter-agency coordination, information sharing, and alignment among stakeholders play a significant role in enabling or constraining benchmarking practices. The relatively high weight assigned to collaboration highlights the importance of institutional linkages and shared performance frameworks in benchmarking initiatives. Quality Management Systems (QMS) followed with a moderate weight ($W = 0.136$), indicating that the presence and integration of formal quality systems contribute to benchmarking effectiveness, although to a lesser extent than technological and collaborative factors.

Lower weights were assigned to leadership commitment ($W = 0.086$) and KPI integration ($W = 0.061$), suggesting that these dimensions are perceived as comparatively less critical at the dimension level. While still relevant, their lower rankings indicate that leadership related and performance measurement issues are viewed as secondary constraints relative to broader system and inter-organizational challenges. Overall, the dimension level fuzzy pairwise comparison establishes a clear priority structure that guides the subsequent analysis of specific barrier indicators and the refinement of results using FAHP.

4.4.1.2 Fuzzy Pairwise Comparison Results for Key Barriers Sub-Dimension 1

The fuzzy pairwise comparison results for the KPI integration sub-dimension indicate varying levels of influence among the identified research indicators, as reflected by their normalized weights in Table 44. Among the indicators, issues related to time, such as schedule delays and project deadline adherence, obtained the highest weight ($W = 0.414$), indicating that inconsistencies in time based performance measurement are perceived as the most significant constraint to effective benchmarking. This suggests that difficulties in standardizing and comparing schedule related indicators across projects hinder meaningful benchmarking efforts.

Table 44: Transformed Fuzzy Pairwise Comparison Matrix for Key Barriers Sub-Dimension 1

	Experts	BSD1.1			BSD1.2			BSD1.3			BSD1.4			BSD1.5			Wi
BSD 1.1	DPWH	1	1	1	4	5	6	3	4	5	1	1	1	1	2	3	0.068
	CEO	1	1	1	1/4	1/3	1/2	3	4	5	2	3	4	1/6	1/5	1/4	
	USTP	1	1	1	1	1	1	1/5	1/4	1/3	1/2	1/4	1/3	1/2	1/6	1/5	
BSD 1.2	DPWH	1/6	1/5	1/4	1	1	1	1/3	1/2	1	1/5	1/4	1/3	1/4	1/3	1/2	0.414
	CEO	2	3	4	1	1	1	4	5	6	3	4	5	1/4	1/3	1/2	
	USTP	1	1	1	1	1	1	1/5	1/4	1/3	1/2	1/4	1/3	1/2	1/6	1/5	
BSD 1.3	DPWH	1/5	1/4	1/3	1	2	3	1	1	1	1	1	1	1/3	1/2	1	0.236
	CEO	1/5	1/4	1/3	1/6	1/5	1/4	1	1	1	1/3	1/2	1	1/6	1/5	1/4	
	USTP	3	4	5	3	4	5	1	1	1	1	2	3	1/4	1/3	1/2	
	DPWH	1	1	1	3	4	5	1	1	1	1	1	1	1	2	3	0.064

BSD 1.4	CEO	1/4	1/3	1/2	1/5	1/4	1/3	1	2	3	1	1	1	1/6	1/5	1/4	
	USTP	2	3	4	2	3	4	1/3	1/2	1	1	1	1	1/4	1/3	1/2	
BSD 1.5	DPWH	1/3	1/2	1	2	3	4	1	2	3	1/3	1/2	1	1	1	1	0.219
	CEO	4	5	6	2	3	4	4	5	6	4	5	6	1	1	1	
	USTP	4	5	6	4	5	6	2	3	4	2	3	4	1	1	1	

The second most influential indicator under this sub-dimension is quality-related KPIs ($W = 0.236$), which include compliance with specifications and quality standards. The relatively high weight assigned to this indicator indicates that variations in quality measurement frameworks and assessment criteria pose notable challenges when comparing performance across agencies or projects. Different projects using different measures ranked next ($W = 0.219$), highlighting the impact of non-uniform KPI definitions and benchmarking bases on project comparability.

Lower weights were observed for government construction projects lacking sufficient use of key performance indicators ($W = 0.068$) and cost-related KPIs being poorly updated or inaccurate ($W = 0.064$). These results suggest that while gaps in KPI integration and cost data quality exist, they are perceived as less critical barriers compared to inconsistencies in time and quality related performance indicators. Overall, the results indicate that challenges in KPI integration are primarily driven by difficulties in standardizing time and quality metrics rather than by the absence of KPIs alone.

4.4.1.3 Fuzzy Pairwise Comparison Results for Key Barriers Sub-Dimension 2

For the Quality Management Systems (QMS) sub-dimension, the results highlight system level weaknesses as the most influential concerns, as reflected by their normalized weights in Table 45. The absence of a structured quality management system obtained the highest weight ($W = 0.388$), indicating that the lack of formalized quality frameworks is perceived as the most significant QMS-related barrier to benchmarking implementation. This result suggests that without an established quality management structure, systematic performance comparison becomes difficult to sustain.

Table 45: Transformed Fuzzy Pairwise Comparison Matrix for Key Barriers Sub-Dimension 2

	Experts	BSD2.1			BSD2.2			BSD2.3			BSD2.4			BSD2.5			Wi
BSD 2.1	DPWH	1	1	1	2	3	4	3	4	5	1	1	1	4	5	6	0.388
	CEO	1	1	1	3	4	5	1/3	1/2	1	1/4	1/3	1/2	2	3	4	
	USTP	1	1	1	2	3	4	1/5	1/4	1/3	1/4	1/3	1/2	2	3	4	
BSD 2.2	DPWH	1/4	1/3	1/2	1	1	1	1	2	3	1/4	1/3	1/2	4	5	6	0.094
	CEO	1/5	1/4	1/3	1	1	1	1/6	1/5	1/4	1/5	1/4	1/3	1/4	1/3	1/2	
	USTP	1/4	1/3	1/2	1	1	1	1/5	1/4	1/3	1/6	1/5	1/4	1/3	1/2	1	
BSD 2.3	DPWH	1/5	1/4	1/3	1	1	1	1	1	1	1/4	1/3	1/2	3	4	5	0.151
	CEO	1	2	3	4	5	6	1	1	1	1/3	1/2	1	2	3	4	
	USTP	3	4	5	3	4	5	1	1	1	1/4	1/3	1/2	3	4	5	
	DPWH	1	1	1	2	3	4	2	3	4	1	1	1	4	5	6	0.319

BSD 2.4	CEO	2	3	4	3	4	5	1	2	3	1	1	1	3	4	5	
	USTP	2	3	4	4	5	6	2	3	4	1	1	1	4	5	6	
BSD 2.5	DPWH	1/6	1/5	1/4	1	1	1	1/5	1/4	1/3	1/6	1/5	1/4	1	1	1	0.049
					/	/	/										
	CEO	1/4	1/3	1/2	2	3	4	1/4	1/3	1/2	1/5	1/4	1/3	1	1	1	
	USTP	1/4	1/3	1/2	1	2	3	1/5	1/4	1/3	1/6	1/5	1/4	1	1	1	

The second most influential indicator is weak integration of quality management systems ($W = 0.319$), highlighting the challenges associated with fragmented or poorly aligned quality processes across projects and agencies. This finding indicates that even when quality systems exist, insufficient integration limits their usefulness for benchmarking purposes. The indicator lack of ISO-based frameworks (e.g., ISO 9001) hindering adoption ranked next ($W = 0.151$), suggesting that the absence of internationally recognized quality standards further constrains benchmarking consistency.

Lower weights were assigned to quality checks being done informally and inconsistently ($W = 0.094$) and the presence of no quality review or audits in many projects ($W = 0.049$). These results indicate that while informal quality checks and limited audits are recognized issues, they are perceived as less critical compared to structural and system level deficiencies in quality management. Overall, the results indicate that barriers within the QMS sub-dimension are primarily driven by the absence and weak integration of formal quality systems rather than by isolated quality control practices.

4.4.1.4 Fuzzy Pairwise Comparison Results for Key Barriers Sub-Dimension 3

Leadership commitment sub-dimension show the greatest influence from capacity and constraints rather than direct resistance, as indicated by the normalized weights in Table 46. The highest weight was assigned to excessive workloads hindering employee involvement in benchmarking activities ($W = 0.500$), indicating that operational pressures and workload demands are perceived as the most significant leadership-related constraint. This result suggests that limited time and capacity reduce opportunities for staff participation in benchmarking initiatives.

Table 46: Transformed Fuzzy Pairwise Comparison Matrix for Key Barriers Sub-Dimension 3

	Experts	BSD3.1			BSD3.2			BSD3.3			BSD3.4			BSD3.5			BSD3.6			Wi
BSD 3.1	DPWH	1	1	1	3	4	5	1/5	1/4	1/3	1/4	1/3	1/2	1/6	1/5	1/4	1/6	1/5	1/4	0.056
	CEO	1	1	1	4	5	6	1	2	3	3	4	5	1	2	3	1	2	3	
	USTP	1	1	1	4	5	6	1	2	3	3	4	5	1	2	3	1	2	3	
BSD 3.2	DPWH	1/5	1/4	1/3	1	1	1	1/6	1/5	1/4	1/3	1/2	1/7	1/6	1/5	1/7	1/6	1/5	1/4	0.031
	CEO	1/6	1/5	1/4	1	1	1	1/5	1/4	1/3	1/2	1	1/5	1/4	1/3	1/5	1/4	1/3	1/5	
	USTP	1/6	1/5	1/4	1	1	1	1/5	1/4	1/3	1/2	1	1/5	1/4	1/3	1/5	1/4	1/3	1/5	
BSD 3.3	DPWH	3	4	5	4	5	6	1	1	1	1	2	3	1/4	1/3	1/2	1/4	1/3	1/2	0.113

	CEO	1/3	1/2	1	3	4	5	1	1	1	2	3	4	1	2	3	1	2	3	
	USTP	1/3	1/2	1	3	4	5	1	1	1	2	3	4	1	1	1	1	1	1	
BSD 3.4	DPWH	2	3	4	3	4	5	1/3	1/2	1	1	1	1	1/5	1/4	1/3	1/5	1/4	1/3	0.068
	CEO	1/5	1/4	1/3	1	2	3	1/4	1/3	1/2	1	1	1	1/4	1/3	1/2	1/4	1/3	1/2	
	USTP	1/5	1/4	1/3	1	2	3	1/4	1/3	1/2	1	1	1	1/4	1/3	1/2	1/4	1/3	1/2	
BSD 3.5	DPWH	4	5	6	5	6	7	2	3	4	3	4	5	1	1	1	1	1	1	0.231
	CEO	1/3	1/2	1	3	4	5	1/3	1/2	1	2	3	4	1	1	1	1	1	1	
	USTP	1/3	1/2	1	3	4	5	1	1	1	2	3	4	1	1	1	1	1	1	
BSD 3.6	DPWH	4	5	6	5	6	7	2	3	4	3	4	5	1/3	1	1	1/3	1	1	0.500
	CEO	2	3	4	5	6	7	3	4	5	5	6	7	3	4	5	3	4	5	
	USTP	4	5	6	5	6	7	4	5	6	5	6	7	3	4	5	3	4	5	

The second most influential indicator was lack of accountability reducing staff participation ($W=0.231$), emphasizing that benchmarking weakens when responsibilities, follow-through, and performance ownership are unclear. Limited leadership focus on KPI driven culture ranked next ($W=0.113$), suggesting that insufficient emphasis on performance measurement culture affects long term institutionalization of benchmarking.

Lower weights were assigned to leaders rarely promoting continuous improvement using KPIs ($W = 0.068$) and some leaders resisting benchmarking initiatives ($W = 0.056$). These results indicate that overt resistance to benchmarking and limited promotion of KPI based improvement are perceived as less critical barriers compared to workload and accountability related issues. Overall, the findings suggest that leadership related barriers to benchmarking are primarily associated with structural and capacity constraints rather than with explicit opposition from management.

4.4.1.5 Fuzzy Pairwise Comparison Results for Key Barriers Sub-Dimension 4

Technology related barriers were heavily differentiated, as reflected by the normalized weights in Table 47, with high costs of digital technologies obtained the highest weight ($W = 0.408$). This indicates that financial constraints associated with acquiring and maintaining digital systems are perceived as the most critical technological barrier. This finding suggests that limited budget allocation for digital infrastructure restricts the adoption of technology enabled benchmarking tools.

Table 47: Transformed Fuzzy Pairwise Comparison Matrix for Key Barriers Sub-Dimension 4

	Experts	BSD4.1			BSD4.2			BSD4.3			BSD4.4			BSD4.5			Wi
BSD 4.1	DPWH	1	1	1	1/4	1/3	1/2	1/5	1/4	1/3	1/4	1/3	1/2	1/6	1/5	1/4	0.063
	CEO	1	1	1	1	1	1	3	4	5	3	4	5	2	3	4	

	USTP	1	1	1	1/4	1/3	1/2	1	2	3	1	1	1	3	4	5	
BSD 4.2	DPWH	2	3	4	1	1	1	1/4	1/3	1/2	1	2	3	1/5	1/4	1/3	0.40
	CEO	1	1	1	1	1	1	3	4	5	3	4	5	2	3	4	8
	USTP	2	3	4	1	1	1	2	3	4	2	3	4	4	5	6	
BSD 4.3	DPWH	3	4	5	2	3	4	1	1	1	2	3	4	1/3	1/2	1	0.19
	CEO	1/5	1/4	1/3	1	1	1	1	1	1	1	1	1	1/3	1/2	1	3
	USTP	1/3	1/2	1	1	1	1	1	1	1/3	1/2	1	3	4	5		
BSD 4.4	DPWH	2	3	4	1/3	1/2	1	1/4	1/3	1/2	1	1	1	1/5	1/4	1/3	0.06
	CEO	1/5	1/4	1/3	1	1	1	1	1	1	1	1	1	1/3	1/2	1	3
	USTP	1	1	1	1/4	1/3	1/2	1	2	3	1	1	1	3	4	5	
BSD 4.5	DPWH	4	5	6	3	4	5	1	2	3	3	4	5	1	1	1	0.27
	CEO	1/4	1/3	1/2	1	2	3	1	2	3	1	2	3	1	1	1	3
	USTP	1/5	1/4	1/3	1/6	1/5	1/4	1/5	1/4	1/3	1/5	1/4	1/3	1	1	1	

The second most influential indicator is the absence of real time data systems affecting accuracy and timeliness ($W = 0.273$). This result highlights the importance of timely and reliable data in supporting benchmarking activities, particularly where performance monitoring depends on updated project information. Skill gaps among personnel hindering effective use of digital technologies ranked next ($W = 0.193$), indicating that insufficient technical competencies among staff further constrain the effective utilization of available digital systems.

Lower weights were assigned to government projects facing challenges in adopting digital tools ($W = 0.063$) and resistance to digital transformation preventing efficient KPI monitoring ($W = 0.063$). These results suggest that while resistance and initial adoption challenges exist, they are perceived as less critical compared to cost, system availability, and skill related issues. Overall, the findings indicate that technological barriers to benchmarking are driven primarily by resource limitations and system capability gaps rather than by resistance to technological change.

4.4.1.6 Fuzzy Pairwise Comparison Results for Key Barriers Sub-Dimension 5

Collaboration related barriers are dominated by measurement incompatibility and data sharing constraints, as presented by the normalized weights in Table 48. The highest weight was assigned to different agencies using different measures making it hard to compare results obtained the highest weight ($W = 0.419$), indicating that the absence of standardized performance metrics across agencies is perceived as the most significant collaboration barrier. This result suggests that inconsistencies in measurement frameworks limit meaningful inter-agency benchmarking.

Table 48: Transformed Fuzzy Pairwise Comparison Matrix for Key Barriers Sub-Dimension 5

Experts	BSD5.1	BSD5.2	BSD5.3	BSD5.4	BSD5.5	Wi										
DPWH	1	1	1	4	5	6	3	4	5	2	3	4	3	4	5	

BSD 5.1	CEO	1	1	1	1	2	3	2	3	4	1/4	1/3	1/2	3	4	5	0.31 7
	USTP	1	1	1	1	2	3	3	4	5	1/4	1/3	1/2	1	1	1	
BSD 5.2	DPWH	1/6	1/5	1/4	1	1	1	1/4	1/3	1/2	1/5	1/4	1/3	1/4	1/3	1/2	0.12 2
	CEO	1/3	1/2	1	1	1	1	1	2	3	1/5	1/4	1/3	2	3	4	
	USTP	1/3	1/2	1	1	1	1	2	3	4	1/5	1/4	1/3	1/3	1/2	1	
BSD 5.3	DPWH	1/5	1/4	1/3	2	3	4	1	1	1	1/4	1/3	1/2	1/3	1/2	1	0.05 7
	CEO	1/4	1/3	1/2	1/3	1/2	1	1	1	1	1/5	1/4	1/3	1	2	3	
	USTP	1/5	1/4	1/3	1/4	1/3	1/2	1	1	1	1/6	1/5	1/4	1/5	1/4	1/3	
BSD 5.4	DPWH	1/4	1/3	1/2	3	4	5	2	3	4	1	1	1	2	3	4	0.41 9
	CEO	2	3	4	3	4	5	3	4	5	1	1	1	4	5	6	
	USTP	2	3	4	3	4	5	4	5	6	1	1	1	2	3	4	
BSD 5.5	DPWH	1/5	1/4	1/3	2	3	4	1	2	3	1/4	1/3	1/2	1	1	1	0.08 5
	CEO	1/5	1/4	1/3	1/4	1/3	1/2	1/3	1/2	1	1/6	1/5	1/4	1	1	1	
	USTP	1	1	1	1	2	3	3	4	5	1/4	1/3	1/2	1	1	1	

The second most influential indicator is government agencies hesitating to share benchmarking data ($W = 0.317$), highlighting the role of data sharing practices and institutional openness in enabling benchmarking initiatives. This finding indicates that limited willingness to exchange performance information constrains collaborative benchmarking efforts. Inter-agency competition and distrust reducing collaboration ranked next ($W = 0.122$), suggesting that organizational dynamics and perceived competition further affect cooperative benchmarking.

Lower weights were assigned to short project timelines discouraging cross-project collaboration ($W = 0.085$) and government units lacking networks or partnerships for benchmarking ($W = 0.057$). These results indicate that while time constraints and limited formal networks are recognized issues, they are perceived as less critical compared to metric incompatibility and data sharing reluctance.

4.4.2 Consistency Ratios for Key Barriers

The consistency of the pairwise comparison judgments was evaluated to ensure the reliability of the expert assessments used in prioritizing benchmarking barriers. As presented in Table 49, the computed Consistency Ratio (CR) values for all evaluated variable sets fall within acceptable limits, ranging from 0.042 to 0.100. These results indicate that the judgments provided by the experts' exhibit an acceptable level of logical consistency. The consistency assessment confirms that the comparison matrices satisfy the required reliability conditions for further analysis. Thus, the derived weights can be treated as dependable inputs for the succeeding FAHP computation and final ranking.

Table 49: Consistency Ratios of Different Set of Key Barriers Variables

Variables' Set	No. of variables (n)	Random Index (RI(n))	λ_{max}	Consistency Index (CI)	Consistency Ratio (CR)
Dimensions	5	1.11	5.438	0.110	0.099
Sub-Dimension1	5	1.11	5.245	0.061	0.055

Sub-Dimension2	5	1.11	5.301	0.075	0.068
Sub-Dimension3	6	1.25	6.627	0.125	0.100
Sub-Dimension4	5	1.11	5.185	0.046	0.042
Sub-Dimension5	5	1.11	5.248	0.062	0.056

At the dimension level, the pairwise comparison recorded a CR value of 0.099, which meets the commonly accepted threshold of 0.10. Sub-Dimensions 1, 2, 4, and 5 yielded CR values well below the limit, indicating a high degree of consistency in the evaluation of their respective indicators. Sub-Dimension 3 recorded a CR value of 0.100, which remains within the acceptable limit and reflects marginal but still acceptable consistency. Overall, these results validate the use of the derived priority weights as a reliable basis for the subsequent FAHP refinement presented in the succeeding section.

4.4.3 Final FAHP Weights and Ranking for Key Barriers

The FAHP analysis integrates the dimension-level weights obtained from the pairwise comparison with the local weights of individual factors to compute the global weights and overall rankings, as shown in Table 50. These global weights represent the relative importance of each barrier under fuzzy conditions, reflecting uncertainty in expert judgment. The results provide a refined and consolidated basis for identifying the most critical barriers to benchmarking implementation.

Table 50: Weights and Rankings of Key Barriers

	Wi	Factors	Local Weights (LW)	Global Weights (GW)	Overall Ranking
BD 4	0.486	High costs of digital technologies limit widespread implementation of benchmarking systems.	0.567	0.276	1
		Absence of real-time data systems reduces accuracy and timeliness of benchmarking outputs.	0.433	0.210	2
BD 5	0.231	Different agencies use different measures, making it hard to standardize benchmarking practices.	0.551	0.127	3
		Government agencies hesitate to share benchmarking data due to confidentiality concerns.	0.449	0.104	4
BD 2	0.136	The absence of a structured Quality Management System (QMS) limits systematic benchmarking implementation.	0.534	0.073	5
		Weak integration of quality management systems reduces the reliability of benchmarking data.	0.466	0.063	6
BD 3	0.086	Excessive workloads hinder employee involvement in benchmarking-related activities.	0.634	0.055	7

BD 1	0.061	Time-related KPIs (e.g., meeting deadlines, project completion time) are often neglected in benchmarking practices.	0.589	0.036	8
BD 3	0.086	Lack of accountability reduces staff participation in benchmarking initiatives.	0.366	0.032	9
BD 1	0.061	Quality-related KPIs (e.g., compliance with specifications, workmanship quality) are difficult to monitor in government projects.	0.411	0.025	10

The FAHP results indicate that high costs of digital technologies ranked first, with the highest global weight (GW = 0.276), highlighting technological investment constraints as the most critical barrier. This is followed by absence of real-time data systems (GW = 0.210) and different agencies using different measures (GW = 0.127), underscoring the importance of system capability and standardization in benchmarking efforts. Barriers related to government agencies’ hesitation to share data (GW = 0.104) and weak integration of quality management systems (GW = 0.063) ranked next, indicating moderate influence on benchmarking implementation. Lower ranked barriers include factors related to KPI integration and leadership commitment, suggesting that while these issues remain relevant, they are perceived as less critical compared to technological and inter-organizational constraints.

4.4.4 Discussion of Key Barriers to Benchmarking Implementation

The integration of the FAHP results with the findings from the Project Management Maturity Model (PMMM) assessment and stakeholders’ perception analysis provides a clearer understanding of the underlying constraints to benchmarking implementation in government construction projects. The prominence of technology related barriers in the FAHP rankings is consistent with the PMMM results, which indicated comparatively lower maturity in knowledge areas that rely heavily on timely data, integrated systems, and analytical capability. These areas include risk management, communications management, and human resource related practices, all of which are directly affected by limitations in technological infrastructure.

In summary, the analysis identified technology related constraints, limited inter-agency collaboration, and weak integration of performance and quality systems as the most critical barriers to benchmarking implementation in government construction projects. These barriers directly affect benchmarking readiness by limiting data availability, comparability, and the effective use of performance information across institutions. While foundational project management practices are largely established, the persistence of these systemic constraints restricts the use of benchmarking as a strategic tool for continuous improvement rather than mere performance monitoring. Addressing these critical barriers provides the necessary basis for the formulation of targeted and prioritized interventions

4.5 Proposed Strategies to Benchmarking Implementation

This section presents the proposed strategies intended to address the key barriers to benchmarking implementation identified in the previous analysis, in line with Research Objective 4. Using the prioritized barriers derived from the pairwise comparison and FAHP results, the strategies were evaluated and ranked

to determine their relative effectiveness in improving benchmarking readiness in government construction projects. The same structured decision-making approach described in Chapter 3 was applied to maintain methodological alignment between barrier identification and strategy formulation. The resulting priorities provide a systematic basis for recommending strategies that are responsive to institutional conditions and practical implementation constraints.

4.5.1 Fuzzy Pairwise Comparison Results for Proposed Strategies

This subsection presents the fuzzy pairwise comparison results conducted to evaluate the proposed strategies for overcoming the identified benchmarking barriers. Using expert judgments expressed through triangular fuzzy numbers, the fuzzy pairwise comparison matrices were constructed to reflect uncertainty and subjectivity in assessing the relative effectiveness of each strategy. The fuzzy comparison results, summarized in the corresponding tables, provide the local priority weights of the proposed strategies prior to defuzzification. These weights reflect the relative emphasis placed on each strategy under fuzzy conditions and form the basis for the subsequent computation of final FAHP priorities.

4.5.1.1 Fuzzy Pairwise Comparison Results for Proposed Strategies Dimensions

The fuzzy comparison results of the strategy dimensions indicates clear differences in perceived importance, as shown in Table 51. Leadership and Quality Culture Maturity Model obtained the highest weight ($W = 0.437$), indicating that strengthening leadership commitment and embedding a quality-oriented culture is viewed as the most impactful strategies for improving benchmarking implementation. This result suggests that organizational readiness and management support play a central role in enabling other benchmarking initiatives.

Table 51: Transformed Fuzzy Pairwise Comparison Matrix for Proposed Strategies Dimensions

	Experts	PD1			PD2			PD3			PD4			PD5			
PD 1	DPWH	1	1	1	1/5	1/4	1/3	1/6	1/5	1/4	1/5	1/4	1/3	1/4	1/3	1/2	0.054
	CEO	1	1	1	1/5	1/4	1/3	1/6	1/5	1/4	1/5	1/4	1/3	1/4	1/3	1/2	
	USTP	1	1	1	1/4	1/3	1/2	1/6	1/5	1/4	1/5	1/4	1/3	1/5	1/4	1/3	
PD 2	DPWH	3	4	5	1	1	1	1/4	1/3	1/2	1	2	3	1	2	3	0.206
	CEO	3	4	5	1	1	1	1/3	1/2	1	1	2	3	2	3	4	
	USTP	2	3	4	1	1	1	1/4	1/3	1/2	1/3	1/2	1	1/3	1/2	1	
PD 3	DPWH	4	5	6	2	3	4	1	1	1	2	3	4	3	4	5	0.437
	CEO	4	5	6	1	2	3	1	1	1	1	2	3	3	4	5	
	USTP	4	5	6	2	3	4	1	1	1	1	2	3	1	2	3	
PD 4	DPWH	3	4	5	1/3	1/2	1	1/4	1/3	1/2	1	1	1	1	2	3	0.206
	CEO	3	4	5	1/3	1/2	1	1/3	1/2	1	1	1	1	2	3	4	
	USTP	3	4	5	1	2	3	1/3	1/2	1	1	1	1	1	2	3	
PD 5	DPWH	2	3	4	1/3	1/2	1	1/5	1/4	1/3	1/3	1/2	1	1	1	1	0.098
	CEO	2	3	4	1/4	1/3	1/2	1/5	1/4	1/3	1/4	1/3	1/2	1	1	1	
	USTP	3	4	5	1	2	3	1/3	1/2	1	1/3	1/2	1	1	1	1	

Phased benchmarking and training, and Prioritization of KPIs both recorded to have equal weights ($W = 0.206$), indicating a moderate level of importance. The paired ranking implies that stakeholders view capacity building and the selection of meaningful performance indicators as complementary requirements. Training supports correct application of benchmarking, while KPI prioritization ensures that performance comparison remain focused and relevant rather than excessive.

Lower weights were assigned to External support, policies, and incentives ($W = 0.098$) and Digital tools and data reliability ($W = 0.054$). Although these remain relevant, their lower priority suggests that stakeholders perceive technology and external mechanisms as enabling supports rather than primary drivers. Overall, the fuzzy pairwise comparison establishes a strategic priority structure that emphasizes leadership and organizational culture as the foundation for effective benchmarking implementation.

4.5.1.2 Fuzzy Pairwise Comparison Results for Proposed Strategies Sub-Dimension 1

The results for Sub-Dimension 1, which focuses on KPI prioritization strategies show variations on views on effectiveness, as demonstrated in Table 52. Prioritizing quality-related KPIs, such as defect rates and rework levels, obtained the highest weight ($W = 0.436$), indicating that respondents consider quality indicators as the most effective strategy within this sub-dimension. This suggests that stakeholders believe benchmarking becomes more valuable when it captures workmanship, specification compliance, and deliverable standards rather than relying mainly on administrative indicators.

Table 52: Transformed Fuzzy Pairwise Comparison Matrix for Proposed Strategies Sub-Dimension 1

	Experts	PSD1.1			PSD1.2			PSD1.3			PSD1.4			PSD1.5			Wi
PSD 1.1	DPWH	1	1	1	4	5	6	3	4	5	1	1	1	1	2	3	0.068
	CEO	1	1	1	1/4	1/3	1/2	3	4	5	2	3	4	1/6	1/5	1/4	
	USTP	1	1	1	1	1	1	1/5	1/4	1/3	1/4	1/3	2	1/6	1/5	1/4	
PSD 1.2	DPWH	1/6	1/5	1/4	1	1	1	1/3	1/2	1	1/5	1/4	1/3	1/4	1/3	1/2	0.414
	CEO	2	3	4	1	1	1	4	5	6	3	4	5	1/4	1/3	1/2	
	USTP	1	1	1	1	1	1	1/5	1/4	1/3	1/4	1/3	2	1/6	1/5	1/4	
PSD 1.3	DPWH	1/5	1/4	1/3	1	2	3	1	1	1	1	1	1	1/3	1/2	1	0.236
	CEO	1/5	1/4	1/3	1/6	1/5	1/4	1	1	1	1/3	1/2	1	1/6	1/5	1/4	
	USTP	3	4	5	3	4	5	1	1	1	1	2	3	1/4	1/3	1/2	
PSD 1.4	DPWH	1	1	1	3	4	5	1	1	1	1	1	1	1	2	3	0.064
	CEO	1/4	1/3	1/2	1/5	1/4	1/3	1	2	3	1	1	1	1/6	1/5	1/4	
	USTP	2	3	4	2	3	4	1/3	1/2	1	1	1	1	1/4	1/3	1/2	
PSD 1.5	DPWH	1/3	1/2	1	2	3	4	1	2	3	1/3	1/2	1	1	1	0.219	
	CEO	4	5	6	2	3	4	4	5	6	4	5	6	1	1		1
	USTP	4	5	6	4	5	6	2	3	4	2	3	4	1	1		1

The second most influential strategy is comparing and ranking KPIs to identify the most important ones to monitor, which recorded a weight of 0.253. This finding indicates that systematic comparison and ranking of KPIs are perceived as valuable for clarifying performance priorities and reducing information overload. Ranking KPIs according to their importance helps focus on what matters most followed with a weight of 0.181, reinforcing the importance of structured prioritization in benchmarking practices.

Lower weights were assigned to using the same KPIs across all projects to ensure fairness and consistency ($W = 0.069$) and the use of analytical tools such as pairwise comparison and fuzzy AHP ($W = 0.061$). These results suggest that stakeholders view standardization and decision tools as supportive mechanisms, but not the primary source of benchmarking effectiveness. Overall, the sub-dimension results highlight that KPI related strategies are valued most when they strengthen the relevance and usefulness of benchmarking metrics, particularly in quality domain.

4.5.1.3 Fuzzy Pairwise Comparison Results for Proposed Strategies Sub-Dimension 2

For leadership and quality culture-oriented strategies presented in Table 53, leadership driven quality assessments obtained the highest weight ($W = 0.338$), indicating that active leadership involvement in quality evaluation is viewed as the most influential approach within this sub-dimension. This suggests that benchmarking is more likely to be sustained when leader directly reinforce accountability and ensure that assessment outcomes impact decisions.

Table 53: Transformed Fuzzy Pairwise Comparison Matrix for Proposed Strategies Sub-Dimension 2

	Experts	PSD2.1			PSD2.2			PSD2.3			PSD2.4			PSD2.5			Wi
PSD 2.1	DPWH	1	1	1	1/4	1/3	1/2	1/6	1/5	1/4	1/4	1/3	1/2	1/5	1/4	1/3	0.388
	CEO	1	1	1	1	2	3	1/3	1/2	1	1/4	1/3	1/2	1	1	1	
	USTP	1	1	1	1/3	1/2	1	1	2	3	1	2	3	1/4	1/3	1/2	
PSD 2.2	DPWH	2	3	4	1	1	1	1/4	1/3	1/2	1	2	3	1/3	1/2	1	0.094
	CEO	1/3	1/2	1	1	1	1	1/3	1/2	1	1/4	1/3	1/2	1/3	1/2	1	
	USTP	1	2	3	1	1	1	1	2	3	1	2	3	1/3	1/2	1	
PSD 2.3	DPWH	4	5	6	2	3	4	1	1	1	2	3	4	1	2	3	0.151
	CEO	1	2	3	1	2	3	1	1	1	1/3	1/2	1	1	2	3	
	USTP	1/3	1/2	1	1/3	1/2	1	1	1	1	1	1	1	1/5	1/4	1/3	
PSD 2.4	DPWH	2	3	4	1/3	1/2	1	1/4	1/3	1/2	1	1	1	1/4	1/3	1/2	0.319
	CEO	2	3	4	2	3	4	1	2	3	1	1	1	1	2	3	
	USTP	1/3	1/2	1	1/3	1/2	1	1	1	1	1	1	1	1/5	1/4	1/3	
PSD 2.5	DPWH	3	4	5	1	2	3	1/3	1/2	1	2	3	4	1	1	1	0.049
	CEO	1	1	1	1	2	3	1/3	1/2	1	1/3	1/2	1	1	1	1	
	USTP	2	3	4	1	2	3	3	4	5	3	4	5	1	1	1	

Regular quality audits ranked closely behind with a recorded weight of 0.324. This highlights the importance of consistent verification mechanisms in improving the credibility of benchmarking results.

Introducing quality management system steps to improve benchmarking practices followed with a moderate weight ($W = 0.162$), indicating that formal process integration supports benchmarking, but is strengthened when paired with leadership oversight and audit based controls.

Lower weights were assigned to incorporating quality-related KPIs into decision making ($W = 0.121$) and promoting a culture of quality ($W = 0.055$). These results suggest that while cultural and KPI related initiatives are recognized as relevant, they are perceived as less immediately impactful compared to direct leadership actions and audit based controls. Overall, the fuzzy comparison results indicate that strategies emphasizing leadership involvement and structured quality assurance activities are prioritized within this sub-dimension.

4.5.1.4 Fuzzy Pairwise Comparison Results for Proposed Strategies Sub-Dimension 3

The results for Sub-Dimension 3, which focuses on leadership commitment and capacity building strategies, show distinct differences in the perceived effectiveness of the proposed approaches. As presented in Table 54, strong leadership commitment received the highest weight ($W = 0.396$), emphasizing that visible and sustained support from management is perceived as the most critical factor for integrating benchmarking into government construction projects. This reinforces the idea that benchmarking adoption depends heavily on leadership setting priorities and ensuring follow-through.

Table 54: Transformed Fuzzy Pairwise Comparison Matrix for Proposed Strategies Sub-Dimension 3

	Experts	PSD3.1			PSD3.2			PSD3.3			PSD3.4			PSD3.5			Wi
PSD 3.1	DPWH	1	1	1	1	2	3	3	4	5	4	5	6	3	4	5	0.396
	CEO	1	1	1	1	1	1	2	3	4	1/3	1/2	1	2	3	4	
	USTP	1	1	1	2	3	4	1	2	3	3	4	5	4	5	6	
PSD 3.2	DPWH	1/3	1/2	1	1	1	1	3	4	5	4	5	6	3	4	5	0.300
	CEO	1	1	1	1	1	1	2	3	4	1/3	1/2	1	2	3	4	
	USTP	1/4	1/3	1/2	1	1	1	1/3	1/2	1	1	2	3	2	3	4	
PSD 3.3	DPWH	1/5	1/4	1/3	1/5	1/4	1/3	1	1	1	1	2	3	1	1	1	0.158
	CEO	1/4	1/3	1/2	1/4	1/3	1/2	1	1	1	1/5	1/4	1/3	1	1	1	
	USTP	1/3	1/2	1	1	2	3	1	1	1	1	2	3	2	3	4	
PSD 3.4	DPWH	1/6	1/5	1/4	1/6	1/5	1/4	1/3	1/2	1	1	1	1	1/3	1/2	1	0.063
	CEO	1	2	3	1	2	3	3	4	5	1	1	1	3	4	5	
	USTP	1/5	1/4	1/3	1/3	1/2	1	1/3	1/2	1	1	1	1	1	2	3	
PSD 3.5	DPWH	1/5	1/4	1/3	1/5	1/4	1/3	1	1	1	1	2	3	1	1	1	0.084
	CEO	1/4	1/3	1/2	1/4	1/3	1/2	1	1	1	1/5	1/4	1/3	1	1	1	
	USTP	1/6	1/5	1/4	1/4	1/3	1/2	1/4	1/3	1/2	1/3	1/2	1	1	1	1	

Capacity-building and training programs to improve employee competence, which recorded a weight of 0.300. This finding suggests that enhancing staff skills and technical knowledge is considered a critical complement to leadership commitment in supporting benchmarking implementation. Leaders who reward

performance and encourage a culture of accountability followed with a moderate weight ($W = 0.158$), indicating that incentive system and recognition practices contribute to sustaining engagement but are secondary to leadership direction and training.

Lower weights were assigned to clear assignment of benchmarking responsibilities ($W = 0.063$) and gradual implementation of benchmarking practices ($W = 0.084$). These findings suggest that role clarity and phased implementation are recognized as supportive measures. They are perceived as less impactful compared to leadership and capacity focused strategies.

4.5.1.5 Fuzzy Pairwise Comparison Results for Proposed Strategies Sub-Dimension 4

For digital adoption and data enabled strategies, presented in Table 55, technical training builds staff competencies in digital benchmarking obtained the highest weight ($W = 0.4863$). This indicates that respondents view internal technical capacity as the most decisive factor for making digital benchmarking workable. The emphasis suggests that tools alone are insufficient if staff lack the skills to manage data, interpret outputs, and use systems consistently.

Table 55: Transformed Fuzzy Pairwise Comparison Matrix for Proposed Strategies Sub-Dimension 4

	Experts	PSD4.1			PSD4.2			PSD4.3			PSD4.4			PSD4.5			Wi
PSD 4.1	DPWH	1	1	1	1	2	3	1/5	1/4	1/3	1	2	3	1/4	1/3	1/2	0.109
	CEO	1	1	1	4	5	6	1/3	1/2	1	1	2	3	2	3	4	
	USTP	1	1	1	1/3	1/2	1	1/4	1/3	1/2	1/3	1/2	1	1	1	1	
PSD 4.2	DPWH	1/3	1/2	1	1	1	1	1/6	1/5	1/4	1/3	1/2	1	1/4	1/3	1/2	0.094
	CEO	1/6	1/5	1/4	1	1	1	1/6	1/5	1/4	1/5	1/4	1/3	1/5	1/4	1/3	
	USTP	1	2	3	1	1	1	1/4	1/3	1/2	1	1	1	1	2	3	
PSD 4.3	DPWH	3	4	5	4	5	6	1	1	1	4	5	6	2	3	4	0.486
	CEO	1	2	3	4	5	6	1	1	1	2	3	4	2	3	4	
	USTP	2	3	4	2	3	4	1	1	1	2	3	4	3	4	5	
PSD 4.4	DPWH	1/3	1/2	1	1	2	3	1/6	1/5	1/4	1	1	1	1/4	1/3	1/2	0.082
	CEO	1/3	1/2	1	3	4	5	1/4	1/3	1/2	1	1	1	1	2	3	
	USTP	1	2	3	1	1	1	1/4	1/3	1/2	1	1	1	1	2	3	
PSD 4.5	DPWH	2	3	4	2	3	4	1/4	1/3	1/2	2	3	4	1	1	1	0.228
	CEO	1/4	1/3	1/2	3	4	5	1/4	1/3	1/2	1/3	1/2	1	1	1	1	
	USTP	1	1	1	1/3	1/2	1	1/5	1/4	1/3	1/3	1/2	1	1	1	1	

The use of real-time dashboards to improve accuracy and speed in monitoring, recorded a weight of 0.228. This finding suggests that timely access to performance data is perceived as a key enabler of effective benchmarking, particularly for monitoring and comparison across projects. Adoption of digital platforms

to streamline benchmarking processes followed with a lower but notable weight ($W = 0.109$), indicating that technology adoption alone is considered less impactful without corresponding skills and data utilization process.

Lower weights were assigned to financial support and incentives to help agencies adopt digital tools ($W = 0.094$) and public-private partnerships to enhance benchmarking technology integration ($W = 0.082$). These results suggest that while external support mechanisms are recognized as beneficial, they are perceived as secondary to internal capability development and data-driven monitoring systems.

4.5.1.6 Fuzzy Pairwise Comparison Results for Proposed Strategies Sub-Dimension 5

The fuzzy pairwise comparison results for Sub-Dimension 5, which addresses collaboration and governance oriented strategies, are presented in Table 56. Alignment of local practices with global standards obtained the highest weight ($W = 0.372$), indicating that harmonizing local practices with established international or national benchmarks is viewed as the most influential strategy within this sub-dimension. This suggests that benchmarking becomes more functional when performance measures and procedures are consistent with recognized benchmarks.

Table 56: Transformed Fuzzy Pairwise Comparison Matrix for Proposed Strategies Sub-Dimension 5

	Experts	PSD5.1			PSD5.2			PSD5.3			PSD5.4			PSD5.5			Wi
PSD 5.1	DPWH	1	1	1	1/5	1/4	1/3	1/5	1/4	1/3	1/6	1/5	1/4	2	3	4	0.091
	CEO	1	1	1	1/3	1/2	1	1/4	1/3	1/2	1/5	1/4	1/3	2	3	4	
	USTP	1	1	1	1/3	1/2	1	1/3	1/2	1	1/5	1/4	1/3	2	3	4	
PSD 5.2	DPWH	3	4	5	1	1	1	1/3	1/2	1	1/4	1/3	1/2	3	4	5	0.211
	CEO	1	2	3	1	1	1	1/3	1/2	1	1/5	1/4	1/3	2	3	4	
	USTP	1	2	3	1	1	1	1	1	1	1/5	1/4	1/3	2	3	4	
PSD 5.3	DPWH	3	4	5	1	2	3	1	1	1	1/4	1/3	1/2	3	4	5	0.267
	CEO	2	3	4	1	2	3	1	1	1	1/4	1/3	1/2	3	4	5	
	USTP	1	2	3	1	1	1	1	1	1	1/5	1/4	1/3	2	3	4	
PSD 5.4	DPWH	4	5	6	2	3	4	2	3	4	1	1	1	4	5	6	0.372
	CEO	3	4	5	3	4	5	2	3	4	1	1	1	4	5	6	
	USTP	3	4	5	3	4	5	3	4	5	1	1	1	4	5	6	
PSD 5.5	DPWH	1/4	1/3	1/2	1/5	1/4	1/3	1/5	1/4	1/3	1/6	1/5	1/4	1	1	1	0.059
	CEO	1/4	1/3	1/2	1/4	1/3	1/2	1/5	1/4	1/3	1/6	1/5	1/4	1	1	1	
	USTP	1/4	1/3	1/2	1/4	1/3	1/2	1/4	1/3	1/2	1/6	1/5	1/4	1	1	1	

The second most influential strategy is industry wide cooperation that helps keep benchmarking consistent, which recorded a weight of 0.267. This finding highlights that sustained coordination among agencies supports continuity and shared learning. Policy-driven frameworks that foster trust and collaboration between agencies followed with a moderate weight ($W = 0.211$), highlighting the role of formal policies in supporting collaborative benchmarking environments.

Lower weights were assigned to secure data sharing platforms that address confidentiality concerns ($W = 0.091$) and partnerships with private groups to support benchmarking implementation ($W = 0.059$). Overall, the fuzzy comparison results indicate that collaboration strategies emphasizing standard

alignment and sustained inter-organizational cooperation are prioritized over technical or partnership-based interventions within this sub-dimension.

4.5.2 Consistency Ratios of Proposed Strategies

The consistency of the fuzzy pairwise comparison judgments for the proposed strategies was evaluated to confirm the reliability of the expert assessments. As shown in Table 57, all computed Consistency Ratio (CR) values are within acceptable threshold of 0.10, indicating coherent and logically consistent judgments across the strategy sets. At the dimension level, CR value 0.057, confirming reliable comparisons among the major strategy dimensions. The sub-dimensions yielded CR values ranging from 0.048 to 0.073, further supporting stable expert evaluations and validating the use of the derived weights for the succeeding FAHP computations.

Table 57: Consistency Ratios of Different Set of Proposed Strategies Variables

	No. of variables (n)	Random Index (RI(n))	λ_{max}	Consistency Index (CI)	Consistency Ratio (CR)
Dimensions	5	1.11	5.252	0.063	0.057
Sub-Dimension1	5	1.11	5.326	0.082	0.073
Sub-Dimension2	5	1.11	5.234	0.059	0.053
Sub-Dimension3	5	1.11	5.266	0.066	0.060
Sub-Dimension4	5	1.11	5.234	0.059	0.053
Sub-Dimension5	5	1.11	5.212	0.053	0.048

Overall, the consistency ratio results validate the use of the derived fuzzy weights and rankings for the proposed strategies. The acceptable consistency levels provide confidence that the prioritization of strategies is based on sound and logically consistent judgments, supporting the robustness of the FAHP results presented in this section.

4.5.3 Final FAHP Weights and Ranking for Proposed Strategies

The final FAHP results consolidate the dimension level and local strategy weights to produce global weights and overall rankings shown in Table 58. The top ranked strategy is strong leadership commitment to benchmarking, with the highest global weight (GW = 0.2395), indicating that leadership engagement is viewed as the most influential driver of successful benchmarking adoption. In practice, this strengthens accountability, ensures benchmarking outputs are acted upon, and enables supporting initiatives, such as training, audits, and digital monitoring. This result underscores the importance of sustained managerial support in institutionalizing benchmarking practices across government construction projects.

Table 58: Weights and Rankings of Proposed Strategies

	Wi	Factors	Local Weights (LW)	Global Weights (GW)	Overall Ranking
PD3	0.437	Strong leadership commitment enhances benchmarking integration in projects.	0.548	0.240	1
		Capacity-building and training programs improve employee readiness for benchmarking practices.	0.452	0.197	2

PD4	0.206	Technical training builds staff competencies in digital benchmarking systems.	0.629	0.129	3
PD2	0.206	Leadership-driven quality assessments reinforce benchmarking accountability and compliance.	0.507	0.104	4
		Conducting regular quality audits strengthens benchmarking reliability.	0.493	0.101	5
PD4	0.206	Real-time dashboards improve accuracy and speed in monitoring projects.	0.371	0.076	6
PD5	0.098	Alignment of local benchmarking practices with global standards enhances competitiveness.	0.553	0.054	7
		Industry-wide cooperation helps keep benchmarking sustainable.	0.447	0.044	8
PD1	0.054	Prioritizing quality-related KPIs, such as defect rates and efficiency, strengthens benchmarking accuracy.	0.592	0.032	9
		Comparing and ranking KPIs can help find the most important ones to use.	0.408	0.022	10

The second and third ranked strategies are capacity building and training programs to improve employee competence (GW = 0.197) and technical training to build staff competencies in digital benchmarking (GW = 0.129). These findings suggest that human capital development is viewed as a critical complement to leadership commitment, particularly in enabling agencies to apply benchmarking tools effectively. Leadership driven quality assessments (GW = 0.104) and conducting regular quality audits (GW = 0.101) followed, indicating that structured quality oversight mechanisms also play an important role in reinforcing benchmarking practices.

Strategies related to real time dashboards for performance monitoring (GW = 0.076) and alignment of local benchmarking practices with global standards (GW = 0.054) ranked at a moderate level, reflecting their supportive but secondary role in benchmarking implementation. Lower ranked strategies include industry wide cooperation to support benchmarking (GW = 0.044), prioritizing quality related KPIs (GW = 0.032), and comparing and ranking KPIs to identify key indicators (GW = 0.022). The final FAHP ranking indicates that strategies emphasizing leadership commitment and capacity development are prioritized over purely technical interventions, providing a clear basis for strategic recommendations discussed in the succeeding section.

4.5.4 Discussion of Proposed Strategies to Benchmarking Implementation

The proposed strategies were formulated and prioritized in direct response to the key barriers identified through the PMMM assessment, stakeholders’ perception analysis, and FAHP results. In particular, the prioritization of strong leadership commitment and structured training programs responds to barriers associated with limited accountability, workload pressures, and insufficient institutional support for benchmarking initiatives.

Strategies focused on leadership engagement and human capital development also align closely with the maturity gaps identified in the PMMM results, especially in knowledge areas that depend on coordination, performance monitoring, and continuous improvement. By strengthening leadership involvement and enhancing staff competencies, these strategies aim to improve organizational readiness and create an enabling environment for benchmarking practices. This alignment indicates that benchmarking readiness is not solely a technical issue but is strongly influenced by institutional culture and management support. Technology related strategies, including technical training for digital benchmarking and the use of real time dashboards, were ranked as supportive but secondary interventions. This prioritization reflects the finding that technological barriers are not driven only by the absence of tools, but by limited capacity to effectively use, integrate, and sustain digital systems. As such, strategies that build skills and reinforce leadership commitment provide a necessary foundation for the successful adoption of digital benchmarking solutions.

Collaboration and standard alignment strategies further address barriers related to inconsistent performance measures and limited data sharing across agencies. Aligning local benchmarking practices with global standards and promoting industry-wide cooperation respond directly to the lack of comparability and coordination identified in the barrier analysis. The results of the strategy prioritization analysis demonstrate that improving benchmarking implementation in government construction projects depends primarily on strengthening leadership commitment, building organizational capacity, and fostering a supportive quality culture. These findings provide a coherent basis for translating analytical results into actionable recommendations.

5. Conclusions and Recommendations

The motivation for this study was to assess the current state of benchmarking implementation in government construction projects in Cagayan de Oro City and to identify practical ways to improve construction quality management within the public sector. Given the increasing complexity of government construction projects and the need for accountability, efficiency, and continuous improvement, the assessment of project management maturity and benchmarking readiness is both timely and relevant. This study contributes to the field of construction management by integrating the Project Management Maturity Model (PMMM), stakeholders' perception analysis, and multi-criteria decision-making techniques to provide a comprehensive evaluation of benchmarking practices. The application of pairwise comparison and the Fuzzy Analytic Hierarchy Process (FAHP) offers a structured and systematic approach to identifying key barriers and prioritizing strategies, supporting evidence-based decision-making in public construction management. Overall, the study provides valuable insights for government agencies, policymakers, and practitioners seeking to strengthen quality management systems and institutionalize benchmarking as a tool for continuous improvement.

5.1 Conclusions

The assessment of benchmarking practices in government construction projects in Cagayan de Oro City provides a grounded contribution to the field of construction quality management and public sector project delivery. By combining PMMM results, stakeholder perception ratings, and FAHP prioritization, the study clarifies maturity levels, explains implementation constraints, and identifies strategies that are most responsive to the institutional environment. The key conclusions of the study are summarized as follows:

- a. The PMMM assessment indicates that government construction agencies generally operate at a moderate to mature level of project management practice, with stronger performance in integration,

scope, time, and cost management. However, relatively lower maturity was observed in human resource management, communications management, and risk management, suggesting gaps in coordination, information flow, and adaptive management functions.

- b. The stakeholders' perception analysis reveals that benchmarking is widely recognized as beneficial, particularly in improving cost efficiency, timeliness, safety, productivity, and quality compliance. Despite the overall positive perception, variations across institutions indicate differing levels of exposure, organizational support, and readiness for benchmarking adoption. These differences highlight the influence of leadership commitment and institutional context on benchmarking effectiveness.
- c. The pairwise comparison and FAHP results identify technological adoption, inter-agency collaboration, and integration of quality management systems as the most critical barriers to benchmarking implementation. Limitations in digital infrastructure, real time and reliable data, and standardized performance measures limit the ability of participating agencies to conduct meaningful benchmarking. Leadership and KPI related barriers, while relevant, were found to be secondary in influence compared to system level constraints.
- d. The prioritized strategies derived from the FAHP emphasize strong leadership commitment, capacity building and training, leadership driven quality procedures, and targeted digital capability development as the most effective interventions. These priorities indicate that improving benchmarking readiness requires an integrated approach that combines organizational support, developing human capital, improving governance mechanisms, and enabling digital systems that support consistent and comparable performance measurement.

5.2 Recommendations

Based on the findings and conclusions of this study, the following recommendations are proposed for government agencies, policymakers, and future researchers:

- a. Government construction agencies should institutionalize benchmarking by formally integrating it into project planning, monitoring, and post project evaluation processes, supported by standardized Key Performance Indicators (KPIs).
- b. Leadership development programs should be strengthened to promote a quality driven and data oriented organizational culture, ensuring sustained management support for benchmarking initiatives.
- c. Investment in digital tools and data infrastructure should be prioritized to improve data reliability, transparency, and real time performance monitoring for benchmarking purposes.
- d. Interagency collaboration mechanisms should be established to facilitate data sharing, harmonization of performance measures, and dissemination of best practices among DPWH, the City Engineer's Office, and USTP.
- e. A phased approach to benchmarking implementation should be adopted, beginning with internal benchmarking and gradually expanding to interagency and sector wide comparisons.
- f. Policymakers should develop supportive policies and incentives that encourage benchmarking adoption, including performance based recognition and alignment with national governance and quality frameworks.
- g. Future studies may expand the scope of this research by including private sector construction projects, conducting longitudinal assessments of benchmarking maturity, or exploring the use of advanced digital technologies such as BIM and data analytics in benchmarking systems.

References

1. World Bank. (2017). *World Development Report 2017: Governance and the Law*. Washington, DC: World Bank. <https://doi.org/10.1596/978-1-4648-0950-7>
2. Camp, R. C. (2006). *Benchmarking: The Search for Industry Best Practices that Lead to Superior Performance*. New York: Productivity Press. <https://doi.org/10.4324/9781003578871>
3. National Research Council. (2005). *Measuring Performance and Benchmarking Project Management at the Department of Energy*. Washington, DC: National Academies Press. <https://doi.org/10.17226/11344>
4. Parmenter, D. (2015). *Key Performance Indicators: Developing, Implementing, and Using Winning KPIs (3rd ed.)*. Hoboken, NJ: John Wiley & Sons. <https://doi.org/10.1002/9781119019855>
5. Kärnä, S., & Junnonen, J.-M. (2016). Benchmarking construction industry, company and project performance by participants' evaluation. *Benchmarking: An International Journal*, 23(7), 2092–2107. <https://doi.org/10.1108/BIJ-07-2015-0067>
6. Riaz, A., Khan, N., Ullah, R., Tahir, M., Alqurashi, M., & Alsulami, H. (2023). Key factors for implementation of total quality management in construction sector using a system dynamics approach. *Ain Shams Engineering Journal*, 14(3), 101903. <https://doi.org/10.1016/j.asej.2022.101903>
7. Costa, D. B., Formoso, C. T., Kagioglou, M., Alarcón, L. F., & Caldas, C. H. (2006). Benchmarking initiatives in the construction industry: Lessons learned and improvement opportunities. *Journal of Management in Engineering*, 22(4), 158–167. [https://doi.org/10.1061/\(ASCE\)0742-597X\(2006\)22:4\(158\)](https://doi.org/10.1061/(ASCE)0742-597X(2006)22:4(158))
8. Sabone, E. J., & Addo-Tenkorang, R. (2016). Benchmarking and performance measurement in the construction industry: A case of Botswana. *Journal of Construction Project Management and Innovation*, 6(Supplement), 1240–1263. <https://doi.org/10.36615/jcpmi.v6iSupplement.106>
9. Budayan, C., & Okudan, O. (2022). Roadmap for the implementation of total quality management in ISO 9001-certified construction companies. *Ain Shams Engineering Journal*, 13(5), 101788. <https://doi.org/10.1016/j.asej.2022.101788>
10. Datta, S., Bhowmik, S., Singh, D., Pandey, A., & Pal, B. (2023). Benefits and barriers of implementing building information modeling (BIM) in construction management: A systematic review. *Sustainability*, 15(16), 12466. <https://doi.org/10.3390/su151612466>
11. International Organization for Standardization. (2015). *ISO 9001:2015—Quality management systems—Requirements*. Geneva: ISO.
12. Luu, V. T., Kim, S.-Y., & Huynh, T.-A. (2008). Improving project management performance of large contractors using benchmarking approach. *International Journal of Project Management*, 26(7), 758–769. <https://doi.org/10.1016/j.ijproman.2007.10.002>
13. Wawak, S., Stecuła, K., & Mikulić, J. (2020). The role of organizational culture and leadership in quality management: A study of the construction industry. *Sustainability*, 12(3), 1025. <https://doi.org/10.3390/su12031025>
14. Ghansah, F. A., & Edwards, D. J. (2024). Digital technologies for quality assurance in the construction industry: Current trend and future research directions towards Industry 4.0. *Buildings*, 14(3), 844. <https://doi.org/10.3390/buildings14030844>
15. Crawford, J. K. (2006). *Project Management Maturity Model (2nd ed.)*. Boca Raton, FL: CRC Press. <https://doi.org/10.1201/9780849379468>

16. Project Management Institute. (2008). *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* (4th ed.). Newtown Square, PA: Project Management Institute.
17. Project Management Institute. (2013). *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* (5th ed.). Newtown Square, PA: Project Management Institute.
18. Kerzner, H. (2019). *Strategic Planning for Project Management Using a Project Management Maturity Model* (3rd ed.). Hoboken, NJ: John Wiley & Sons. <https://doi.org/10.1002/9781119559078>
19. Cooke-Davies, T. J., & Arzymanow, A. (2003). The maturity of project management in different industries: An investigation into variations between project management models. *International Journal of Project Management*, 21(6), 471–478. [https://doi.org/10.1016/S0263-7863\(02\)00084-4](https://doi.org/10.1016/S0263-7863(02)00084-4)
20. Salonga, K. (2025, December 4). COA: Gov't lost P6.45B in 2024 from 'unusable or idle' DPWH projects. ABS-CBN News.
21. Dimaculangan, E. (2023). Issues and challenges in the Philippine construction industry. *Bicol University College of Science and Technology Journal*.
22. World Bank. (2025). *Project Information Document (PID): Philippines—Supporting Innovation in TVET and Workforce Readiness*. World Bank. (PDF).
23. Koenig, N. (2015). *Project management maturity in local government* (Undergraduate thesis). University of Southern Queensland.
24. Bonilla, M., & Castillo, T. (2020). Benchmarking the construction industry: An adaptation of the World Management Survey methodology. In *Proceedings of the 28th Annual Conference of the International Group for Lean Construction* (pp. 217–228). <https://doi.org/10.24928/2020/0057>
25. Garcia, C. O., Garrido, J. L. S., Campoverde, T. O. C., & Cárdenas, L. F. A. (2023). Methodological proposal to assess management practices for incorporating benchmarking into the Chilean construction industry. *Europub Journal of Multidisciplinary Research*, 4(1), 33–49. <https://doi.org/10.55033/ejmr4n1-003>
26. Ackah, D., & Amponsah, R. (2024). Evaluating project management maturity in the construction industry of developing countries: Ghana in perspective. *Project Management Scientific Journal*, 7(9), 1–15. <https://doi.org/10.4314/pmsj.v7i9.1>
27. Cox, R. F., Issa, R. R., & Ahrens, D. (2003). Management's perception of key performance indicators for construction. *Journal of construction engineering and management*, 129(2), 142–151.
28. Oda, M., Momen, M. A., Tayeh, B., Alhammadi, S., & Abu Aisheh, Y. (2022). Key indicators for evaluating the performance of construction companies from the perspective of owners and consultants in Gaza Strip. *Results in Engineering*, 15, 100596. <https://doi.org/10.1016/j.rineng.2022.100596>
29. Costa, D. B. & Formoso, C. T.. (2003). *Guidelines for Conception, Implementation and Use of Performance Measurement Systems in Construction Companies*. 11th Annual Conference of the International Group for Lean Construction.
30. Kaiser, H. F. (1970). A second generation little jiffy. *Psychometrika*, 35(4), 401–415. <https://doi.org/10.1007/BF02291817>
31. Bartlett, M. S. (1954). A note on the multiplying factors for various chi-square approximations. *Journal of the Royal Statistical Society: Series B (Methodological)*, 16(2), 296–298.
32. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Cengage Learning.
33. Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3), 297–334. <https://doi.org/10.1007/BF02310555>

34. DeVellis, R. F. (2012). *Scale development: Theory and applications* (3rd ed.). SAGE Publications.
35. Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, 2, 53–55. <https://doi.org/10.5116/ijme.4dfb.8dfd>
36. Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, 1(1), 83–98. <https://doi.org/10.1504/IJSSCI.2008.017590>
37. Vaidya, O. S., & Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research*, 169(1), 1–29. <https://doi.org/10.1016/j.ejor.2004.04.028>
38. Zavadskas, E. K., & Turskis, Z. (2011). Multiple criteria decision making (MCDM) methods in economics: An overview. *Technological and Economic Development of Economy*, 17(2), 397–427. <https://doi.org/10.3846/20294913.2011.593291>
39. Buckley, J. J. (1985). Fuzzy hierarchical analysis. *Fuzzy Sets and Systems*, 17(3), 233–247. [https://doi.org/10.1016/0165-0114\(85\)90090-9](https://doi.org/10.1016/0165-0114(85)90090-9)
40. Badihaveli, K. S., & Vyas, G. S. (2019). Benchmarking construction quality attributes for township projects. In *Proceedings of the National Conference on Sustainable Infrastructure Development and Management*.
41. Karim, R. A., Latief, Y., & Zagloel, T. Y. (2022). Measuring and benchmarking the quality culture maturity of construction companies in Indonesia. *International Journal of Engineering, Transactions A: Basics*, 35(10), 2028–2039. <https://doi.org/10.5829/ije.2022.35.10a.20>
42. Chang, D.-Y. (1996). Applications of the extent analysis method on fuzzy AHP. *European Journal of Operational Research*, 95(3), 649–655. [https://doi.org/10.1016/0377-2217\(95\)00300-2](https://doi.org/10.1016/0377-2217(95)00300-2)
43. Abdulrahman, R. S., Ibrahim, A. D., & Chindo, P. G. (2019). Assessment of risk management maturity of construction organisations in joint venture projects. *Journal of Engineering, Project, and Production Management*, 9(1), 20–28. <https://doi.org/10.2478/jepmm-2019-0004>
44. Ahmad, N., & Qahmash, A. (2020). Implementing fuzzy AHP and FUCOM to evaluate critical success factors for sustained academic quality assurance and ABET accreditation. *PLOS ONE*, 15(9), e0239140. <https://doi.org/10.1371/journal.pone.0239140>
45. Ahmed, S. K. (2024). How to choose a sampling technique and determine sample size for research: A simplified guide for researchers. *Oral Oncology Reports*, 12, 100662. <https://doi.org/10.1016/j.oor.2024.100662>
46. Albertin, M. R., Pontes, H. L., Aragão, D. P., Prata Junior, B. A., & Baltazar, M. C. (2021). A new flexible benchmarking monitoring system: A case study for the civil construction sector in Brazil. *Espacios*, 42(16), 50–60. <https://doi.org/10.48082/espacios-a21v42n16p04>
47. Alofi, K., & Younes, A. M. (2019). Total quality management implementation in the manufacturing sector in Saudi Arabia: A systematic review. *Business and Management Research*, 8(1), 41–52. <https://doi.org/10.5430/bmr.v8n1p41>
48. Chaudhari, G. (2018). Quality benchmarking in the construction industry. *International Research Journal of Engineering and Technology*, 5(12).
49. Dilawo, R. S., & Salimi, Z. (2019). Understanding TQM implementation barriers involving construction companies in a difficult environment. *International Journal of Quality & Reliability Management*, 36(7), 1137–1158. <https://doi.org/10.1108/IJQRM-05-2017-0096>
50. Ikpe, E., Jergeas, G., & Kumar, J. (2015). Benchmarking projects: How to apply it on non-industrial projects. *Business and Management Horizons*, 3(1), 24–35. <https://doi.org/10.5296/bmh.v3i1.7704>
51. Kahraman, C., Cebeci, U., & Ulukan, Z. (2004). Multi-criteria supplier selection using fuzzy AHP.

- Logistics Information Management, 17(6), 382–394. <https://doi.org/10.1108/09576050410559294>
52. Kloppenborg, T. J. (1999). The ten commandments of assessing project management maturity. *PM Network*, 13(11), 64–66.
53. Lakew, T., Admassu, K., & Maru, E. (2022). Framework on effective stakeholders' management process related to project success in public building construction projects: The case of Gondar City, Ethiopia. *International Journal of Advanced Research and Publications*, 5(4).
54. Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. SAGE Publications.
55. Luo, H., Lin, L., Chen, K., Antwi-Afari, M. F., & Chen, L. (2022). Digital technology for quality management in construction: A review and future research directions. *Developments in the Built Environment*, 12, 100087. <https://doi.org/10.1016/j.dibe.2022.100087>
56. Marinelli, M., Konanahalli, A., Dwarapudi, R., & Janardhanan, M. (2022). Assessment of barriers and strategies for the enhancement of off-site construction in India: An ISM approach. *Sustainability*, 14(11), 6595. <https://doi.org/10.3390/su14116595>
57. Mbugua, M., Ajwang', P., & Winja, M. M. O. (2021). Identification and ranking of key performance indicators in building construction projects in Kenya. *Engineering, Technology & Applied Science Research*, 11(1), 6668–6673. <https://doi.org/10.48084/etasr.3912>
58. Munaro, M. R., & Tavares, S. F. (2023). A review on barriers, drivers, and stakeholders towards the circular economy: The construction sector perspective. *Journal of Cleaner Production*, 382, 135296. <https://doi.org/10.1016/j.jclepro.2023.135296>
59. Oluwatosin, E. A. (2024). Quality management in construction projects. *International Journal of Research Publication and Reviews*, 5(7), 432–439. <https://doi.org/10.55248/gengpi.5.0724.1615>
60. Othman, I., Kineber, A. F., Oke, A. E., Zayed, T., & Buniya, M. K. (2021). Barriers of value management implementation for building projects in the Egyptian construction industry. *Ain Shams Engineering Journal*, 12(1), 21–30. <https://doi.org/10.1016/j.asej.2020.08.004>
61. Patel, C. S., & Pitroda, J. R. (2021). Quality management system in construction: A review. *RT&A*, 16(Special Issue 1), 60.
62. Pratama, F. H., Andhika, R., & Latief, Y. (2021). The framework of quality culture maturity in Indonesian construction company to reduce the construction failure rate. *IOP Conference Series: Earth and Environmental Science*, 794(1), 012027. <https://doi.org/10.1088/1755-1315/794/1/012027>
63. Rawale, P. P., & Mahatme, P. S. (2021). A study on quality management in construction projects at Amravati. *Open Access International Journal of Science & Engineering*, 6(7).
64. Salkind, N. J. (2006). *Encyclopedia of measurement and statistics* (1st ed.). SAGE Publications.
65. Salawu, R. A., & Abdullah, F. (2015). Assessing risk management maturity of construction organisations on infrastructural project delivery in Nigeria. *Procedia – Social and Behavioral Sciences*, 172, 643–650. <https://doi.org/10.1016/j.sbspro.2015.01.419>
66. Shah, H., & Pitroda, J. R. (2018). A critical literature review on quality management for infrastructure projects. *International Journal of Engineering Research and Development*, 14(3), 18–21.
67. Sheoran, V., & Thakur, D. J. (2023). A study on evaluation of quality management systems in construction projects. *International Journal of Membrane Science and Technology*, 10(4), 2037–2048. <https://doi.org/10.15379/ijmst.v10i4.2357>
68. Shirandula, F. C., Kisimbii, J., & Otieno, M. (2018). Influence of total quality management practices on the performance of the construction industry in Mombasa County, Kenya. *International Journal of Advanced Research and Publications*, 2(9).

69. Singh, A. S., & Masuku, M. B. (2014). Sampling techniques and determination of sample size in applied statistics research: An overview. *International Journal of Economics, Commerce and Management*, 2(11). <http://ijecm.co.uk/>
70. Statistische Beratung Leonardo Miljko. (n.d.). Exploratory factor analysis (EFA): How to interpret KMO and Bartlett's test [PDF]. https://www.statistischerdatenanalyse.de/images/Exploratory_Factor_Analysis-EFAHow_to_interpret_KMO_and_Bartletts_test.pdf
71. Wankhade, S. A., & Kesarkar, R. B. (2021). Effectiveness of quality management system on construction industry. *International Research Journal of Modernization in Engineering Technology and Science*, 3(6). <https://www.irjmets.com>
72. Wawak, S., Ljevo, Z., & Vukomanović, M. (2020). Understanding the key quality factors in construction projects: A systematic literature review. *Sustainability*, 12(24), 10376. <https://doi.org/10.3390/su122410376>
73. Wyke, S., Lindhard, S. M., & Larsen, J. K. (2024). Using principal component analysis to identify latent factors affecting cost and time overrun in public construction projects. *Engineering, Construction and Architectural Management*, 31(6), 2415–2436. <https://doi.org/10.1108/ECAM-02-2022-0189>
74. Yang, Y., Wei, Z., & Zhang, Z. (2023). Stakeholder relationships in construction projects: A mixed-methods review. *Buildings*, 13, 3122. <https://doi.org/10.3390/buildings13123122>