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Web-Based E-Procurement Development in Regional-Owned Enterprises (BUMD): An R&D Approach

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ABSTRACT

This study presents the design, development, and evaluation of a web-based e-procurement system tailored to the institutional needs of a Regional-Owned Enterprise (BUMD), with a case implementation at PDAM Tirta Kahuripan. Employing a Research and Development (R&D) methodology and assessed using ISO/IEC 25010 standards, the system integrates six core procurement modules—e-Planning, e-Budgeting, e-Preparation, e-Sourcing, e-Contracting, and e-Inventory—alongside a Vendor Management System (VMS) to enhance procurement transparency and supplier accountability. System testing involved both quantitative and qualitative assessments. Functionality and reliability achieved perfect scores (100%), usability scored 79 based on a System Usability Scale (SUS) survey completed by 20 procurement personnel, and maintainability recorded a moderate index of 82.85 based on PHP Metrics analysis. Efficiency testing using GTMetrix resulted in a Grade C, indicating areas for performance optimization. These findings demonstrate that the system is both technically robust and operationally relevant, offering a replicable model for digital procurement reform in decentralized public institutions. The study contributes to interdisciplinary knowledge across software engineering, public sector management, and procurement governance, with implications for future integration, scalability, and policy adoption in similar institutional contexts.

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1. INTRODUCTION

Procurement of goods and services constitutes a strategic function within the governance of public sector institutions, including Regional-Owned Enterprises (Badan Usaha Milik Daerah or BUMD) such as Regional Drinking Water Companies (PDAMs). The effectiveness and efficiency of procurement processes are critical to the operational success of BUMDs, as they not only influence budgetary optimization but also reflect institutional accountability and transparency in the digital era. Nevertheless, procurement practices in many BUMDs remain predominantly manual, relying on physical documentation and fragmented record-keeping systems. These practices are often accompanied by weak internal controls and the absence of standardized procedures, thereby increasing administrative risks, reducing operational efficiency, and creating opportunities for non-

transparent practices—all of which ultimately compromise service quality and organizational performance (Budiawan, 2024; Neupane et al., 2012).

As the role of information technology expands across public institutions, digital transformation in procurement has become increasingly necessary. A prominent manifestation of this trend is the adoption of electronic procurement (e-procurement) systems, which enable procurement activities to be carried out electronically in a more integrated, traceable, and efficient manner. Numerous studies have demonstrated the value of e-procurement in accelerating procurement cycles, reducing transaction costs, enhancing operational efficiency, and reinforcing institutional transparency and accountability (Suwardi & Prasetyo, 2018; Jonathan et al., 2017; Khan, 2025). Internationally, e-procurement is widely recognized as a key indicator of good governance, with ex-ante transparency—i.e., transparency prior to contract award—identified as one of the most effective strategies for reducing corruption risks in public procurement (Mu'ah et al., 2024; Bauhr et al., 2020; Mahuwi & Israel, 2024).

Implementation of e-procurement systems within BUMDs, however, is not without its challenges. These include misalignment between system design and internal workflows, limited digital competencies among staff, and insufficient institutional support to sustain innovation. Addressing these constraints requires the development of systems that are closely aligned with operational realities and the regulatory environment. The use of a structured Research and Development (R&D) approach is particularly relevant, as it allows for the systematic design of systems rooted in actual user needs. This approach enables iterative development stages—from requirement analysis and prototyping to implementation and evaluation—ensuring contextual relevance and system usability. Prior research confirms the value of R&D in generating systems that meet both technical standards and institutional constraints (Nur et al., 2023). The ISO/IEC 25010 framework further provides a rigorous structure for evaluating software quality across five key dimensions: functionality, usability, efficiency, reliability, and maintainability (Peters & Aggrey, 2020).

Previous studies have explored the development of e-procurement systems across various institutional settings. Kusaini (2018) developed a seminar management information system using the R&D model and ISO/IEC 25010 as the evaluation framework. Burhanuddin (2020) implemented a web-based direct procurement platform for a higher education institution. Sanjana (2019) applied SDLC to develop an e-procurement system at a BUMN subsidiary, while Qomariah (2021) built a UML-based procurement system for local government entities without incorporating a software quality evaluation. Brianu (2019) adopted the FAST methodology to digitize procurement at a state-owned port enterprise. These studies demonstrate ongoing efforts to modernize procurement systems, but many remain partial in scope, focused on centralized institutions, or limited in methodological rigor and evaluation tools.

In view of this landscape, the present study undertakes the design and implementation of a more integrated and context-specific e-procurement system for a regional-owned enterprise. The system includes a full procurement cycle—ranging from planning to inventory management—and incorporates a dedicated Vendor Management System (VMS). It applies a multidimensional evaluation framework aligned with ISO/IEC 25010, utilizing GTMetrix for performance analysis, WAPT for reliability testing, the System Usability Scale (SUS) for user assessment, and PHP Metrics for maintainability evaluation. Through this combination of design and testing, the study offers a scalable and replicable system model while contributing methodologically to the literature on public sector information systems.

In addition to the development and evaluation components, the study embraces an interdisciplinary orientation. It integrates principles from software engineering, public administration, human-computer interaction (HCI), and procurement governance. The conceptual framework aims to strengthen institutional capacity in managing procurement processes through digital platforms that align with both technical and governance standards. The findings offer relevance across multiple domains: system developers may adopt the technical framework, procurement officials may refer to the structured workflows, and oversight agencies may benefit from enhanced transparency and traceability features. As such, the study contributes not only to

organizational improvement at the institutional level but also to broader efforts in advancing technology-enabled public sector reform.

This research offers insights that intersect with various domains, making its findings potentially useful to a wide range of readers, including professionals in information systems, public administration, and governance. By focusing on a real-world case and addressing practical procurement challenges through a technically sound and contextually grounded solution, the study highlights the potential of digital innovation to strengthen institutional processes. The integration of diverse disciplinary perspectives encourages ongoing dialogue across sectors, supporting the advancement of responsive and transparent public service delivery.

2. RESEARCH METHOD

2.1 Research Design

This study integrates a descriptive quantitative method with a Research and Development (R&D) approach to design and implement a web-based e-procurement system that aligns with the operational characteristics of Regional-Owned Enterprises (BUMDs). The R&D framework guided the development through a structured progression—needs assessment, system design, prototyping, testing, and final validation—ensuring that the resulting system was responsive to user requirements and institutional workflows. Meanwhile, the descriptive quantitative method facilitated a data-driven evaluation of system quality, emphasizing the dimensions of functionality, efficiency, reliability, usability, and maintainability. This methodological combination provides a dual emphasis: iterative system development on one side, and measurable evaluation on the other, offering a systematic foundation for both technical implementation and empirical assessment, as noted by Kurnia and Rohman (2023).

The system was developed by adopting the standard phases of the R&D approach, beginning with a comprehensive analysis of organizational needs and procurement workflows. This was followed by system design, modular development, user validation, and performance testing. The process is illustrated in Figure 1, which outlines the conceptual sequence adopted during development. Each phase contributed to ensuring that the system conformed to PDAM's internal procurement standards while meeting international software quality criteria.

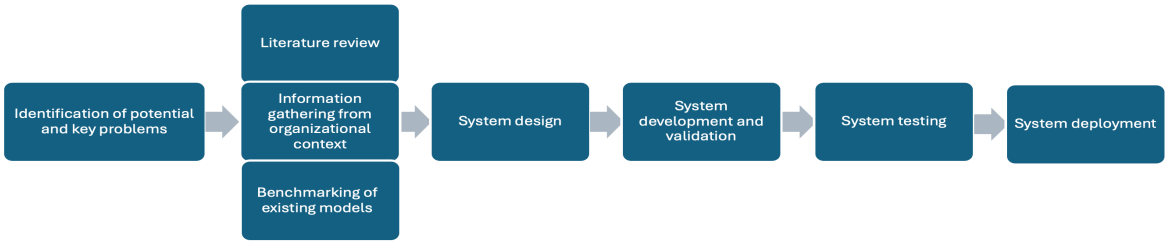

Figure 1. Research and Development Phases in E-Procurement System Design

The research was conducted at PT Tirta Kahuripan, a regional water utility in Bogor Regency, chosen purposively to represent a typical BUMD requiring digital procurement transformation. The unit of analysis centered on the Procurement Division, which included system users and organizational decision-makers. Data collection methods consisted of direct observation of existing workflows, semi-structured interviews with five key informants, document analysis of procurement SOPs, and administration of the System Usability Scale (SUS) questionnaire. These multiple data sources allowed for a detailed mapping of technical and institutional requirements, contributing to a more targeted and applicable system design. The results correspond with earlier studies emphasizing the importance of aligning digital system development with organizational realities and user engagement (Adityo et al., 2022; Suparto & Dai, 2021).

A distinctive feature of the research lies in the integration of R&D-based system development with a multi-instrument evaluation framework built on ISO/IEC 25010 standards. Beyond general functionality and usability tests, the study employed GTMetrix to assess performance efficiency, WAPT for load reliability, SUS for measuring user experience, and PHP

Metrics for analyzing code maintainability. This composite evaluation method not only ensured technical rigor and operational viability but also offered a replicable model for public sector organizations seeking structured procurement digitalization. The approach connects system engineering, institutional analysis, and software assurance, distinguishing this study from earlier research that often focuses solely on partial implementation or singular technical evaluation.

2.2 Needs Analysis and System Requirements

The needs analysis stage was critical to the R&D method, serving as the foundation for developing a contextually appropriate e-procurement system. Conducted through on-site observations and interviews at PDAM Tirta Kahuripan, this stage identified both functional and non-functional requirements, including essential features for each procurement phase. The process adhered to principles of requirements engineering, emphasizing active user involvement in defining system specifications based on operational realities (Adil et al., 2014).

Benchmarking was conducted on government sector e-procurement models to adopt relevant best practices tailored to PDAM's unique context. The preliminary design was validated through stakeholder discussions to ensure alignment with internal needs, promoting efficiency and institutional accountability. This approach is supported by previous findings emphasizing the integration of local context and user participation in designing effective public information systems (Torvinen & Haukipuro, 2018).

2.3 System Design, Development, and Testing

The system development phase was structured in accordance with the R&D methodology, ensuring technical feasibility and functional adequacy. It began with system modeling through Context Diagrams, Data Flow Diagrams (DFD), and Entity Relationship Diagrams (ERD) to outline system interactions, process flows, and database structure. This modeling approach enhanced development speed and minimized implementation errors (Martin et al., 2025).

The system was built using a combination of PHP (Yii Framework), MySQL, and Bootstrap, supported by XAMPP and Visual Studio Code. Key modules included e-Planning, e-Budgeting, e-Sourcing, and Vendor Management System (VMS), all integrated to support end-to-end digital procurement workflows. The Yii-MySQL combination enabled system stability, while modular integration facilitated digital transformation and overall system adaptability (Egloffstein & Ifenthaler, 2023).

System quality was comprehensively evaluated in accordance with the ISO/IEC 25010 international standard, which provides a multidimensional framework for assessing software quality. The evaluation focused on five core dimensions—functionality, efficiency, usability, reliability, and maintainability—each representing a critical aspect of the system's performance and sustainability.

Functionality

The functionality aspect represents a primary dimension in the evaluation of software quality, as outlined in the ISO/IEC 25010 standard. This evaluation is aimed at ensuring that each feature within the e-procurement system operates in accordance with both the technical specifications and the specific needs of its users. The assessment was conducted using the Guttman Scale, which evaluates the operability of each feature through a definitive and binary (yes/no) scoring mechanism. This method provides a high degree of precision in measuring the extent to which the system's functionalities are fulfilled within the operational context (Sugiyono, 2014).

The score was calculated using the following formula:

$$\text{Result} = \frac{\text{Obtained Score}}{\text{Maximum Score}} \text{ x } 100\%$$

Subsequently, the measurement results were categorized into five levels based on a Likert Scale, as presented in the table below. This categorization allows for a more structured interpretation of the system's performance, facilitating clear benchmarking against established quality thresholds.

It also provides actionable insights for identifying areas of strength and pinpointing specific aspects that require improvement. By translating raw scores into qualitative categories, the evaluation becomes more accessible for stakeholders and decision-makers involved in system enhancement and implementation.

Table 1. Functionality Percentage Scale

No	Range Result (%)	Category
1	0% s.d. 20%	Very Poor
2	21% s.d 40%	Poor
3	41% s.d. 60%	Fair
4	61% s.d. 80%	Good
5	81% s.d 100%	Excellen

Efficiency

The evaluation of the efficiency aspect was conducted using the GTMetrix tool, which technically analyzes page load speed, system file size, and the number of HTTP requests. This testing is essential to assess how optimally the system utilizes available resources to deliver fast and efficient response times for users (Puspito, 2024). Efficiency is a critical factor in the development of web-based systems, as it directly affects user experience, bandwidth consumption, and server capacity. A system with poor efficiency can lead to longer loading times, higher operational costs, and reduced user satisfaction, particularly during peak usage periods.

Therefore, measuring and improving efficiency is crucial not only for enhancing technical performance but also for supporting broader organizational goals such as operational scalability and digital service quality. The test results were classified according to the GTMetrix grading system, which categorizes performance into six efficiency levels, as shown in the following table:

Table 2. GTMetrix Efficiency Grades

GTMetrix Grade (%)	GTMetrix Grade Level	Interpretation
90 – 100	A	Highly Efficient
80 – 89	B	Efficient
70 – 79	C	Moderately Efficient
60 – 69	D	Less Efficient
50 – 59	E	Inefficient
0 – 49	F	Highly Inefficient

Usability

The usability aspect measures the extent to which the system is easy to understand, learn, and use by users to achieve their objectives effectively, efficiently, and satisfactorily. The evaluation was conducted using the System Usability Scale (SUS) method, a standardized assessment instrument widely adopted in information systems research and user interface design studies (Suria, 2024). This method employs ten statements rated by users on a 5-point Likert scale, reflecting their perceptions of ease of use and satisfaction during interaction with the system. The interpretation of SUS scores is based on the following classification:

To ensure consistency and comparability, the SUS scoring procedure follows a structured method in which user responses to positively and negatively worded items are adjusted to eliminate scale bias. Scores for odd-numbered items are calculated by subtracting 1 from the response, while even-numbered items are reverse scored by subtracting the response from 5. The total score is then multiplied by 2.5 to yield a final score ranging from 0 to 100. This method enables systematic assessment of usability perceptions, allowing researchers and system designers to benchmark the user experience against established thresholds in usability studies. The SUS instrument is particularly suited for evaluating public-facing systems, where user acceptance is influenced by clarity, efficiency, and perceived ease of use.

The interpretation of SUS scores is based on the following classification:

Table 3. SUS Score Interpretation

Grade	SUS	Percentile range	Adjective	Acceptable	NPS
A+	84.1 – 100	96 – 100	Best Imaginable	Acceptable	Promoter
A	80.8 – 84.0	90 – 95	Excellent	Acceptable	Promoter
A-	78.9 – 80.7	85 – 89		Acceptable	Promoter
B+	77.2 – 78.8	80 – 84	Good	Acceptable	Passive
B	74.1 – 77.1	70 – 79		Acceptable	Passive
B-	72.6 – 74.0	65 – 69		Acceptable	Passive
C+	71.1 – 72.5	60 – 64		Acceptable	Passive
C	65.0 – 71.0	41 – 59		Marginal	Passive
C-	62.7 – 64.9	35 – 40	OK	Marginal	Passive
D	51.7 – 62.6	15 – 34		Marginal	Detravtor

The SUS score is calculated by summing the contributions from each item. For odd-numbered statements, the contribution score is obtained by subtracting 1 from the user's score (x – 1), while for even-numbered statements, the contribution is calculated by subtracting the user's score from 5 (5 – x). The total contribution score is then multiplied by 2.5 to obtain the final score, which ranges from 0 to 100.

Reablity

The reliability aspect, as defined in the ISO/IEC 25010 standard, emphasizes the system's ability to operate stably and consistently under both normal and high-load conditions. This testing aims to assess the system's success rate in executing tasks without failure, while also identifying any potential instability during user interaction processes (Sarwosri et al., 2023). The evaluation was conducted using the Web Application Performance Testing (WAPT) tool, which simulates parallel user loads to measure the system's responsiveness under heavy traffic scenarios.

The test produced six key parameters: successful sessions, failed sessions, successful pages, failed pages, successful hits, and failed hits. The final reliability score was calculated using the following formula:

$$\text{Result} = \frac{\text{Succesfull Session} + \text{Succesfull Pages} + \text{Succesfull Hits}}{\text{Total Session} + \text{Total Pages} + \text{Total Hits}} \text{ x } 100\%$$

The outcomes were then classified into five interpretative levels, as shown in the table below:

Table 4. Reliability Score Classification

No	Result Range (%)	Category
1	0% - 20%	Very Low
2	21% - 40%	Low
3	41% - 60%	Fair
4	61% - 80%	High
5	81% - 100%	Very High

Maintainability

The maintainability aspect evaluates the extent to which a software system can be easily modified, whether for the purpose of fixing defects, enhancing features, or adapting to new requirements (Simalango & Adrian, 2022). The assessment was carried out using the PHP Metrics tool, which automatically analyzes the source code structure to assess programming quality based on a set of technical indicators. The evaluation produced a primary score known as the Maintainability Index (MI)—an aggregate value that reflects the overall ease of system maintenance, derived from the combination of the aforementioned metrics. The interpretation of the MI score is categorized as follows:

Table 5. Maintainability Index (MI) Categories

MI Score	Category	Description
<65	Low	Difficult to maintain and contains technical issues
65 s.d 85	Medium	Maintainable with no significant problems
>85	High	Highly maintainable with excellent system quality

3. RESULTS AND DISCUSSION

This section outlines the key results of the study, including the analysis of the existing procurement process, the development of the web-based e-procurement system, and the outcomes of system testing based on ISO/IEC 25010 quality standards.

3.1. Procurement Process Analysis Results

The initial development of the e-procurement system began with an analysis of the manual procurement process at PDAM Tirta Kahuripan, aiming to identify problems such as data duplication, delays, and weak coordination. Observations and interviews revealed the absence of a digital system, which hindered traceability and increased administrative risks. The findings from this analysis formed the basis for designing the e-procurement system to streamline workflows, improve data accuracy, and enhance transparency and accountability (Ngayu & Juma, 2019). Six main procurement stages were subsequently designed for integrated digitalization.

Procurement Planning (e-Planning)

This module facilitates the preparation and digital archiving of Terms of Reference (TOR) and Budget Plan documents, ensuring that the procurement process is initiated with well-structured and traceable planning documentation. It also supports internal coordination by providing a clear foundation for subsequent procurement stages.

Budget Review (e-Budgeting)

This module facilitates the preparation and digital archiving of Terms of Reference (TOR) and Budget Plan documents, ensuring that the procurement process is initiated with well-structured and traceable planning documentation. It also supports internal coordination by providing a clear foundation for subsequent procurement stages. In addition, this feature facilitates verification of alignment between budget codes and procurement cost allocations, ensuring consistency between planning and budget realization.

Procurement Preparation (e-Preparation)

This module covers the preparation and management of technical documents, such as item/service specifications, Owner's Estimate (OE), and draft contracts, ensuring that all procurement requirements are clearly defined and properly documented to support a transparent and well-regulated supplier selection process.

Supplier Selection (e-Sourcing)

This system is designed to support the digital and structured selection of vendors through both tender and non-tender mechanisms, ensuring compliance with procurement regulations while enhancing the efficiency, traceability, and integrity of the supplier selection process.

Contract Management (e-Contracting)

This module is used to monitor contract implementation, record work progress, and manage documentation related to contract execution, thereby ensuring that all contractual obligations are tracked systematically and that the execution process remains transparent, accountable, and aligned with the agreed terms.

Goods/Services Inventory (e-Inventory)

This system functions to record and track data on procured goods or services, including storage location, quantity, and distribution status, thereby enabling effective inventory control,

supporting asset management, and facilitating real-time reporting for better decision-making and operational efficiency.

The digitalization of these six stages is expected to foster a procurement process that is more transparent, efficient, and accountable, while comprehensively addressing the complexities and challenges of procurement management within Regional-Owned Enterprises (BUMDs), particularly in aligning operational practices with principles of good governance and institutional performance improvement.

3.2. System Development Results

Based on the results of the process analysis and user needs assessment, a web-based e-procurement system was developed using a design-based approach within an R&D framework. This system was designed to automate all procurement stages—from planning to inventory—using PHP (Yii Framework), MySQL, and a responsive Bootstrap-based user interface. Each procurement stage was realized in the form of integrated modules, as follows:

Vendor Management System (VMS)

This module centrally manages vendor data, including registration, verification, and updating of vendor qualification documents. The VMS only allows verified vendors to participate in the procurement process, thereby enhancing efficiency, transparency, and preventing administrative irregularities. By streamlining vendor management from the outset, the system ensures greater control over supplier eligibility and supports compliance with institutional procurement policies. Furthermore, it facilitates continuous monitoring of vendor performance and document validity, enabling proactive risk mitigation throughout the procurement lifecycle.

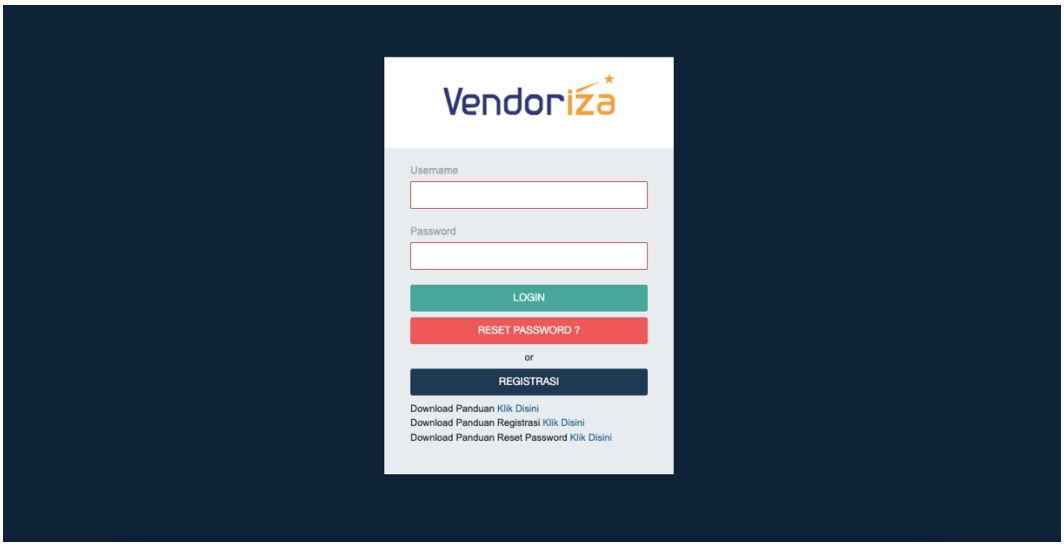

Figure 3. Vendor Management System

Procurement Planning Module (e-Planning)

This module enables the preparation and storage of initial documents such as Terms of Reference (TOR) and Budget Planning, and facilitates internal approvals digitally, supporting efficiency and traceability from the planning stage. It provides a centralized repository for planning documents, reducing the risk of data fragmentation and document loss. Additionally, the module enhances inter-departmental coordination by ensuring that all stakeholders have access to up-to-date and authorized planning information in real time.

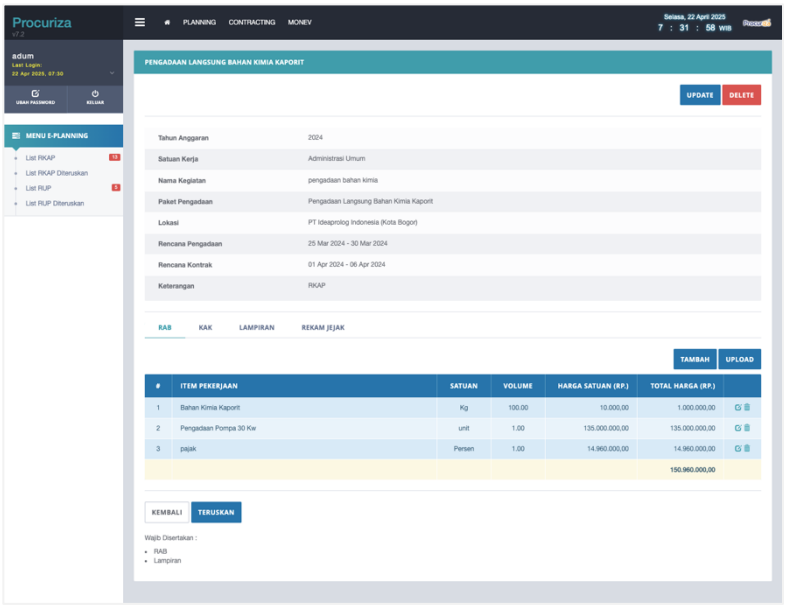

Figure 4. Procurement Planning Module

Procurement Preparation Module (e-Preparation)

Used to prepare technical documents such as specifications, HPS, and draft contracts, ensuring that the supplier selection process proceeds smoothly and in compliance with regulations. This module enables standardization of procurement documentation, reducing ambiguity and improving the quality of tender submissions. It also supports version control and structured workflows, allowing authorized personnel to review and approve documents efficiently. By digitizing this preparatory phase, the system enhances accountability and minimizes the risk of procedural errors that could compromise procurement integrity

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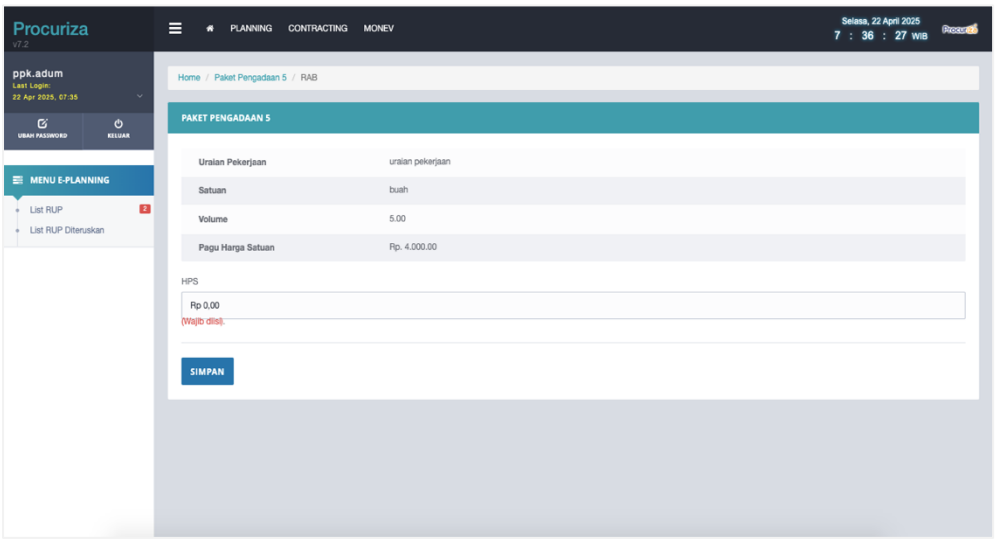


Figure 5. Procurement Preparation Module

Supplier Selection Module (e-Sourcing)

Manages the vendor selection process—both tender and non-tender—from package announcement to winner determination, in a systematic and regulatory-compliant manner. This module ensures that all stages of the selection process are properly documented and traceable, supporting audit readiness and procedural transparency. It includes features for bid submission, evaluation scoring, and decision justification, which streamline the assessment and approval

workflow. By automating key steps and enforcing rule-based validations, the system minimizes human error and enhances the objectivity and fairness of vendor selection.

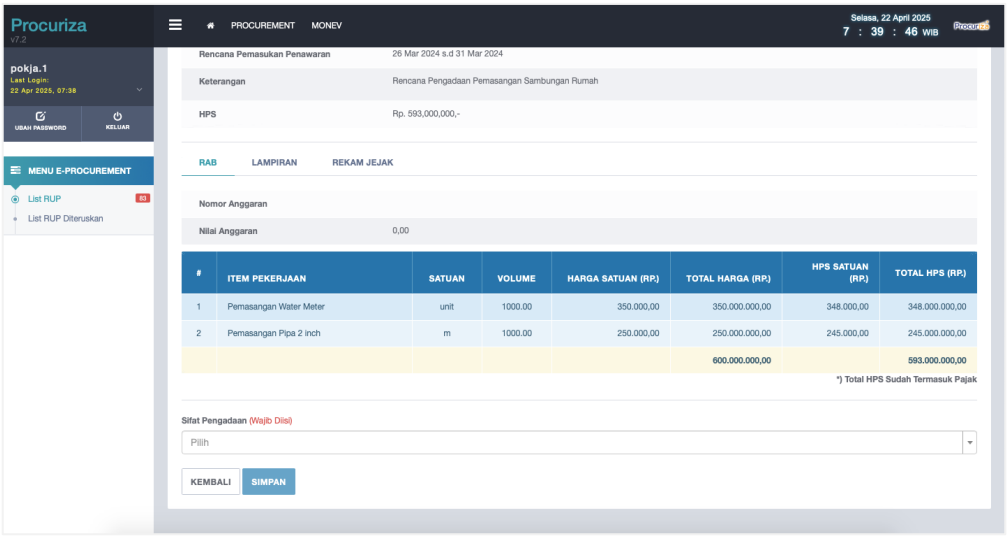


Figure 6. Supplier Selection Module

Contract Module (e-Contracting)

Handles contract documentation and monitoring, including implementation data, work progress, and supporting documents, to ensure that contract execution is digitally tracked and supervised. This module enables real-time updates on contract milestones, deadlines, and deliverables, promoting proactive management and timely interventions when needed. It also facilitates collaboration among stakeholders by providing shared access to contract records and communication logs. By maintaining a centralized and secure digital record of contract activities, the system strengthens accountability and mitigates the risk of disputes or non-compliance during execution.

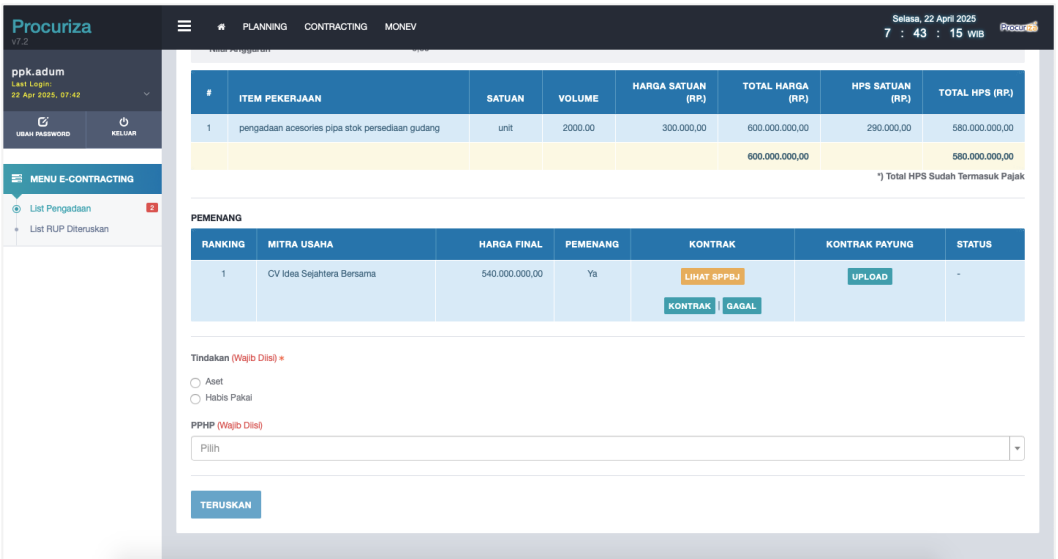


Figure 7. Contract Module

Inventory Module

Records procured goods/services data such as specifications, quantity, storage location, and status. This module supports inventory accuracy by automatically updating stock levels upon receipt or distribution of items. It provides visibility into asset availability and movement, which is essential

for planning, auditing, and operational decision-making. Additionally, the system helps prevent redundancy and losses by ensuring that inventory data is consistent, traceable, and aligned with procurement records.

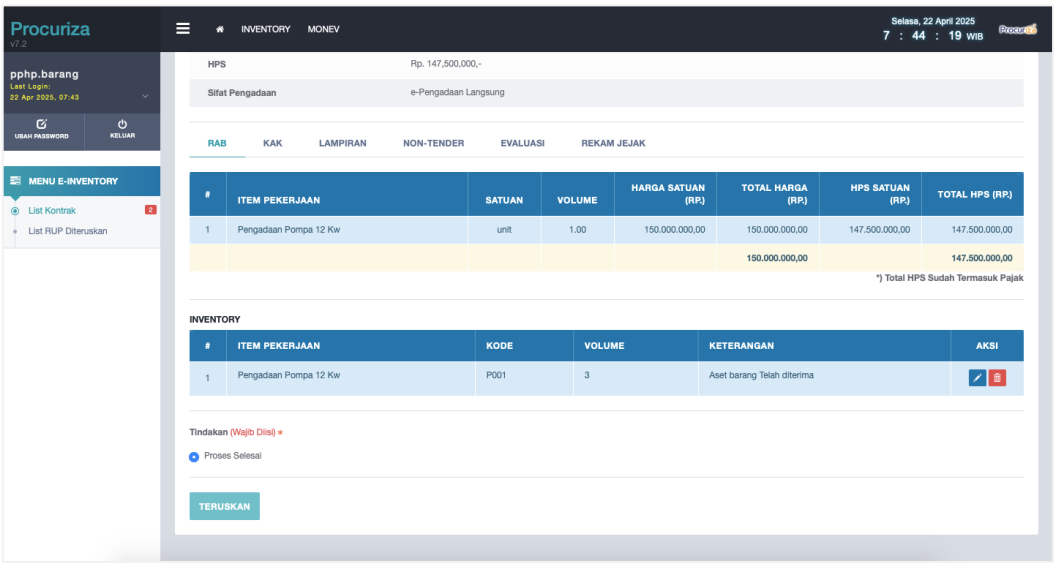


Figure 8. Inventory Module

The user interface was developed in accordance with the Procurement SOP and validated by key users to ensure usability by non-technical staff. The system features a real-time monitoring dashboard with intuitive navigation and clear icons, designed to streamline user interaction and reduce the learning curve. By combining functional clarity with user-centered design principles, the interface minimizes errors, enhances task efficiency, and supports consistent adherence to procurement workflows.

3.2. System Testing Results

System testing was conducted to ensure that the e-procurement system meets ISO/IEC 25010 software quality standards and aligns with user requirements. Five quality dimensions were tested using different methods and tools, as follows:

Functionality

Evaluation by three expert evaluators confirmed that all features functioned without failure, achieving a 100% score. This indicates that the system is capable of executing the entire procurement process completely, accurately, and as designed. The result reflects the robustness of the system architecture and the effectiveness of its modular integration in supporting end-to-end procurement activities.

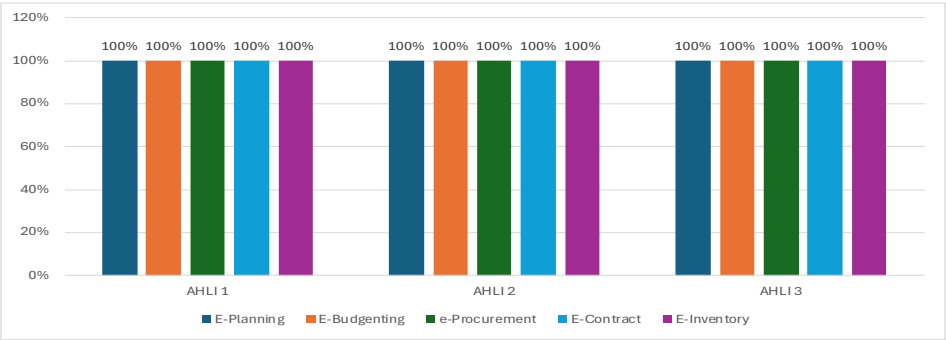


Figure 9. Functionality Testing Results

Efficiency

Testing using GTMetrix yielded a Performance Grade of 66% and a Structure Score of 80%, resulting in an overall Grade C. The Fully Loaded Time was recorded at 3.9 seconds, with a Total Page Size of 1.91 MB and 83 HTTP Requests. The Time to Interactive was 2.9 seconds, while Largest Contentful Paint (LCP) was measured at 3.7 seconds, which is considered suboptimal for user experience.

These results indicate moderate system efficiency, with room for performance enhancement particularly in front-end rendering and asset delivery. Recommended technical optimizations include enabling browser caching, compressing large image files, deferring offscreen images, reducing unused JavaScript and CSS, and minimizing server requests through better code bundling. Addressing these issues is expected to reduce page load time, improve responsiveness, and enhance the overall user experience in accessing the e-procurement system.

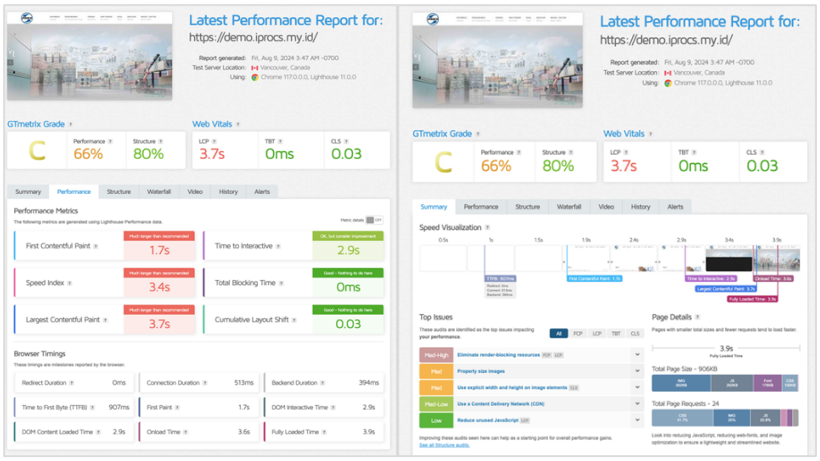


Figure 10. Efficiency Testing Results

Usability

The usability testing conducted using the System Usability Scale (SUS) method yielded a score of 79, which falls within the “Good” category. This result indicates that the system is user-friendly and aligns with user expectations in supporting digital procurement processes. The score reflects the clarity of the user interface, the logical flow of functions, and the system’s accessibility to non-technical users. It also suggests that the training required to operate the system is minimal, which is essential for ensuring smooth implementation and sustained user engagement within the procurement unit.

The SUS score was obtained through a structured survey administered to 20 members of the Procurement Division at PT Tirta Kahuripan, who participated in evaluating the system after user testing. Each respondent completed a questionnaire and provided ratings based on a five-point Likert scale, assessing ten standard usability items. The aggregated results of this survey are presented in Table 6 below.

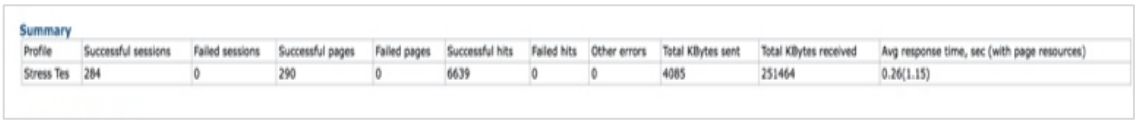
In addition to the quantitative SUS score, qualitative feedback was obtained through post-testing interviews with procurement practitioners at PT Tirta Kahuripan, namely one Head of the Procurement Division and two Heads of Subdivision. Users highlighted the intuitive navigation structure, simplified document workflows, and clear categorization of procurement stages as the system’s primary usability strengths. They reported that the system significantly reduced the time and effort required to carry out routine procurement tasks, especially when compared to the previous manual processes. Nonetheless, several suggestions for further development were also noted, such as the inclusion of visual indicators for progress tracking and more comprehensive tooltip-based guidance for first-time users. This user input affirms the system’s overall usability while providing valuable direction for future refinements grounded in actual user experience.

Table 6. SUS Score Testing Results

No Pernyataan	STS	TS	KS	S	SS	Nilai
1	0	0	0	8	2	42
2	2	5	2	0	0	18
3	0	0	0	8	2	42
4	0	7	2	1	0	24
5	0	1	1	7	1	38
6	1	6	3	0	0	22
7	0	0	2	7	1	39
8	2	6	2	0	0	20
9	0	4	0	6	0	32
10	0	1	0	8	1	39
Jumlah Nilai						316
Rata-Rata Nilai						31,6
Rata-Rata Nilai RAW SUS Score						79

Reliability

Using the WAPT application, the system was tested under simultaneous access conditions and successfully handled 284 sessions, 290 pages, and 6,639 requests without failure. A 100% score indicates that the system is highly stable and reliable. This result demonstrates the system's ability to maintain consistent performance under high user load, a critical requirement for real-time procurement operations. It also confirms the robustness of the backend infrastructure in handling concurrent transactions without degradation or error.



Summary

Profile	Successful sessions	Failed sessions	Successful pages	Failed pages	Successful hits	Failed hits	Other errors	Total KBytes sent	Total KBytes received	Avg response time, sec (with page resources)
Stress Tes	284	0	290	0	6639	0	0	4085	251464	0.26(1.15)

Figure 11. Reliability Testing Results

Maintainability

Testing using PHP Metrics produced a Maintainability Index (MI) score of 82.85, which falls into the “moderate” category. This indicates that the system is generally maintainable, although some structural refinements may enhance long-term sustainability. Supporting metrics include an average cyclomatic complexity per class of 3.52, an average weighted method count per class of 7.58, and an average relative system complexity of 82.85. These figures suggest a manageable codebase with acceptable complexity for future updates. Additionally, the system registered an average of 0.18 bugs (Halstead) and 0.31 defects (Kan) per class, reflecting a relatively clean implementation with low potential for major refactoring. Overall, these metrics demonstrate that the system's architecture supports future modifications such as feature enhancements, bug fixes, and third-party integrations with manageable maintenance effort.

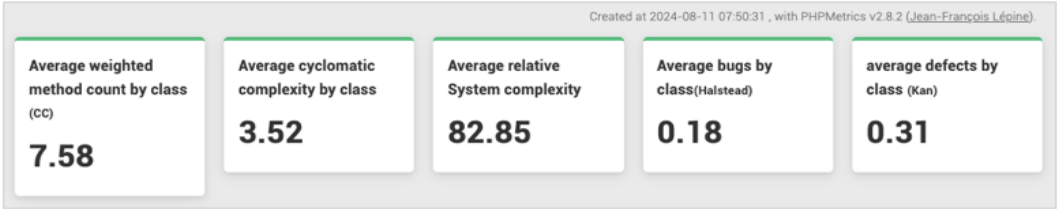


Figure 12. Maintainability Testing Results

The initial analysis revealed that the procurement process at PDAM Tirta Kahuripan, which had previously been conducted manually, resulted in several issues such as workflow inefficiencies, process delays, and weak inter-unit integration. To address these challenges, a web-based e-procurement system was developed, digitalizing six core procurement stages: e-Planning, e-

Budgeting, e-Preparation, e-Sourcing, e-Contracting, and e-Inventory. Each module was designed based on actual user needs and aligned with PDAM's internal procurement Standard Operating Procedures (SOP). The system was built using PHP (Yii Framework), MySQL, and Bootstrap, forming a responsive and stable platform. Additionally, a Vendor Management System (VMS) was developed as a key component to verify and centrally manage goods/service providers from the outset of the procurement process.

System validation was conducted iteratively through pilot testing with key users. The testing results demonstrated excellent performance in functionality and reliability (100%), good usability (SUS Score of 79), fairly good maintainability (MI of 82.85), and efficiency that still requires optimization (Grade C). Based on these results, the system is deemed suitable to support digital transformation in the procurement environment of Regional-Owned Enterprises (BUMDs).

These findings reinforce those of Suwardi and Prasetyo (2018), who found that the implementation of e-procurement significantly enhances efficiency and transparency in public sector procurement processes. However, this study advances further by designing a system that not only supports the tender process but also encompasses the entire procurement cycle in an integrated manner, including planning and inventory components. Moreover, unlike the study by Nur et al. (2023), which focused on developing procurement information systems for local governments with an emphasis on planning and contracting, this research adopts a holistic approach through the integration of VMS, ensuring compliance and accountability from the initial stage of vendor registration.

Accordingly, the scientific contribution of this study lies in the development of an e-procurement system tailored to the unique needs of hybrid organizations such as BUMDs, which operate neither fully under public sector regulations nor entirely within market-driven frameworks. This makes the developed system model more flexible and applicable to similar organizational contexts that require digital efficiency, process transparency, and robust administrative control. The system bridges the gap between regulatory compliance and operational agility, enabling BUMDs to adapt procurement practices to their dual mandates. Moreover, it offers a replicable model for organizations facing similar institutional complexities, particularly in regions with evolving governance structures.

3.3. Technical Accountability and Research Limitations

The comprehensive testing results presented in the previous section demonstrate that the developed e-procurement system meets key software quality dimensions and performs reliably in real-world operational settings. Built through a structured Research and Development (R&D) approach, the system was evaluated based on ISO/IEC 25010 standards using a set of technical tools that support objective and verifiable assessments. These include GTMetrix for performance efficiency, WAPT for reliability under concurrent load conditions, the System Usability Scale (SUS) for user-friendliness, and PHP Metrics for structural maintainability.

Functionality and reliability testing indicated full operational integrity, with both aspects scoring 100%, showing that the system could execute all procurement processes without failure. Usability testing using the SUS method yielded a score of 79, classified as “Good,” suggesting the system is intuitive and accessible to non-technical users with minimal training. The maintainability index of 82.85, calculated using PHP Metrics, reflects that the system’s codebase is sufficiently structured to accommodate future updates, enhancements, or integration efforts. Efficiency testing, performed via GTMetrix, returned a Grade C, signifying moderate performance with identifiable areas for optimization, particularly in front-end rendering and server-side responsiveness.

In addition to its technical performance, the system offers substantive design features that support institutional needs. The modular structure not only automates the full procurement cycle but also incorporates a Vendor Management System (VMS), enabling centralized registration, verification, and performance tracking of suppliers. This integration ensures tighter control over vendor compliance and procurement risk, contributing to more accountable and transparent procurement practices.

While the system meets its intended objectives within the scope of this development effort, some limitations remain. The design and testing were conducted within a single institutional context—PDAM Tirta Kahuripan in Bogor Regency—limiting immediate generalizability to other BUMDs or sectors. Moreover, although the internal modules cover the end-to-end procurement cycle, integration with external platforms such as regional budgeting systems or electronic auditing tools was beyond the current scope. Additionally, user feedback was collected during system validation and pilot use, but longer-term adoption patterns and impact on organizational performance have not yet been studied.

These limitations suggest future research directions, including implementation testing across multiple BUMDs and the exploration of system interoperability with broader digital governance infrastructures. Further optimization of system efficiency and extended stakeholder feedback cycles would also support the refinement and scalability of the platform. Collectively, these steps would enhance the system's potential as a replicable model for digital procurement transformation in hybrid public organizations.

4. CONCLUSION

This study demonstrates the design, development, and evaluation of a web-based e-procurement system tailored to the operational characteristics and institutional structure of a Regional-Owned Enterprise (BUMD). Developed through a Research and Development (R&D) approach and evaluated using ISO/IEC 25010 standards, the system integrates key procurement stages including planning, budgeting, sourcing, contracting, and inventory management. The inclusion of a Vendor Management System (VMS) further enhances the system's capacity for monitoring supplier compliance and institutional transparency.

System testing yielded strong results across several quality dimensions: functionality and reliability scored 100%, usability was rated as "Good" with a SUS score of 79, and maintainability achieved a moderate index of 82.85. While efficiency received a GTMetrix grade of C, this result points to specific areas for technical optimization, particularly in front-end and server-side performance.

The findings affirm the feasibility of implementing structured digital procurement solutions in decentralized public entities such as PDAMs. By aligning system architecture with internal workflows and governance principles, the developed model addresses real institutional challenges and contributes to procurement reform through digital means. In doing so, it strengthens operational control, enhances transparency, and supports procurement accountability.

In addition to its technical and organizational implications, the study bridges multiple disciplinary perspectives including software engineering, public management, user interaction design, and procurement policy. The resulting system framework serves not only as a practical tool for BUMD procurement modernization, but also as a reference model for researchers and practitioners seeking to advance digital transformation within hybrid public organizations. As public institutions continue to evolve in complexity and expectations of service delivery, the integration of adaptable, evaluative, and user-aligned procurement systems becomes increasingly relevant.

Future research may expand upon these contributions by implementing the system across varied organizational contexts, testing integration with financial and regulatory infrastructures, and evaluating long-term impacts on institutional performance. These directions will further enrich the discourse on digital innovation and strengthen the role of information systems in public sector transformation.

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