The Application of Retrieval-Augmented Generation (RAG) in Developing an Intelligent Risk Management Platform: A Case Study at Statistics Jawa Timur

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Abstract. Risk management is a crucial element in the governance of modern organizations, especially for public institutions such as Statistics Indonesia (BPS), which is responsible for providing official state statistics. Currently, the conventional methodology at Statistics Jawa Timur remains manual, relying on spreadsheet software, which results in slow and unresponsive processes for addressing dynamic risks. This condition reduces the effectiveness of internal controls, particularly with a massive strategic agenda like the 2026 Economic Census (SE2026) approaching. To address these limitations, this research proposes the development of Kadiri-A Risk Management Information System and Worksheet, an intelligent system that integrates Artificial Intelligence (AI) technology, specifically Large Language Models using the Retrieval-Augmented Generation (RAG) method. The Kadiri system is designed to transform risk management from a reactive to an initiative-taking process, accelerating the identification, analysis, and mitigation recommendations by leveraging BPS internal knowledge base. The RAG methodology enables an AI model, such as Google Gemini, to provide contextual and relevant suggestions based on the organization's historical data. The outcome of this development is a digital platform that speeds up risk analysis, enhances accountability, and aligns with the bureaucracy reform agenda.

Keyword: Artificial Intelligence, Retrieval Augmented Generation, Information System, Risk Management, Economic Census 2026

1. Introduction

The practical implementation of risk management is a crucial element of good governance. In the public sector, this function is increasingly important for ensuring accountability, efficiency, and achievement of strategic objectives. Regulation of Government of the Republic of Indonesia Number 60 of 2008 on concerning the Government Internal Control System (SPIP) and Regulation of the Ministry of State Apparatus Utilization and Bureaucratic Reform Number 5 of 2020 on concerning Guidelines for Risk Management of the Electronic-Based Government System (SPBE) explicitly mandates that government agencies to implement risk management as an integral part of their control systems [1] [2]. For Statistics Indonesia (BPS), whose role as the source of official state statistics risk in data is crucial. Failure to manage risks could threaten data quality, decrease public trust in BPS data, and disrupt field survey continuity, ultimately undermining evidence-based policymaking and hindering national development

The scope of BPS activities encompasses the entire territory of Indonesia, including the province of East Java. East Java is a province characterized by its large and complex volume of survey samples. Therefore, this study, which utilizes the conditions in East Java as its sample, can provide a general representation of the implementation of risk management within BPS. A detailed observation of the current conditions in Statistics Jawa Timur reveals a significant gap in risk management implementation. To ensure data quality and operational efficiency, BPS comprehensively implements risk management across all stages of its statistical activities, from planning to dissemination, in accordance with the Generic Statistical Business Process Model (GSBPM) framework. However, a detailed observation of the current conditions in Statistics Jawa Timur reveals a significant gap between this ideal framework and its actual implementation. The existing process relies on a conventional approach, where risk analysis and documentation are performed manually, often using spreadsheet software. This method has several fundamental weaknesses: a slow risk management cycle from identification to response, a limited ability to process large volumes of narrative data, and a reliance on individual institutional memory, which is prone to information loss. Consequently, the organization remains reactive rather than initiative-taking, and its capacity to respond to risks fails to match the pace of their emergence.

The urgent need for this transformation is amplified by the national agenda that BPS is about to face: the 2026 Economic Census (SE2026). SE2026 is a massive and complex project involving data collection from millions of business units across Indonesia. Based on prior census or survey-based economic data, the activity in a dynamic environment, with the potential for risks to emerge rapidly, such as data errors, technical disruptions, or operational challenges in the field, is crucial to assess. All these risks will impact aspects such as inefficient budget allocation, overuse, data quality problems, and failure to meet timeliness targets if not detected early or identified.

In response to these challenges, Artificial Intelligence (AI) technology offers a new paradigm in risk management. AI, particularly Large Language Models (LLMs), has a unique capability to process and analyze large volumes of textual data at a speed unattainable by humans [3] [4] [5]. This allows for the automation of analytical tasks, such as identifying risk patterns from historical reports or formulating mitigation recommendations based on existing best practices. The integration of AI into risk management can transform it into a proactive, intelligent, and near-real-time process.

This research aims to address the existing gap by designing and developing an intelligent risk management system named Kadiri-A Risk Management Information System and Worksheet. In this research, Kadiri will use Retrieval-Augmented Generation (RAG). RAG is a cutting-edge methodology that addresses the limitations of conventional LLMs, reducing the risk of "hallucinations" by integrating factual data from an external knowledge base before generating a response [6] [7] [8] [9] [10] [11]. By implementing the RAG method, Kadiri is designed to leverage the internal knowledge of Statistics Jawa Timur optimally and, even more, provide solutions that are not only efficient but also relevant and contextual. This makes RAG highly suitable for risk management applications that demand high accuracy [12] [13] [14].

Furthermore, this system will adopt the risk management principles and framework in accordance with the Indonesian National Standards (SNI) International Organization for Standardization (ISO) 31000 to ensure consistent and effective risk management. According to SNI ISO 31000, risk management generally consists of four stages: Scope, Context, and Criteria; Risk Assessment; Risk Treatment; and Monitoring and Review. The Risk Assessment stage is further divided into three components: Risk Identification, Risk Analysis, and Risk Evaluation. [15].

2. Research Method

This study employs a Design and Development Research approach to design and build an integrated intelligent risk management system [16] [17]. The research methodology is divided into four main stages: Data Collection, System Development, LLMs Implementation, and System Evaluation.

2.1. Data Collection

The data collection methods used in this study are interviews. The interview method was chosen because it allows the researchers to gather in-depth information from informants, consistent with the principles outlined [18]. Interviews were conducted with the Risk Management Unit of Statistics Jawa Timur. The questions focused on the current business processes, the problems that arise from them, and the needs and expectations for the proposed system. Subsequently, an observation was conducted to understand the manual workflow of risk management directly and to identify gaps or inefficiencies that the proposed system could address.

2.2. System Development

The system development method used is the Software Development Life Cycle (SDLC) prototype model. This model was chosen because the software to be built is complex and requires intensive interaction with users to ensure the suitability of its features and functionality [19] [20].

The prototype model consists of six iterative stages [21] [22].

- Analysis: This initial stage involves identifying user needs and the problems faced in managing activity agendas.
- Design: This stage aims to design the system and its features, typically in the form of a Unified Modeling Language (UML).
- Prototype: The system begins to be developed, producing a functional prototype for evaluation.
- Evaluation: The prototype is evaluated by users to assess its performance and usability. If improvements are needed, the cycle iterates back to the design stage.
- Testing: Once the prototype is approved, extensive testing is conducted to ensure the system functions according to specifications. Testing includes unit testing, integration testing, end-to-end testing, and manual testing by users.
- Implementation: The final stage, where the system is deployed on the Statistics Jawa Timur server and becomes operational.

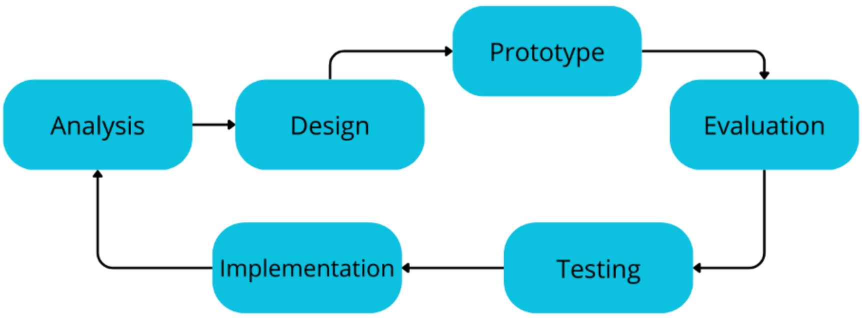

Figure 17. SDLC Model Prototype

2.3. LLMs Implementation

The implementation of the LLM in this system uses the RAG method [11] [12]. RAG integrates a generative LLM (Google Gemini) with the internal knowledge base of Statistics Jawa Timur to produce accurate and contextual responses.

- Knowledge Base Construction: Critical documents (Risk Bank, reports, SOPs) are collected, and their textual content is extracted and partitioned into smaller, meaningful segments. Each segment is subsequently converted into a numerical vector representation, known as an embedding, utilizing Google's text-embedding-004 model. Finally, these vectors are stored and indexed within a Vector Database, implemented with PostgreSQL and the pgvector extension, to enable highly efficient and relevant information retrieval based on semantic similarity.

- RAG Workflow: RAG is a process that consists of three main stages, namely: Retrieval, Augmentation, and Generation.
    - Retrieval: A user's query triggers a semantic search in the Vector Database to find the most relevant document "chunks."
    - Augmentation: The retrieved information is then combined with the user's original query to enrich the prompt.
    - Generation: The enriched prompt is sent to the Google Gemini API to generate an intelligent and relevant answer.

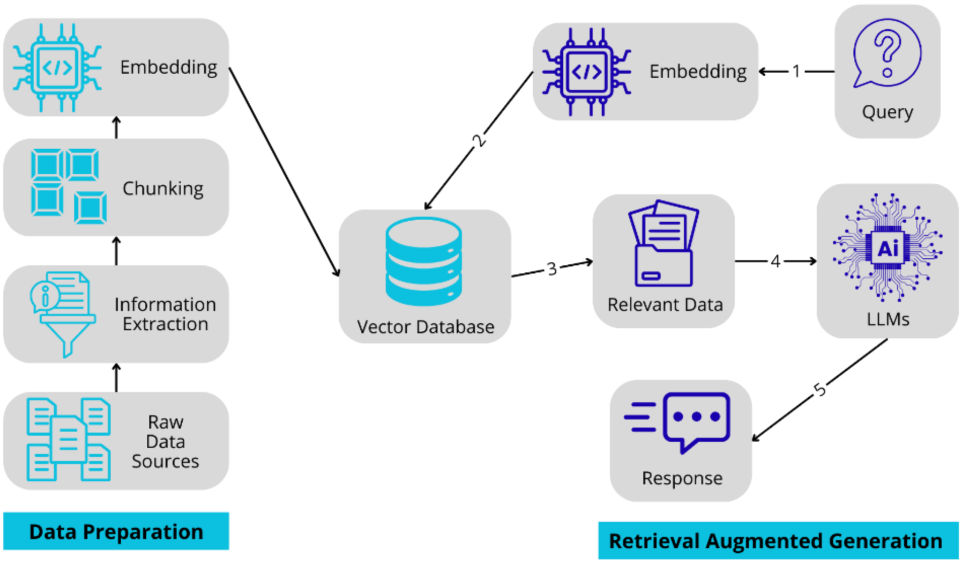

Figure 18. LLM with RAG

2.4. System Evaluation

The system evaluation in this study focuses on assessing the usability of the developed system. To achieve this, we use the Post-Study System Usability Questionnaire (PSSUQ). PSSUQ is a standard questionnaire for evaluating user satisfaction with a system. It consists of 16 questions on a seven-point scale, plus a "N/A" option. The questions are designed to measure three key usability dimensions: user satisfaction, effectiveness, and efficiency [23] [24]. PSSUQ was chosen to gain a comprehensive impression of the end-user's experience with the system [25]. The questionnaire will be administered to specific Statistics Jawa Timur employees who have used the Kadiri system, as described in Table 5. The collected data will be analyzed to assess the overall usability of the system and serve as a basis for future improvements.

Table 5. PSSUQ Questions

	Questions
Q1	Overall, I am satisfied with how easy it is to use this system
Q2	It was simple to use this system.
Q3	I was able to complete the tasks and scenarios quickly using this system.
Q4	I felt comfortable using this system.
Q5	It was easy to learn to use this system.

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Q6	I believe I could become productive quickly using this system.
Q7	The system gave error messages that clearly told me how to fix problems.
Q8	Whenever I made a mistake using the system, I could recover easily and quickly.
Q9	The information (such as online help, on-screen messages, and other documentation) provided with this system was clear.
Q10	It was easy to find the information I needed.
Q11	The information was effective in helping me complete the tasks and scenarios.
Q12	The organization of information on the system screens was clear.
Q13	The interface of this system was pleasant.
Q14	I liked using the interface of this system.
Q15	This system has all the functions and capabilities I expect it to have.
Q16	Overall, I am satisfied with this system.

3. Results and Discussion

The following are the results of the Kadiri system development based on the SDLC prototyping stages.

3.1. Analysis

The initial stage of this analysis involves the application of the fishbone diagram, also known as the cause-and-effect or Ishikawa diagram. This diagnostic tool is used to systematically identify and categorize the potential root causes of a problem into four primary classifications, known as the 4Ms: Man, Method, Machine, and Measurement. The fishbone diagram is presented in Figure 19.

- Measurement
  - Infrequent Risk Evaluation and Reporting: The absence of regular monitoring and evaluation of risks prevents early detection of potential issues. This activity resulted in a reactive response rather than proactive problem management mechanism.
- Method
  - Lack of a Standard Operating Procedure (SOP) for Risk Management: The non-existence of a formal SOP leads to inconsistencies in work processes and varied interpretations among employees. This undermines the standardization and effectiveness of risk management implementation.
- Man
  - Limited Employee Comprehension: A lack of understanding among staff regarding the concepts and importance of risk management hinders their active participation in risk identification and mitigation.
  - Inadequate Number of Operators: A limited number of personnel dedicated to risk management directly impacts the efficiency and effectiveness of its execution.
  - Insufficient Team Involvement: The failure to involve all relevant teams in risk management leads to a non-comprehensive approach and a lack of holistic perspectives.
- Machine
  - Restricted Access to the Maritemen Application: Technical constraints in accessing the information system cause delays and hindrances in data input and risk monitoring.
  - Manual Data Entry in Worksheets: Manual recording carries a high risk of human error and is less efficient compared to automated systems, thus compromising overall operational efficiency.

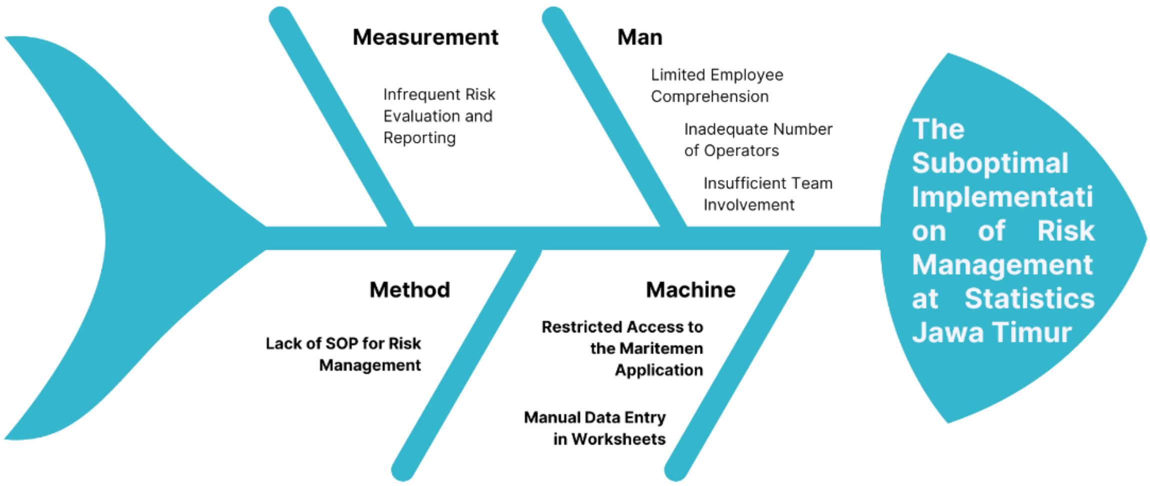

Figure 19. Fishbone Diagram

The analysis of the current business process is conducted using the Business Process Model and Notation (BPMN). The execution process of the BPMN, as illustrated in Figure 20, was obtained from interviews with the Risk Management Unit.

Based on the visualization of the current system's BPMN in Figure 20, it can be concluded that the entire process is still carried out manually. This condition leads to a high potential for errors and increased complexity within the business process.

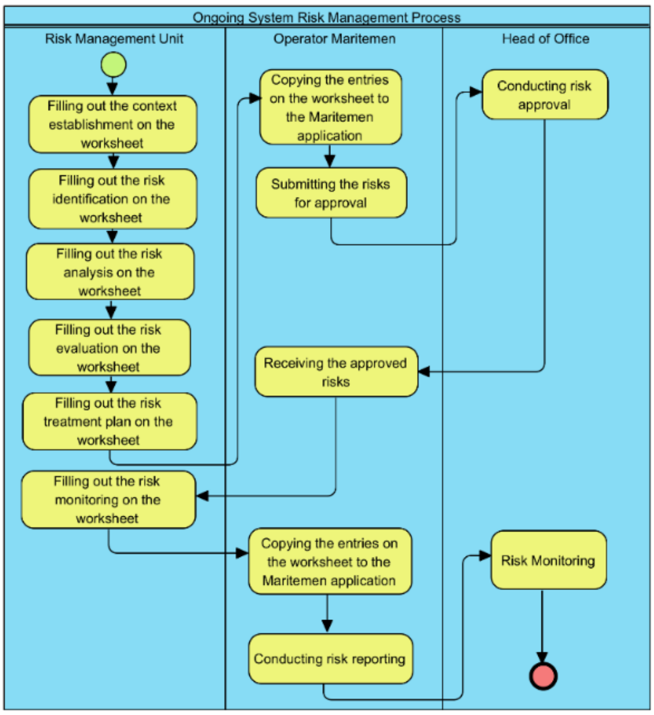

Figure 20. BPMN Risk Management

3.2. Design

After performing a system analysis, the next step is to perform system design. One of the UML diagrams used in system design is the use case diagram. The use case diagram, designed to illustrate the interaction between actors and the system during the ongoing system design, is shown in Figure 21.

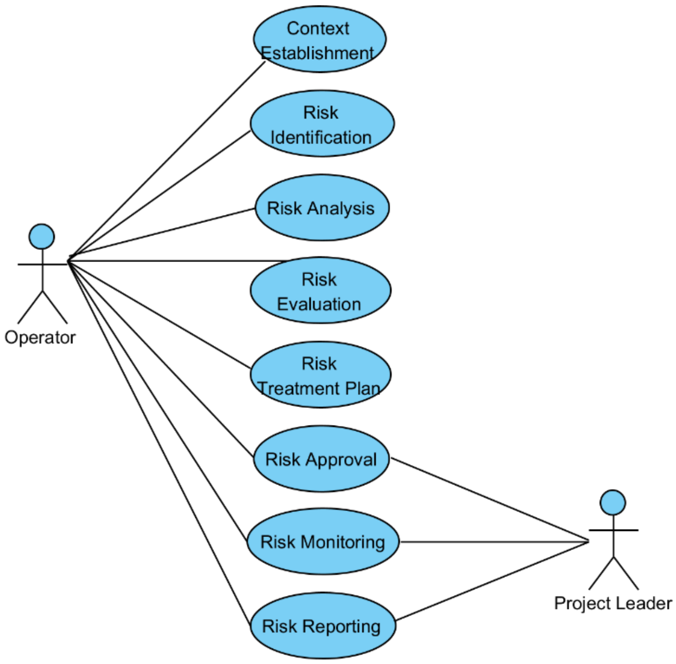

Figure 21. Use Case Diagram

Based on the use case diagram in Figure 21, there are two actors involved in this system. These actors are the operator and the project leader. The next step is to create a user interface design. The user interface design in the form of a wireframe for the 'Risk Identification' page can be seen in Figure 22.

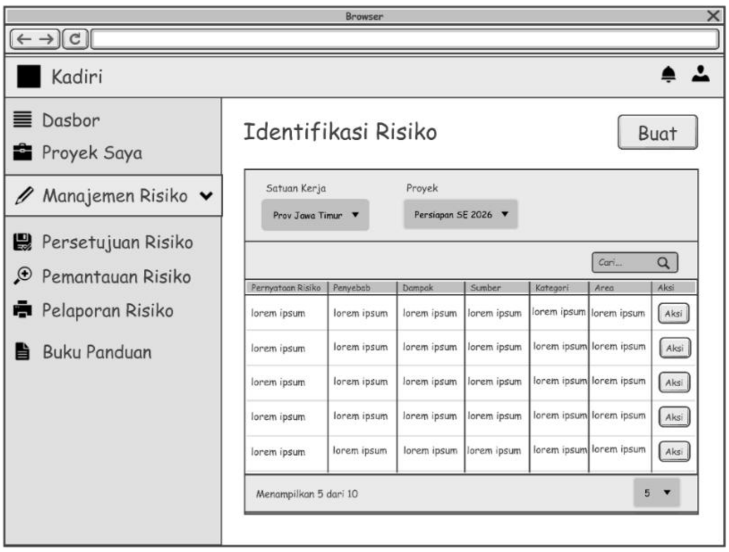

Figure 22. Wireframe Risk Identification

3.3. Prototype

The prototyping phase was conducted after the completion of the system design. For this prototype, a modern technology stack was utilized to ensure development, efficiency, and scalability. PHP 8.x was chosen as the primary programming language, supported by the Laravel 12.x framework for the backend. To accelerate the design of the administration panel interface, Filament 4.x was integrated. The entire frontend architecture was built using the TALL Stack (Tailwind CSS, Alpine.js, Livewire, Laravel) to create a dynamic and responsive user interface.

The process begins when a user accesses a form. Subsequently, the user can press the “Saran AI” button to activate the system's intelligent feature, as shown in Figure 23 and Figure 24. Upon pressing the “Saran AI” button, the AI will generate recommendations about the risk statement. These will include details on potential causes and projected impacts. The user can then review and adjust these recommendations as needed. If the initial suggestions are not suitable, the user can select “Saran AI” button again to receive alternative options. Once satisfied, the user can press the “Buat” button to save the results.

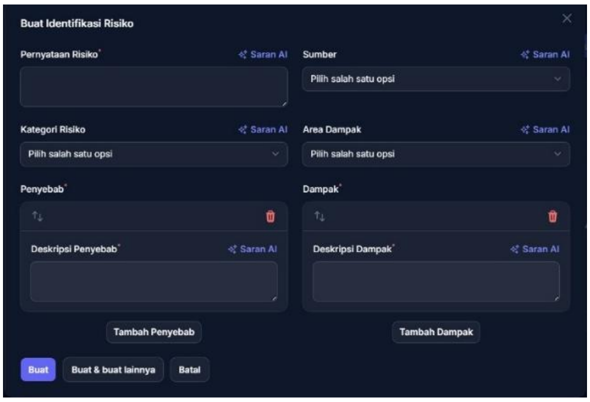

Figure 23. Risk Form in Kadiri

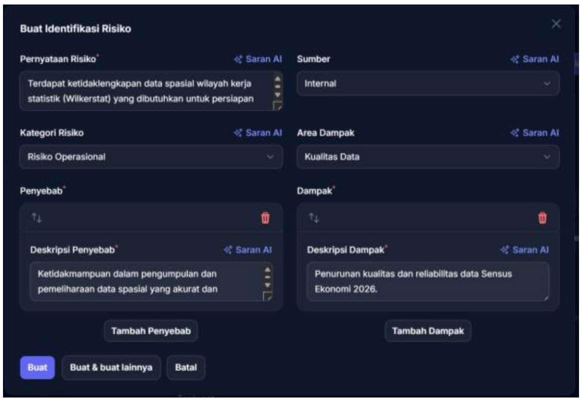

Figure 24. Generate results from AI

This feature is powered by RAG architecture, which enhances the quality of responses from an LLM. First, an extraction process is performed to retrieve text from various uploaded file formats, such as Word, Excel, and PDF. The extracted text is then further processed. For the retrieval process, a Google text-embedding model is used to convert text data from a risk bank and historical reports into a vector representation. These vectors are then indexed and stored in a PostgreSQL database with the pgvector extension, which enables efficient semantic search. As the main generator, Google Gemini API is utilized to process the retrieved data and present it as structured recommendations. These recommendations include more formal risk statements, details of various potential causes, and a projection of risk impacts. By combining these components, the system can retrieve context from the vector database and provide it to the Gemini model, which generates an objective and contextual analysis draft, thereby accelerating the risk mitigation process.

The adoption of Kadiri, not only transforms a manual workflow into a digital one but also brings a fundamental shift in how Statistics Jawa Timur manages risk. The system enables risk management to become a proactive, data-driven process, rather than merely reacting. By accelerating the risk identification and analysis cycle, the organization can respond to challenges more swiftly and effectively, especially when facing large-scale projects like SE2026.

3.4. *Evaluation*

After the prototype was finished, the next step was to evaluate it with users. This evaluation involved 19 users from the Risk Management Unit. To collect feedback, a Google Form was sent out to the participants using the WhatsApp broadcast feature. Here is a summary of the evaluation results:

- Pop-up Guidance: There is a need for a pop-up guidance system for new users. Given the quick staff rotation, this guidance will make it easier for users to operate the system.
- User Interface (UI): The interface could be more eye-catching; some suggestions included using more varied font colors, adding the Kadiri logo to the dashboard (which is currently plain white), and including a risk map on the dashboard.
- Menu Separation: The collapsible menus should be separated. The menu for initial data entry (like performance targets and stakeholders) should be distinct from the menus that only contain information (like risk sources and risk categories). This will help mitigate issues if the risk management team changes at the district/city level and make the system easier for newcomers to use.
- Reminder Feature: A reminder feature is needed to help with the smooth execution and completion of risk monitoring, realization planning, and risk reporting.

3.5. *Testing*

After evaluation and refinement, the developed system is concluded to have met the requirements. The system was then evaluated manually using ten test cases.

Table 6. Test Case Result

Test Case	Pct by users	Result
Login with Majapahit	19/19 (100%)	Succeed
Login with Email BPS	19/19 (100%)	Succeed
Context Establishment	19/19 (100%)	Succeed
Risk Identification	19/19 (100%)	Succeed
Risk Analysis	19/19 (100%)	Succeed
Risk Evaluation	19/19 (100%)	Succeed
Risk Treatment Plan	19/19 (100%)	Succeed
Risk Approval	18/19 (94,7%)	Succeed (in range of tolerance)
Risk Monitoring	18/19 (94,7%)	Succeed (in range of tolerance)
Risk Reporting	19/19 (100%)	Succeed

Based on the information in Table 6, the evaluation and testing phases of the system have yielded highly satisfactory results. Out of a total of 10 test cases assessed using the black box testing method with the involvement of 19 users, 8 test cases achieved a 100% success rate. The remaining two test cases, however, reached a success rate of 94.7%. Following a functional review, a bug was identified as the cause of this partial failure. After the necessary corrections were implemented, all test cases were successfully re-executed with a 100% success rate, indicating that the system is now fully operational.

3.6. Implementation

The next stage is the implementation phase, during which the system is deployed and configured. After completion, a questionnaire was distributed to the Risk Management Unit to evaluate the system's usability. PSSUQ is often used in information systems as a standard questionnaire for assessing user satisfaction with a system. The PSSUQ uses a 7-point Likert scale with responses ranging from Strongly Agree to Disagree Strongly, and it also includes an N/A option.

Table 7. PSSUQ Result

	Lower Limit	Mean	Upper Limit	Result
System Usefulness	2.57	2.8	3.62	1.84
Information Quality	2.79	3.02	3.24	1.89
Interface Quality	2.28	2.49	2.71	1.95
Overall	2.62	2.82	3.02	1.88

Based on the results of the questionnaire completed by 19 users, the average values for several indicators, as presented in Table 7, were obtained. As indicated in Table 7, the average values for System Usefulness, Information Quality, and Interface Quality were at the established lower limits. This signifies that the system provides excellent usability in terms of user satisfaction, information quality, and display quality. Furthermore, the Overall average also demonstrated outstanding results. Thus, the system's overall usability is considered particularly good for the employees of Statistics Jawa Timur.

4. Conclusion

The implementation of RAG technology in intelligent risk management systems has led to tangible improvements in the usage of risk management applications. It is helpful for users to gain information from the risk identification to the risk evaluation phase. The integration of LLMs with internal knowledge repositories enables the generation of more targeted, data-driven recommendations while reducing the likelihood of misinformation. Employing a prototype-based development methodology and systematic usability evaluation, the resulting system has demonstrated high user acceptance.

While a complete quantitative impact analysis is premature, as the system has been operational for less than a year, early indicators and qualitative feedback suggest significant potential for broader deployment. Employing a prototype-based development methodology and systematic usability evaluation, the resulting system has demonstrated high user acceptance and strong potential for wider deployment. Notably, the system plays a strategic role in supporting the preparation and execution of the 2026 Economic Census, accelerating the identification and mitigation of complex risks. These findings underscore the transformative potential of AI-driven digital innovation as a key enabler of bureaucratic reform and the advancement of adaptive, data-centric governance.

Furthermore, the generalizability of these research results is high. The developed system can be replicated and adapted by other institutions for several key reasons. First, its use of RAG architecture is technologically agnostic, allowing an institution to leverage various LLMs and connect them to their unique internal knowledge repositories. Second, the implemented risk management process aligns with the SNI ISO 31000 standard, a common framework used across many organizations. These factors ensure that this research serves not just as a case study but as a widely applicable model for enhancing risk management capabilities.

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