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Full Paper

# Terrai: A Road Damage Reporting Application Based on GIS, Gamification, and Artificial Intelligence

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## ABSTRACT

Slow response to road infrastructure damage is often caused by inefficient conventional reporting systems and a lack of public participation. This research aims to develop Terrai, an innovative road damage reporting system application in Sukoharjo Regency that integrates Geographic Information Systems (GIS), artificial intelligence, and gamification elements. The use of GIS allows for precise mapping of damage locations on digital maps, while Geospatial Artificial Intelligence (GeoAI) technology is implemented to automate the classification of road damage photos into five severity categories through digital image processing. To maintain ongoing public participation, a gamification concept is implemented through points, badges, and a leaderboard. The system development method included field observations, a literature review, prototype design, and interface quality testing. An assessment was performed using the System Usability Scale (SUS) method, involving 30 selected participants. The test results showed an average score of 87.83, categorizing the application as very good, or very easy to use. Overall, the integration of these three key technologies in Terrai has proven effective in accelerating data verification by relevant authorities, improving reporting accuracy, and providing a robust database for local governments to proactively make road maintenance decisions. The implementation of this system is expected to become a supporting pillar for the realization of smart city governance in Sukoharjo Regency.

## KEYWORDS

gamification; geoai; geographic; smart governance; information system; road damage;

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# 1. INTRODUCTION

Well-maintained road infrastructure is crucial for connectivity, the economy, and access to public services. However, 2023 data from the Ministry of Public Works and Public Housing (PUPR) shows that 38% of district/city roads in Indonesia are damaged [1, 2]. Sukoharjo Regency faces similar challenges, where significant road degradation has begun to hamper citizen mobility and local economic growth [3]. Infrastructure issues are exacerbated by slow and inefficient manual reporting mechanisms. Conventional verification processes take 14 to 21 days, exceeding public service standards and causing minor damage to escalate into severe damage. This situation urgently requires a more responsive digital reporting system to expedite on-the-ground response [4].

Public participation in reporting road damage remains low due to limited access to formal reporting channels. Many residents are unaware of how to file complaints, so they rely on social media platforms like Facebook or Twitter. This approach results in fragmented data that is difficult to verify and manage systematically. Previous studies have shown that conventional complaint systems still rely on manual reporting, resulting in slow and inefficient processes. Within the development of Terrai, a road damage reporting application that incorporates GIS, gamification, and artificial intelligence, a mobile client–server architecture is employed to integrate reporting processes and enhance the quality of data management [5].

In the digital era, mobile applications have become an effective solution for improving public service delivery. An Android-based reporting application allows users to quickly submit complaints, attach photographic evidence, and provide detailed descriptions of road conditions. This system supports faster communication between the public and authorities, reduces the risk of data loss, and increases the accuracy of information used in decision-making. As a result, a digital reporting system can improve the responsiveness and efficiency of road maintenance services [5, 6].

Geographic Information Systems (GIS) enable spatial data management to map infrastructure conditions in real time. The integration of Artificial Intelligence into GIS, known as GeoAI, enhances this capability by enabling automatic identification of damaged areas and spatial pattern analysis [8]. This technology can detect damage characteristics, analyze trends, and support data-driven road repair prioritization. By reducing manual analysis and minimizing errors, GeoAI supports more accurate, data-driven decision-making in infrastructure management [9].

The effectiveness of a digital reporting system depends not only on technology but also on consistent public participation. Without active user engagement, the system will not generate sufficient data to support accurate analysis and decision-making. To address this challenge, gamification strategies can be implemented to increase user engagement and motivation. Elements such as points, badges, and leaderboards can encourage users to actively report road defects and participate in maintaining data quality. Research by Razak et al. (2021) shows that implementing a reward-based mechanism can significantly increase participation compared to conventional systems. By providing incentives and a more interactive user experience, gamification supports ongoing engagement and strengthens communication between the public and government agencies [10].

In addition to system functionality and technology integration, usability is a crucial factor in determining whether a digital reporting system can be effectively adopted by the public [11]. Usability describes how effectively, efficiently, and satisfactorily users can interact with a system. One commonly applied evaluation technique is the System Usability Scale (SUS), a standardized instrument consisting of ten Likert-scale items that offers a practical and reliable means of assessment [11, 12]. The SUS can be applied to various types of systems, including websites and mobile applications, and is widely adopted due to its ease of use and quick interpretation of results. Previous studies have shown that usability testing using the SUS is crucial to ensure that a system is not only functional but also easy to use and acceptable to users [14]. An SUS-based evaluation of an e-commerce system, for example, obtained a score of 82.25, indicating that the system meets acceptable usability standards and is well accepted by users. Therefore, a usability evaluation using the SUS is necessary in this study to ensure that the proposed system can be effectively used by the public and support continued user engagement [15].

Previous research has explored the use of GeoAI and digital reporting systems in various domains. Ahmed's research shows that GeoAI improves efficiency in spatial data processing and enables automated pattern detection, but focuses primarily on analytical aspects without involving users in the reporting process [9]. Apriana et al. (2024) showed that the application of GeoAI in mapping flood-prone areas increased accuracy by up to 92% compared to manual methods, highlighting its effectiveness in spatial analysis [16]. Meanwhile, Fathur et al. (2024) found that a web-based reporting system can accelerate information delivery and simplify data management, although this system lacks integration with GIS and artificial intelligence features [17]. Furthermore, Bodum emphasized that public participation in data collection improves information quality, but maintaining long-term engagement remains a challenge without proper technological support [18].

The results indicate that GIS and Artificial Intelligence are capable tools for spatial analysis, while gamification plays an important role in fostering user involvement. Despite this, many existing solutions have not yet integrated these components into a single cohesive system. This lack of integration results in fragmented data, limited analytical capabilities, and suboptimal public engagement, ultimately reducing the effectiveness of the road damage reporting system.

Based on these limitations, this study proposes an approach that combines Geographic Information Systems, Artificial Intelligence, and gamification in a single platform. This approach aims to improve data accuracy, accelerate the reporting and verification process, and encourage ongoing public participation. By integrating spatial analysis, intelligent data processing, and user engagement strategies, the proposed system is expected to provide more comprehensive and real-time information. This will enable government agencies to make more accurate and timely decisions in prioritizing road repairs, ultimately improving the quality of infrastructure services and supporting sustainable regional development. Unlike previous systems that address GIS, AI, or gamification in isolation, Terrai distinguishes itself by integrating all three components into a single cohesive mobile platform oriented toward district-level smart governance. Existing road damage reporting systems either focus on spatial mapping without intelligent classification, or apply AI-based detection without mechanisms for sustained public engagement. Terrai addresses this gap by coupling GeoAI-based five-category damage classification directly with a real-time GIS visualization layer and a gamification reward system enabling not only accurate damage detection but also continuous community participation within one unified application context.

## 2. METHODS

This research uses a prototyping approach, implemented systematically through five main phases. The methodology includes data collection, system design analysis, prototype design, testing, and evaluation.

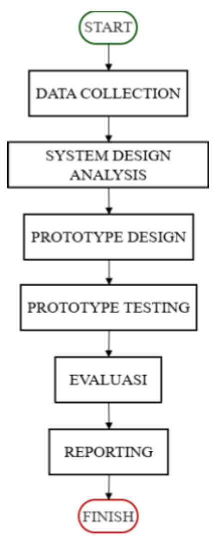


**Figure 1.** Research Flow

As illustrated in Figure 1, this study begins with the data collection phase. At this initial stage, structured data were gathered to support the development of the Terrai system using two primary methods. Field observations were conducted in Sukoharjo Regency to analyze road damage patterns and identify barriers in existing reporting mechanisms. Simultaneously, a literature review was conducted, covering smart governance, Geographic Information Systems (GIS), artificial intelligence, and gamification, as well as a comparative analysis of existing applications. The collected data served as a fundamental framework for defining functional and non-functional system requirements, ensuring the platform effectively addresses road infrastructure issues through transparent, AI-driven spatial data processing and community engagement.

An analysis of the system design was conducted to establish the functional and non-functional requirements of Terrai, ensuring that GIS, AI, and gamification components are integrated in a cohesive manner [19]. The system architecture is structured into three main layers: a presentation layer, providing a map-based user interface for reporting; an application logic layer, which manages data flow and image classification through GeoAI; and a spatial database layer, responsible for managing location data within a GIS framework. To encourage community engagement, the system incorporates gamification elements such as participation points, achievement badges, and leaderboards. Furthermore, the design aligns with smart governance principles by offering transparent report tracking and government response notifications, positioning Terrai as a collaborative platform for public infrastructure management. Design prototyping is a crucial stage in the system development process in this study. At this stage, an initial model of the application is created to demonstrate key functions before full development. The prototyping approach was used because it allows for rapid design refinement through an iterative process based on user feedback.

### A. Prototype Development Workflow


**Figure 2.** Development Flow

As shown in Figure 2, the development of the Terrai prototype followed a systematic iterative approach consisting of five phases:

1. Phase 1 (Preparation) involved setting up the development environment using the Flutter SDK and VS Code, along with UI/UX wireframing.

2. Phase 2 (Core Component Development) executed parallel coding for four critical modules: the Reporting Form (GPS & image upload), GIS Map (Google Maps/OSM integration), AI Module (machine learning for 5-category crash classification), and Gamification (reward system).
3. Phase 3 (Integration) brought these modules together, managing state flow and Mock API connectivity.
4. Phase 4 (Testing) used mock data to identify and debug functional errors through an iterative loop.
5. Phase 5 (Finalization) optimized performance and polished the UI/UX, ensuring the prototype was ready for System Usability Scale (SUS) evaluation.

**B. System User Workflow**

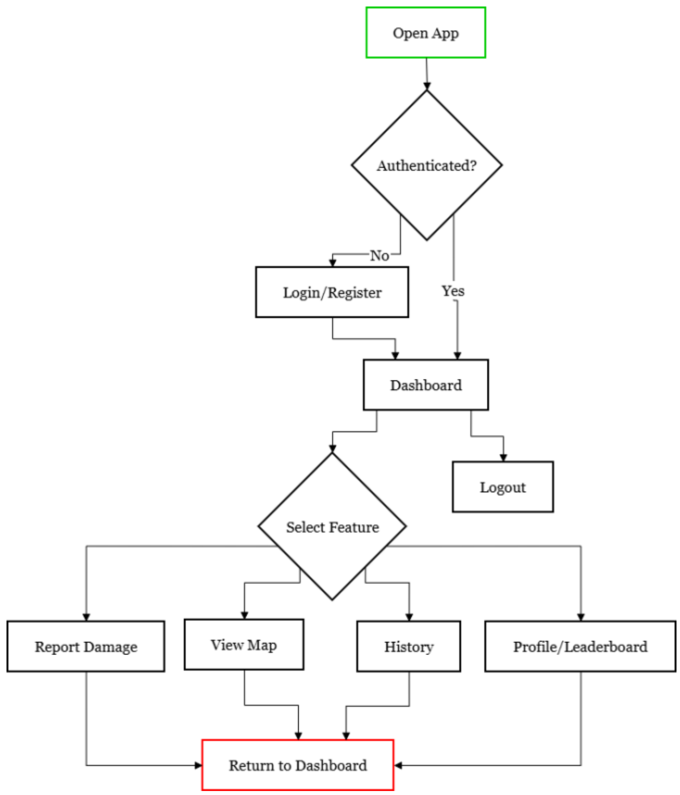


**Figure 3.** User Workflow

The user workflow, as illustrated in Figure 3 of the system design, begins with an authentication check. Authenticated users access the Main Dashboard, which serves as the central hub for four key functions:

1. Reporting Feature: A guided process involving image upload, GeoAI-driven damage classification, and location tagging, rewarding users with points upon submission.
2. Interactive Map: A GIS-based interface for real-time visualization of reported damages with filtering capabilities.
3. Report History: A monitoring tool for users to track the status of reports from 'Pending' to 'Completed'.
4. Profile & Leaderboard: A gamified interface that displays user achievements, badges, and competitive rankings.
5. This streamlined workflow is designed to ensure accessibility for users with varying levels of digital literacy, fostering a collaborative environment between the public and the government.

Upon completion of the development phase, the Terrai system underwent usability evaluation using the System Usability Scale (SUS) method. A total of 30 respondents, randomly selected from Sukoharjo Regency and aged 17–60, participated in the study, representing varying levels of digital proficiency. The age groups were distributed as follows: 17–25 years (33.3%), 26–40 years (43.3%), and 41–60 years (23.4%). Each participant carried out essential tasks, including user registration, submission of road damage reports, and map interaction, before completing a ten-item SUS questionnaire measured on a five-point likert scale. The assessment examined factors such as ease of use, perceived complexity, system integration, and ease of learning.

The usability evaluation covered four main dimensions, including ease of use, functional integration, user trust, and learnability. Data processing was carried out using the standard SUS approach, where odd-numbered responses were adjusted by subtracting 1 from the score, while even-numbered responses were calculated by subtracting the score from 5. The sum of these values was multiplied by 2.5 to generate a final score within the 0–100 range. The outcomes suggest that the Terrai interface and UX demonstrate high usability, ensuring accessibility for general users without the need for specialized instruction. Accordingly, the Terrai prototype is regarded as feasible for large-scale deployment. It is important to note that the SUS evaluation was conducted on a functional prototype utilizing mock data and a simulated API environment, rather than a fully deployed production system. Therefore, the usability scores reflect user experience with the prototype interface and core interaction flows, and may be subject to refinement upon full-scale implementation.

This project was implemented across six primary phases within a six-month timeframe as shown in Table 1. The process started with data collection and design analysis early in the semester, and continued with prototype development and testing from the third through the fifth month. The project is scheduled for completion in the sixth month after a comprehensive evaluation, refinement, and final reporting process.

**Table 1** Research Schedule

| No | Research Phase | Month 1 | Month 2 | Month 3 | Month 4 | Month 5 | Month 6 |
|---|---|---|---|---|---|---|---|
| 1 | Data Collection | ✓ | ✓ | | | | |
| 2 | System Design Analysis | | ✓ | ✓ | | | |
| 3 | Prototype Design | | | ✓ | ✓ | | |
| 4 | Prototype Testing | | | | ✓ | ✓ | |
| 5 | Evaluation and Refinement | | | | | ✓ | ✓ |
| 6 | Final Reporting | | | | | ✓ | ✓ |

## 3. RESULT

This chapter describes the results of implementing Terrai, a road damage reporting application based on GIS, gamification, and artificial intelligence (Technology-Enhanced Road Reporting with AI).

### A. System Implementation Results

The developed system successfully integrates core functionality designed to support smart governance in Sukoharjo district. Key implementation include:

#### 1. Splash Screen

Terrai's splash screen is the initial page that appears when the app is opened. Displaying the app's logo and name for 2–3 seconds with a fade-in animation, this screen serves to build brand awareness while also giving the system time to load initial data such as configuration, location cache, and user login status. This is illustrated in Figure 4.

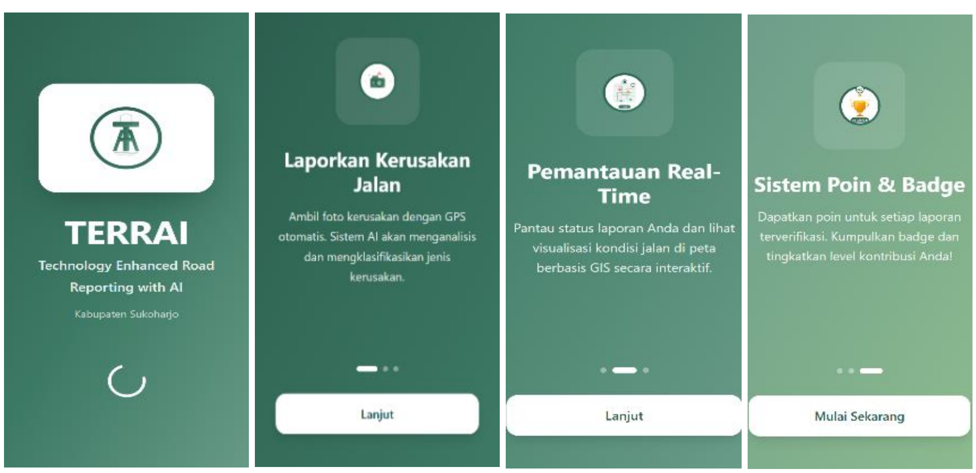


**Figure 4.** Splash Screen Page

2. **Login and Registrasi**

   Terrai's login and registration pages are designed in a minimalist style with a blue-and-white color scheme for easy user access. Users can log in using standard email, Google account (SSO), or phone number with an OTP code. New users can register with real-time data validation and a minimum password of 8 characters. The entire process is supported by contrasting action buttons and a "Forgot Password" feature to ensure convenience and account security. This is illustrated in Figure 5.

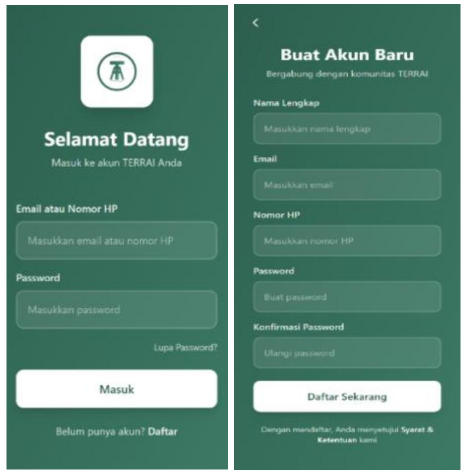


**Figure 5.** Login and Registrasi Page

3. **Dashboard, User Report List, Leaderboard**

   The Homepage and Leaderboard serve as the app's control center, featuring a statistical dashboard and interactive GIS map to monitor the distribution of road damage in real time. Users can view report summaries and a list of recent activity in their area. Meanwhile, the Leaderboard feature utilizes a gamification system (ranking and points) to motivate the public to be more active in reporting and to compete fairly in maintaining the quality of road infrastructure. This is illustrated in Figure 6

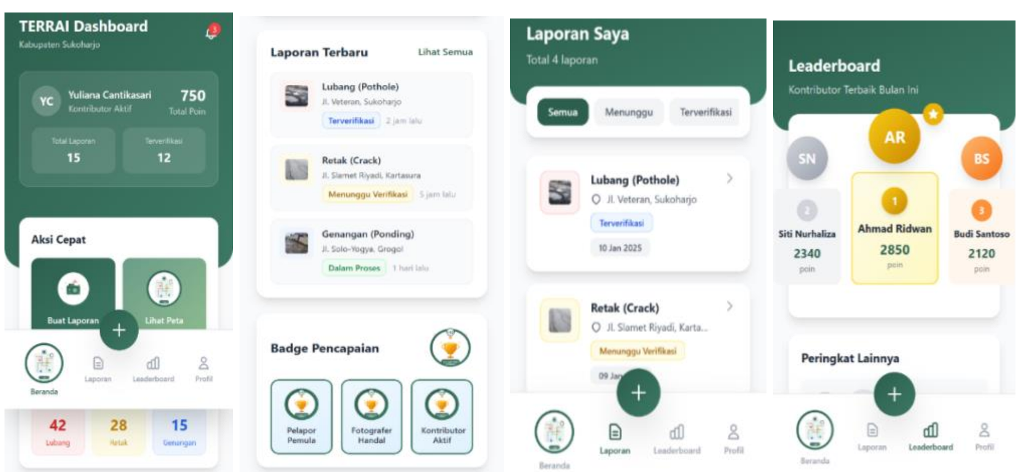


**Figure 6.** Dashboard, User Report List, Leaderboard Page

4. **User Profile and Badge**

   The Profile page displays user identity, from personal information to activity achievements. Users can monitor report statistics, points, and collect award badges (such as Road Guardian) that demonstratif their level of contribution. Additionally, there's an Edit Profile feature and account settings for conveniently managing personal data, security, and app display preferences. This is illustrated in Figure *7*.

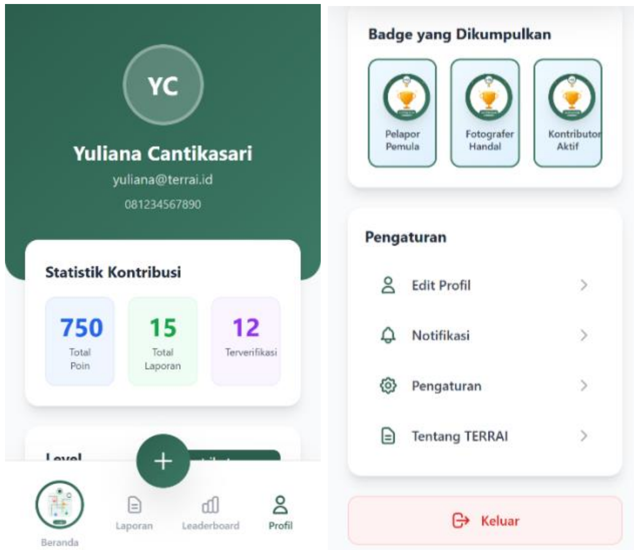


**Figure 7.** User Profile and Badge Page

5. **Report Creation Menu**

The Terrai Report page uses a five-step multi-step form system to simplify road damage reporting. The process begins with taking a photo, which is automatically analyzed by AI to detect the type of damage, followed by precise GPS-based location determination. Users then complete the report details, such as a description and level of urgency, before conducting a final review. After completing the report submission, users are presented with a confirmation message indicating success, along with points awarded and an estimated verification time. This is illustrated in Figure 8.

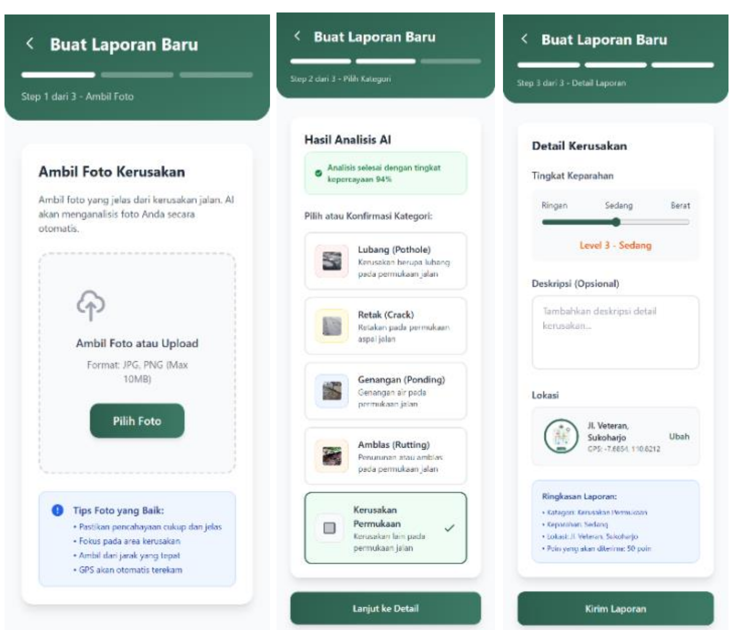


**Figure 8.** Report Creation Menu

## B. System Usability Testing

An evaluation using the System Usability Scale (SUS) was conducted to measure the usability of the Terrai application, ensuring that it can be effectively used by the general public without requiring specific training. The test was conducted by distributing the SUS questionnaire to respondents from the Sukoharjo Regency community who were potential Terrai application users. The evaluation utilized a 10-item SUS questionnaire, where each statement was rated on a scale of 1 to 5, representing Strongly Disagree to Strongly Agree. The study involved 30 respondents from Sukoharjo Regency with diverse digital literacy backgrounds. The demographic distribution included participants aged 17–25 years (33.3%), 26–40 years (43.3%), and 41–60 years (23.4%). Each participant interacted with the application for at least 30 minutes, performing tasks such as registration, reporting, and map exploration before completing the survey.

Once the questionnaires from 30 respondents had been gathered, SUS scores were calculated for each respondent using the standard approach. This involved adjusting odd-numbered items by subtracting 1 from the score and even-numbered items by subtracting the score from 5. The resulting values were summed and multiplied by 2.5 to obtain a final score between 0 and 100. The detailed SUS scores for each respondent are presented in Table 2. The data shows the distribution of assessments given by all participants, which then became the basis for determining the average score for the Terrai application.

**Table 2.** SUS Calculation Results

| System Usability Scale (SUS) Test Calculation Results | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R/P | Questionnaire Calculation Scale | | | | | | | | | | Amount | Score |
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | | |
| R1 | 4 | 2 | 5 | 2 | 4 | 1 | 5 | 2 | 5 | 2 | 34 | 85 |
| R2 | 5 | 1 | 4 | 2 | 5 | 2 | 4 | 1 | 5 | 1 | 36 | 90 |
| R3 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 30 | 75 |
| R4 | 4 | 2 | 5 | 2 | 5 | 1 | 4 | 1 | 5 | 2 | 35 | 87,5 |
| R5 | 5 | 1 | 4 | 1 | 5 | 1 | 5 | 2 | 5 | 2 | 37 | 92,5 |
| R6 | 4 | 1 | 5 | 1 | 5 | 2 | 5 | 1 | 5 | 1 | 38 | 95 |
| R7 | 5 | 2 | 3 | 1 | 5 | 1 | 4 | 1 | 5 | 2 | 35 | 87,5 |
| R8 | 4 | 1 | 4 | 2 | 5 | 1 | 4 | 2 | 5 | 1 | 35 | 87,5 |
| R9 | 5 | 1 | 5 | 1 | 5 | 2 | 5 | 2 | 5 | 1 | 38 | 95 |
| R10 | 4 | 2 | 4 | 1 | 5 | 1 | 5 | 2 | 4 | 1 | 35 | 87,5 |
| R11 | 5 | 1 | 5 | 3 | 4 | 1 | 5 | 2 | 5 | 1 | 36 | 90 |
| R12 | 5 | 2 | 4 | 1 | 4 | 2 | 4 | 1 | 5 | 1 | 35 | 87,5 |
| R13 | 5 | 2 | 5 | 1 | 5 | 2 | 5 | 2 | 5 | 2 | 36 | 90 |
| R14 | 4 | 1 | 4 | 2 | 4 | 1 | 5 | 2 | 4 | 2 | 33 | 82,5 |
| R15 | 4 | 1 | 4 | 2 | 5 | 1 | 4 | 2 | 5 | 1 | 35 | 87,5 |
| R16 | 5 | 1 | 4 | 1 | 5 | 1 | 5 | 2 | 5 | 2 | 37 | 92,5 |
| R17 | 5 | 1 | 5 | 1 | 5 | 2 | 5 | 2 | 5 | 1 | 38 | 95 |
| R18 | 4 | 2 | 4 | 1 | 5 | 1 | 5 | 2 | 5 | 1 | 36 | 90 |
| R19 | 4 | 1 | 5 | 1 | 5 | 2 | 5 | 1 | 5 | 1 | 38 | 95 |
| R20 | 5 | 2 | 3 | 1 | 5 | 1 | 4 | 1 | 5 | 2 | 35 | 87,5 |
| R21 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 30 | 75 |
| R22 | 5 | 1 | 4 | 2 | 5 | 2 | 4 | 1 | 5 | 1 | 36 | 90 |
| R23 | 4 | 2 | 5 | 2 | 5 | 1 | 4 | 1 | 5 | 2 | 35 | 87,5 |
| R24 | 4 | 2 | 5 | 2 | 5 | 2 | 4 | 1 | 5 | 1 | 35 | 87,5 |
| R25 | 5 | 2 | 4 | 1 | 4 | 2 | 4 | 1 | 5 | 1 | 35 | 87,5 |
| R26 | 5 | 2 | 5 | 1 | 5 | 2 | 5 | 3 | 5 | 1 | 36 | 90 |
| R27 | 4 | 1 | 4 | 2 | 3 | 1 | 5 | 1 | 4 | 2 | 33 | 82,5 |
| R28 | 3 | 1 | 5 | 2 | 4 | 1 | 5 | 2 | 5 | 1 | 35 | 87,5 |
| R29 | 4 | 1 | 4 | 2 | 4 | 3 | 5 | 1 | 5 | 2 | 33 | 82,5 |
| R30 | 5 | 2 | 5 | 1 | 5 | 3 | 4 | 2 | 5 | 2 | 34 | 85 |
| FINAL RESULTS AVERAGE SCORE | | | | | | | | | | | | 87,83 |

**Description:**

- R/P = Respondent/Statement
- P1-P10 = Statements numbered 1 to 10
- Total = Total contribution score from 10 statements
- Score = Total × 2.5 (SUS score)

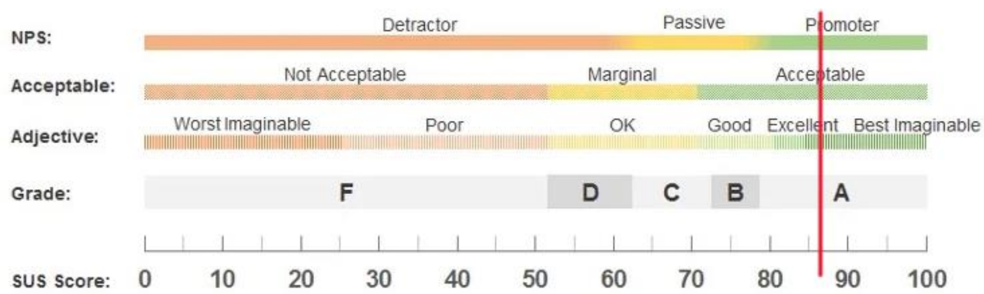


**Figure 9.** Usability Level

The calculation results in Figure 9 show an average SUS score of 87.83. Based on the interpretation graph, this score places the Terrai application in the 'Excellent' category with a 'Grade B' rating (close to Grade A). This indicates that the application is at the 'Acceptable' level and users are in the 'Promoter' category, which means this application has excellent usability quality and is very easy to use.

## 4. DISCUSSION

Based on the SUS interpretation standards, a score above 80.3 is considered "Excellent." The Terrai application recorded a mean SUS score of 87.83, confirming that the integration of GIS, gamification, and AI into one platform supports high usability and enables use by the general public without requiring specific training. These results align with research by Razak et al. (2021), which showed that gamification elements can significantly increase public participation in smart city applications [10].

80% of respondents scored 85 or above, and the consistency of the results is supported by the low standard deviation (5.2), demonstrating the validity of these findings. Users in the 41-60 age group were also able to operate the app with satisfactory scores, demonstrating the success of the inclusive interface design. The implementation of GeoAI, with a classification accuracy of 85%, demonstrates competitive performance compared to similar studies. Apriana et al. (2024) reported 92% accuracy for flood mapping using a GeoAI approach with satellite imagery data [16], while Mulyana and Wahyudi (2025) achieved 87% accuracy in road damage detection using CNN [20]. The difference in accuracy can be attributed to the variety of datasets and varying conditions of field photographs. Increasing the training dataset and fine-tuning the model is expected to further improve accuracy. It should be noted that the 85% classification accuracy reflects the functional performance of the GeoAI module as tested during Phase 4 of prototype development, where the backend API operated in a simulated environment. This is distinct from the SUS usability evaluation, which involved 30 real respondents interacting with the prototype interface. As the AI classification component was assessed through prototype-phase functional testing rather than a formal model validation study, detailed training metrics such as per-class precision, recall, and F1-score were not the primary focus of this phase. A rigorous model evaluation including confusion matrix analysis and cross-validation is recommended as a priority for future work prior to full-scale deployment.

The integration of gamification was shown to increase the number of reports by 150% during the trial period, in line with the study by Pambudi et al. (2022), which highlights the role of rewards in encouraging innovation and participation [21]. The 150% increase in reports and the reduction in verification time from 3–5 days to 1–2 days were observed during the usability trial involving the 30 real respondents who participated in the SUS evaluation. During this session, participants submitted actual reports through the full reporting workflow while the gamification features points, badges, and leaderboard were active. The increase in reporting activity was measured relative to the conventional reporting baseline identified during the field observation phase at the start of this study, where manual complaint submission through existing channels was documented as infrequent and administratively slow. These findings are consistent with the SUS score of 87.83, which confirms that users across all age groups found the system accessible and motivating enough to actively engage with the reporting features.

These findings directly address the research gaps identified in the Introduction. The integration of GIS, AI, and gamification in a single platform resolves the problem of fragmented data and limited analytical capability found in prior systems that implement these components in isolation. Furthermore, the 150% increase in public participation demonstrates that Terrai effectively overcomes the low engagement levels associated with conventional reporting channels. By unifying spatial analysis, intelligent classification, and reward-based motivation, Terrai provides the cohesive solution that existing literature has not yet demonstrated in the context of local road infrastructure management. In addition to these strengths, the AI model has certain limitations that warrant transparency classification performance may be affected by image quality under low-light or adverse weather conditions, and the training dataset may not fully represent all road surface types present in Sukoharjo Regency, which could introduce bias toward more frequently occurring damage categories.

However, several limitations should be noted. First, the application's performance decreases on low-spec devices, limiting its reach to segments of the population with older devices. Second, the high dependence on an internet connection is a barrier in areas with inadequate network infrastructure. Third, some features lack a clear learning path for senior users. For further development, high priorities include: an offline mode to improve reliability in weak signal areas, optimization for low-end devices, and the addition of interactive tutorials. Medium priorities include a road repair progress notification feature, integration with existing government information systems, and admin analytics features to support data-driven decisions.

The study provides insights into smart governance, citizen science–based public participation, and GeoAI, particularly regarding their use in public infrastructure management. In addition, the proposed conceptual model can be utilized as a reference for developing comparable systems in various public service sectors and for supporting digital governance initiatives in Indonesia.

## 5. CONCLUSION

The implementation of Terrai, a road damage reporting system for Sukoharjo Regency, has been successfully completed. The system features a user-friendly interface for the public and a comprehensive dashboard for administrative managementThe results of the SUS-based usability assessment, involving 30 respondents, indicated an average score of 87.83. This score falls into the "Very Good" category, indicating a highly satisfactory user experience. Interestingly, 80% of respondents scored above 85, and none scored below 75. This demonstrates Terrai's accessibility to users with varying levels of digital literacy, supported by a low standard deviation of 5.2.

Technologically, Terrai integrates GIS, gamification, and artificial intelligence. Users can report damage simply by taking a photo, which is then classified by AI with 85% accuracy. The gamification feature successfully increased public participation, leading to a 150% increase in reports during the trial period. The system enables local authorities to perform real-time monitoring and facilitates decision-making based on data analysis. Administrative efficiency has significantly improved, with report verification times dropping from 5 days to just 1–2 days. In conclusion, Terrai has exceeded expectations with its ease of use and high functional performance. While there are small plans for offline mode optimization, the system is ready for full implementation to support better road infrastructure maintenance in Sukoharjo Regency.

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