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Examination Of Investment Viability Through ROI and BCR Regarding The Creation Of A WebGIS-Based Road Damage Management Software At The Mojokerto PJJ UPT

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ABSTRACT

Public participation in reporting road conditions is increasing through digital-based road damage complaint applications. However, handling road damage complaints is still hampered by inaccurate data, inadequate system monitoring of repairs and quality, manual management of costs and repair history, and a lack of data integration. This situation necessitates repair cost analysis for each repair, documentation of damage history and repair methods, and WebGIS-based spatial mapping of repairs to ensure data is documented, tracked, and analyzed more systematically for monitoring and evaluating road maintenance within a single system. This research is important to conduct because it can contribute to the development of a WebGIS-based road maintenance monitoring and evaluation system integrated with road damage complaints. The research not only analyzes the condition of road damage and repairs, but also analyzes the economic feasibility of developing WebGIS using the ROI and BCR methods. The results of the research are expected to help road management agencies in improving the effectiveness and efficiency of road maintenance through the use of WebGIS technology. The feasibility analysis of WebGIS investment using the ROI method yielded a positive ROI of 76.90%, making it financially viable. The calculated BCR value of 1.68 indicates that the benefits of WebGIS development are financially viable (BCR > 1)

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INTRODUCTION

Roads play a crucial role as transportation infrastructure, connecting various regions and supporting the distribution of goods and services. Good road conditions improve travel efficiency, reduce vehicle operating costs, and enhance road user safety. Conversely, road damage such as potholes, cracks, deformation, and pavement deterioration can have significant negative impacts, both in terms of safety and economics. Road damage management that does not comply with repair standards and lack of oversight of repair implementation will impact the quality of the results. Therefore, a system is needed that integrates road damage conditions, compliance with repair standards, and monitoring and evaluation of repairs in road maintenance.

Developments in information technology and geographic information systems (GIS) currently offer significant opportunities for digital and integrated road infrastructure management. One emerging technology is WebGIS, a web-based geographic information system capable of displaying spatial data in real-time and interactively. The use of WebGIS in road infrastructure allows for the identification of damage locations, monitoring of repair processes, and evaluation of repair management, enabling more effective and efficient road maintenance decisions. In addition to technological advancements, public participation in reporting road conditions is also increasing through digital-based road damage complaint applications. Public complaint data is a crucial source of information for quickly identifying the location and type of road damage. Using public complaint data is considered more responsive because damage information can be received directly from road users. However, public complaint data still needs to be integrated with a technical evaluation system to serve as a basis for monitoring and evaluating road maintenance.

The East Java Public Works and Bridges Agency (PUBG) provide a public complaint service regarding road damage through a WhatsApp call center. The public can participate by submitting complaints about road damage as an effort to maintain road infrastructure through prompt and appropriate repairs. A total of 222 complaints were received through the WhatsApp call center, distributed across 11 Road and Bridge Management Technical Implementation Units (UPT PJJ). The Mojokerto UPT PJJ received a significant number of complaints, with 30 complaints. In practice, handling damaged roads through the WhatsApp call center still faces various challenges. These include inappropriate location of damaged roads, undocumented repair standards, the lack of a real-time monitoring system for repair implementation, and the lack of a repair history for repair evaluation. Therefore, road damage complaint data received through the WhatsApp call center still needs to be integrated with the technical evaluation system for use in road maintenance monitoring and evaluation. (source: East Java Public Works and Bridges Agency, 2026).

The Bina Marga method is used to assess pavement conditions based on the type and extent of damage to determine the appropriate repair treatment. Damage to the pavement or asphalt covering should be prioritized for repair, as pavement conditions can deteriorate rapidly in areas with high rainfall. The road condition survey manual serves as the basis for conducting condition surveys on

road sections, and the standard repair manual serves as the basis for implementing road maintenance activities. The road condition survey method and the standard repair method are inseparable. (Source: Ministry of Public Works, 2011)

Extensive research has been conducted on road damage analysis using the Bina Marga method. Research by Hasibuan and Harahap (2024) demonstrated that the Bina Marga method can be used to determine the level of road damage and recommend maintenance programs based on pavement conditions. The study concluded that the results of the road condition evaluation can be used as a basis for determining maintenance priorities to extend the service life of the road.

Another study conducted by Mulyana et al. (2025) on road damage mapping using the Pavement Condition Index (PCI) and the Bina Marga method showed that the combination of damage assessment methods and geographic information systems (GIS) can provide a more comprehensive and detailed evaluation of road conditions. The study explained that GIS-based mapping facilitates the identification of damage locations and supports the determination of road maintenance priorities.

Furthermore, a study by Handayani et al. (2025) on road damage analysis using the Bina Marga method and GIS mapping showed that the integration of the Bina Marga method with GIS technology was effective in identifying the type, extent, and location of road damage in detail. The study also confirmed that spatial mapping of road damage can assist the planning and decision-making process for road maintenance.

Although numerous studies have been conducted on road damage and the Bina Marga method, research integrating the quality aspects of road damage complaint handling with a WebGIS-based monitoring and evaluation system is still relatively limited. Most previous studies focused on identifying the level of road damage and recommending treatment types without evaluating the effectiveness and quality of maintenance results. However, the implementation of treatment and the quality of maintenance results must also be evaluated to ensure that road damage repairs meet technical standards. On the other hand, conventional road maintenance monitoring and evaluation still faces various obstacles, such as limited spatial data, delays in road damage information, and difficulties in monitoring the progress of damaged road repairs. Therefore, a WebGIS-based monitoring system is needed that can integrate road damage data, public complaints, and maintenance quality in an integrated manner.

The use of WebGIS in road maintenance monitoring and evaluation is expected to provide more accurate spatial information regarding road conditions, damage locations, types of treatment, and maintenance status in real time. With a WebGIS-based system, road management agencies can monitor the distribution of road damage, the effectiveness of treatment, and monitor and evaluate maintenance quality more quickly and efficiently. Furthermore, integrating public complaint data into a WebGIS-based monitoring system can improve the responsiveness of damaged road repairs. Public complaints can be used as an initial source of information to identify road damage, allowing for

faster and more effective handling before the damage becomes more severe. This aligns with the concept of smart infrastructure management, which emphasizes the importance of information technology and public participation in public infrastructure management.

This research is important to conduct because it can contribute to the development of a WebGIS-based road maintenance monitoring and evaluation system integrated with road damage complaints. The research not only analyzes the condition of road damage and repairs, but also analyzes the economic feasibility of developing WebGIS using the ROI and BCR methods. The results of the research are expected to help road management agencies in improving the effectiveness and efficiency of road maintenance through the use of WebGIS technology. The WebGIS-based monitoring system can be used to monitor road conditions spatially, evaluate the quality of treatment results, and support a more targeted road maintenance planning process. Based on the description, the research entitled "Analysis of the Quality of Road Damage Complaint Handling Based on Bina Marga Standards and the Feasibility of WebGIS Investment Using the ROI and BCR Methods at the Mojokerto PJJ UPT" needs to be conducted to support more effective, efficient, and sustainable road infrastructure management.

THEORETICAL REVIEW

Several previous studies that have been conducted and are relevant to road damage analysis, repair methods, repair cost requirements, the relationship between cost and quality in triple constraint project management, and the use of WebGIS, which can be used as guidelines in compiling this research, are as follows:

In a 2025 study by Adi Purwanto, Hanie Teki Tjendani, and Budi Witjaksana entitled, "Estimation of Road Repair Costs for the Genengan–Lembeyan Section in Magetan Regency Based on the 2024 Bina Marga Guidelines," the results showed that the types of damage include potholes, waves, grooves, sinkholes, bumps, edge cracks, alligator cracks, longitudinal cracks, rutting, and peeling.

In the research of Anang Mashudi, Haris Muhammadun, Risma Marleno in 2024 entitled "Analysis of Road Damage Using the Bina Marga Method on the Lamongan City - Mojokerto Border Road Section" in the journal International Journal of Social Science and Community Service, 2024, 2(4), 235-245 In 2024, the results showed that the types of damage were peeling aggregates, crocodile cracks, and sinkholes. The cost of handling road maintenance using the Bina Marga method includes periodic maintenance and routine maintenance, amounting to Rp. 9,479,663,479.46

In a 2024 study by Rissa Andriana Devi Novianti and Wateno Oetomo Nurani Hartatik entitled "Road Damage Analysis Using the 1990 Bina Marga Method on the Kelud Mountain Road Section, Kediri District Station 0+000 - 6+000" published in the Journal of Scientech Research and Development Volume 6, Issue 1, June 2024, the results showed that the types of damage included potholes, waves, grooves, sinkholes, bumps, edge damage, alligator cracks, line

cracks, fattening, and peeling. The priority order calculated using the Bina Marga Method was 5, with a recommendation for regular maintenance.

In a 2023 study by Agdicaller Vietrain Kaibi, Ani Tjitra Handayani, and Herna Puji Astutik, entitled "Analysis of Road Damage Conditions and Its Management on Pavement Surface Layers (Case Study of Kaliurang Road, Km. 13.5 - Km. 15.5 Yogyakarta)" published in the 2023 National Proceedings of the XVIII Industrial Technology and Information Engineering Journal (ReTII), the types of damage were identified as alligator skin cracks, checkered cracks, potholes, patches, side cracks, aggregate wear, and grain detachment. The recommended treatment options are P2 (local asphalt overlay) and P3 (crack coating) based on the Bina Marga method. In a 2025 study by Putri Handayani, Lucia I. R. Lefrandt, and Sisca V. Pandey entitled "Road Damage Analysis Using the Bina Marga Method and GIS Mapping (Case Study: Wolter Monginsidi Road)" published in Jurnal Tekno Volume 23, No. 92, 2025, the results showed that the dominant damage was crocodile skin cracks and potholes at 39 points along a 500-meter stretch, with a priority of periodic maintenance level 4. This combination of methods effectively assisted in mapping and determining repair priorities.

In a 2024 study by Andi Patriadi, Jaka Purnama, and Paschal Rumihin, entitled "Application of Geographic Information Systems (GIS) for Health Data Management in Kalipecabean Village: Enhancing Public Health Interventions" published in the 2024 International Conference of Innovation and Community Engagement – ICoICE Journal, analysis found that the implementation of GIS has improved the ability to manage data securely and minimize the risk of data loss. The research results demonstrate the effectiveness of GIS-based thematic mapping in improving resource monitoring and allocation.

In a 2025 study by Achmad Fathoni, Hanie Teki Tjendani, and Budi Witjaksana, entitled "Analysis of Geographic Information System-Based Road Ledger Development in Monitoring and Evaluation of Road Space Utilization," for their Master's Thesis in Civil Engineering at the University of 17 August 1945 Surabaya, the development of a GIS ledger has the potential to become a monitoring and evaluation tool for Rumija. Economic analysis showed an ROI of 16.56%. This feasibility is reinforced by a BCR of 1.17 (>1), indicating that the development of a GIS ledger is feasible.

METHODOLOGY

Data Collection Procedure

Data collection for this study was conducted through secondary data collection at the Public Works and Highways Agency, comprising the following data:

a. Complaints about road damage within the Mojokerto UPT PJJ area;
b. Provincial Road section data;
c. DPA/RKA data.

Grouping Investment Costs and Annual Costs

To develop a detailed cost model for developing a WebGIS-based road damage complaint system, the first step is to identify all required components, from road map inventory and digitization, spatial database development,

hardware and software procurement, human resource training, to operational data updates and system maintenance. Each component is then systematically grouped into:
Investment costs, such as:
1. Initial development costs
2. Server/computer procurement
3. Initial licenses, and
4. Initial training; and
Annual Costs, such as:
1. System maintenance costs
2. Routine data updates
3. Annual licenses
4. Technical support, and
5. QA/QC activities.
Total Benefits:
1. Operational cost savings
2. Increased work efficiency
3. Increased revenue
4. Reduced losses

Cost data is obtained from budget documents (DPA/RKA), government cost standards, and vendor quotation references. Then, parameterized (e.g., per kilometer of road, per segment, or per work unit) so that the model can be used for various application scales. The resulting cost model is validated through reviews with finance, planning, and technical practitioners, resulting in a realistic, transparent investment and annual cost structure that can be used as a reference for WebGIS development budgeting.

Return of Investment (ROI)

To evaluate the benefits of GIS ledger development in manual, semi-digital, and full GIS scenarios, an ROI analysis is conducted, which provides a percentage of investment efficiency. The following steps are used to calculate ROI:
1. Group the types of investment costs, annual costs, and benefit values as described previously.
2. Using equation (2.3), the ROI value is determined by comparing the difference between total benefits and total costs to the total investment cost.

Narratively, ROI shows how much net profit is obtained compared to the funds invested.

Benefit Cost Ratio (BCR)

The Benefit Cost Ratio (BCR) analysis is used to assess the economic feasibility of implementing WebGIS for road damage, considering the time and money values. The steps taken to determine the BCR are as follows:

1. Determine the analysis period (t) based on the useful life of the WebGIS system. In this study, the period was determined to be 4 years, according to the amortization group of intangible assets.
2. Determine the discount rate (i), which is the benchmark interest rate, inflation, or the minimum rate of return set by the government. This discount rate is used to convert all future benefits and costs to their present value.

3. Calculate the Present Value of Benefits (PV(Bt)). Using equation (2.4), the annual benefits from implementing WebGIS (Bt) are discounted to their present value using a predetermined discount rate. All annual benefits are summed to obtain the Present Value of Benefits (PV(Bt)).
4. Calculating the Present Value of Costs (PV(Ct)): All costs associated with the WebGIS road damage project, including both initial investment and annual costs (operational and maintenance), are calculated at their present value to obtain the Present Value of Costs (PV(Ct)) using equation (2.5).
5. Calculating and Interpreting the BCR by comparing PV(Bt) to PV(Ct) using equation (2.6). In the context of WebGIS development work:

A BCR > 1 indicates that the benefits of implementing WebGIS outweigh the costs, making the project economically feasible. A BCR = 1 indicates a break-even point, and a BCR < 1 indicates that the system is not yet economically feasible.

Using ROI and BCR analysis, the implementation of WebGIS-based road damage complaint handling can be quantitatively evaluated from an economic perspective. ROI reflects the return on investment, while BCR ensures that the benefits of the digital system outweigh the long-term costs. This analysis provides a strong basis for decision-making regarding the development and implementation of a WebGIS-based road damage management system in road management agencies.

RESULTS AND DISCUSSION

WebGIS Investment Feasibility Analysis

The investment feasibility analysis uses the ROI and BCR methods. Identification of the cost and economic benefit components is used to measure whether WebGIS is feasible to develop. The investment budget includes all initial investment expenses, such as WebGIS development, equipment procurement, system installation, and training costs. Meanwhile, the operational cost budget covers routine operational costs, including system maintenance, labor, and daily administrative and operational costs.

a. Identification of Cost Components

Initial Investment Costs include:

- WebGIS development;
- Supporting hardware/software;
- Human Resource training.

No	Description	Qty	Unit	Unit price	Total
1	Application development for fiscal year 2026				
	WebGIS Creation	1	Package	22,250,000.00	22,250,000.00
2	Office Supplies Procurement				
	License domain + Hosting	1	Year	3,560,000.00	3,560,000.00

3	HR training including accommodation				
	Training Daily Money	2	People / times	300,000.00	600,000.00
	Lodging	2	People / times	640,000.00	1,280,000.00
	Transportation	2	People / times	250,000.00	500,000.00
4	GIS Operational System				
	Leaflet *(open source)*	1	Set	-	-
				Total Cost (11% VAT)	28,190,000.00
				Total Cost (rounded)	28,200,000.00

Annual Fees include:
• System maintenance
• Technical support equipment

No	Description	Qty	Unit	Unit price	Total
1	Application Maintenance				
	WebGIS Maintenance	1	Package	8,900,000.00	8,900,000.00
	License domain + Hosting	1	Year	3,560,000.00	3,560,000.00
				Total Cost (11% VAT)	12,460,000.00
				Total Cost (rounded)	12,500,000.00

Based on the calculation data in tables 4.4 and 4.5, the annual investment and operational costs required are: 40,700,000.00

Economic Benefit Estimation

Economic benefit estimation is calculated to assess the extent to which a project provides financial and non-financial benefits. The types of benefits that can be measured in this study are:
• Administrative cost efficiency;
• Survey cost efficiency.

The value of the economic benefits obtained based on calculation table 4.7 is: 68,500,000.00

ROI Analysis

From the previous calculation analysis, the following parameter values were obtained:
Initial investment cost = Rp. 28,200,000.00
Annual cost = Rp. 12,500,000.00
Benefit = Rp. 68,500,000.00
Using equation (2.3), the ROI value is obtained:
ROI = (68,500,000.00 - 37,200,000.00)/ (28,200,000.00 + 12,500,000.00) x 100%

= 31,300,000.00/40,700,000.00 x 100%
= 76.90%

The ROI is positive at 76.90%. This means the benefits are sufficient to cover operational costs, especially the initial investment. Furthermore, the net profit is also positive, indicating that the benefits exceed operational costs. Under these conditions, the project is deemed financially feasible and can be recommended for continuation.

BCR Analysis

Before calculating the BCR, a discount rate must be determined. Bappenas recommends a Social Discount Rate of 6%–10% for public sector projects. In this study, the discount rate was set at 6% with an i value of 1.3382 and an analysis horizon of 4 years. By using equations (2.4) and (2.5), the Bt and Ct values are obtained as follows:

$$PV(Bt) = B_t/〖(1+i)〗^t \quad PV(Ct) = C_t/〖(1+i)〗^t$$

= 68,500,000.00/〖(1+1.3382)〗^4 =40,700,000.00/〖(1+1.3382)〗^4
= 2,291,733 =1,361,657

Next, using equation (2.6), the BCR value is obtained as follows:

$$BCR = (\Sigma_{(t=0)}^{T} B_t/(1+r)^t)/(\Sigma_{(t=0)}^{T} C_t/(1+r)^t)$$

= (2,291,733/〖(1+1.3382)〗^4)/ (1,361,657/〖(1+1.3382)〗^4)
=76,672.09/45,555.54
=1.68

The calculation results show a BCR of 1.68. A BCR value > 1 means the resulting benefits are able to cover the total costs for 4 years, making the investment financially feasible.

CONCLUSION AND RECOMMENDATION

The feasibility analysis of WebGIS investment using the ROI method yielded a positive ROI of 76.90%, making it financially viable. The calculated BCR value of 1.68 indicates that the benefits of WebGIS development are financially viable (BCR > 1).

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