ASTONJADRO

pISSN 2302-4240
eISSN 2655-2086

Volume 14, Issue 1, February 2025, pp.0349-0365
DOI: http://dx.doi.org/10.32832/astonjadro.v14i1 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Analysis of Road Preservation on the Parung-Bogor Road Traffic Flow

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| Submitted: November 26, 2024 | Revised: December 22, 2024 | Accepted: January 02, 2025 |

| Published: January 06, 2025 |

ABSTRACT

Continuous waterlogging on the road surface accelerates deformation due to the erosion process of the road base material and weakening of the pavement layer. At the same time, water flowing along the side of the road also has the potential to increase damage by eroding the structure of the roadside. Road preservation is an effort to maintain and repair to maintain the condition and function of the road so that it remains suitable for use, safe, and comfortable for users. The objectives of this study are: 1) to identify the existing condition of the height of the drainage channel against road damage, 2) to obtain the results of the study of the criteria needed for road preservation at the time of the study, 3) to analyze the results of the road preservation study against field conditions. The method used is a literature study and expert opinions on road preservation, using the Analytical Hierarchy Process (AHP). The results of this study are 1) the existing condition of the Parung-Salabenda highway found that the condition in the field of the drainage channel is higher than the road surface, so that when it rains the road will flood, 2) based on the study that the technology criteria have a very large influence, namely 0.665. This means that technology plays a very important role compared to economic and environmental criteria, 3) the results of the paired comparison analysis of technology criteria with the highest road preservation sub-criteria of 0.546 and the economic criteria sub-criteria of reducing road maintenance costs of 0.538 and finally the environmental criteria sub-criteria of high rainfall of 0.630. So that more intensive handling is needed to prevent further damage.

Keywords: road preservation: AHP; technology; economy; environment.

INTRODUCTION

Road preservation problems are issues that are often encountered in many areas, especially in areas with poor drainage conditions. Drainage that does not function properly plays a major role in accelerating road damage and causing various technical and environmental problems. When road drainage is inadequate, rainwater and runoff from the surrounding area tend to stagnate on the road surface or seep into the pavement layer. This causes the road structure to experience faster degradation, ranging from small cracks to the formation of large holes or other damage that has the potential to endanger road users (Heni S et al., 2016); (Benny HRP et al., 2022).

Continuous waterlogging on the road surface accelerates deformation due to the road base material's erosion process and the pavement layer's weakening. At the same time, water flowing along the side of the road also has the potential to increase damage by eroding the structure of the roadside. This water accumulation is often exacerbated by a less than optimal drainage system, such as clogged or insufficiently wide channels, and the absence of adequate road slopes to help water flow. This condition not only causes the road to deteriorate more quickly, but also increases maintenance and care costs. If left unchecked, this will require the authorities to reconstruct the road at a cost much greater than the cost required for routine maintenance (Rivan A et al., 2022). In addition, the presence of poor drainage has an impact on the safety of road users. Waterlogging on the road surface can cause aquaplaning or vehicle skidding, which is a high risk to safety, especially at high speeds. Roads damaged by puddles can also cause accidents due to holes that are not visible to drivers, especially at night or in unfavorable weather conditions. From an economic perspective, damaged and uncomfortable roads can affect transportation and distribution activities, which ultimately cause economic losses on a regional to national scale (Akhmad Z et al., 2021).

The negative impact of suboptimal drainage on roads also affects the environment. Poorly managed drainage can cause rainwater runoff that carries sediment, garbage, and other pollutants directly into surrounding waterways. This has the potential to pollute groundwater and affect water quality in the area. Therefore, drainage management in road preservation efforts is very necessary to minimize wider negative impacts (Tini NH et al., 2018).

Overall, preserving roads with poor drainage systems is a challenge that requires a holistic approach. Road maintenance is not only focused on the pavement aspect, but also includes sustainable surface water management. By repairing and optimizing the drainage system, it will not only extend the life of the road but also improve the comfort, safety, and quality of life of the surrounding community. This improvement must be seen as a long-term investment that not only reduces maintenance costs but also has a positive impact on safety, the economy, and the surrounding environment (Firdausi N et al., 2023).

The following are three research objectives regarding road preservation with drainage channels that are higher than the road surface: 1) identifying the existing conditions of drainage channel heights against road damage, 2) obtaining the results of the study of the criteria needed for road preservation at the time of the study, 3) analyzing the results of the road preservation study against field conditions.

Road maintenance plays a crucial role in ensuring the smooth flow of traffic on highways, enhancing safety, and extending the lifespan of road infrastructure. Over time, highways are subjected to constant wear and tear due to heavy traffic volumes, adverse weather conditions, and natural degradation. Without regular maintenance, cracks, potholes, and surface irregularities can develop, posing risks to motorists and contributing to congestion and accidents (Syaiful S, Rusfana H, 2022; Triyanto T et.al, 2020). The process of road maintenance involves a range of activities aimed at preserving the structural integrity of the highway, improving driving conditions, and preventing costly repairs in the future. One of the primary objectives of road maintenance is to minimize disruptions caused by deteriorating road surfaces. Smooth, well-maintained highways reduce vehicle operating costs, minimize travel time, and enhance overall driver comfort. By addressing minor issues early, maintenance crews can prevent small cracks from evolving into larger problems that require extensive rehabilitation. Routine inspections and assessments are conducted to identify areas that require attention, enabling highway authorities to prioritize repairs and allocate resources efficiently. Technologies such as pavement management systems help in monitoring the condition of the road, predicting future deterioration, and planning maintenance schedules accordingly (Syaiful S et.al, 2021; Syaiful S et.al, 2022).

Surface treatments, such as seal coating and resurfacing, are commonly employed to restore the smoothness of the road and protect it from further damage. Seal coating involves applying a protective layer to the road surface, preventing water infiltration and reducing the likelihood of cracks and potholes. Resurfacing, on the other hand, involves laying a new layer of asphalt over the existing pavement, effectively smoothing out irregularities and reinforcing the road's durability (Syaiful S et.al, 2023). These processes are often scheduled during off-peak hours or nighttime to minimize the impact on traffic flow, ensuring that the work is completed with minimal inconvenience to motorists. In addition to surface maintenance, drainage systems play a critical role in preserving the highway. Proper drainage ensures that water does not accumulate on the road, which can weaken the pavement and lead to erosion. Regular clearing of drainage channels and culverts prevents blockages and mitigates the risk of flooding during heavy rains. Road markings and signage are also essential components of highway maintenance, as they provide critical information to drivers and enhance overall road safety. Repainting faded lane markings, replacing damaged signs, and ensuring the visibility of reflectors contribute to a safer and more organized driving environment (Syaiful S et.al, 2022; Gibran R et.al, 2024).

Theory of road preservation

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Road preservation is an effort to maintain and repair the condition and function of the road so that it remains suitable for use, safe, and comfortable for users. This activity is important to maintain road infrastructure so that it has a long life and remains in good condition. In general, road preservation aims to reduce the level of road damage, minimize long-term repair costs, and maintain optimal road service quality.

Cracks and deformation of the road surface

Cracks in the road are often an early indicator of suboptimal maintenance. If these cracks are left untreated, rainwater can enter the pavement structure and weaken the material underneath. As a result, the road will experience deformation which can be in the form of peeling, potholes, or even large cracks. If this damage has occurred, repairs become more difficult and require greater costs because reconstruction or rehabilitation is needed.

Poor drainage and accumulation of puddles

Drainage that does not function properly or clogged channels causes rainwater to pool on the road surface. This puddle accelerates damage to the road surface through the process of weathering and weakening the road structure. In areas without good drainage, water can also erode the roadbed and cause erosion, which requires larger and more complex repair actions for recovery.

Inappropriate materials

The use of inappropriate materials in road construction or repair is one form of inadequate maintenance. For example, using an asphalt or concrete mixture that is not appropriate for the climate conditions or the type of vehicle load that passes. When the material used is not strong or durable, damage will occur more quickly, and the road will need to be repaired more often. This results in higher preservation costs in the future.

Deteriorating environmental conditions

Poor road maintenance also has an impact on the surrounding environment. Damaged roads can cause vehicles to emit more emissions because drivers have to brake, accelerate, or maneuver to avoid damage. In addition, puddles or road damage can cause erosion around the road area, which can damage the surrounding soil and plants and pollute water sources in the area.

High Risk of Accidents

Damaged roads are very dangerous for drivers. Potholes, cracks, or deformations can cause vehicles to lose control, especially for motorcyclists or small vehicles. Roads in poor condition increase the risk of accidents, which have an impact on public safety as well as health and economic costs for the community (Monginsidi et al., 2023); (Slamet P, 2022).

Drainage Theory

Drainage is a water management system that aims to drain excess water from an area to prevent puddles or flooding. Drainage usually includes a series of channels, culverts, pipes, and ditches designed to drain rainwater, surface water, and wastewater to a disposal site or larger body of water such as a river, lake, or sea. The main function of drainage is to control and manage water flow to prevent infrastructure damage and reduce the risk of flooding. In an urban context, drainage also aims to maintain water quality, prevent erosion, and minimize damage to roads and other public facilities due to puddles (Tini NH et al., 2018).

Road division

Roads can be divided into several types or groups based on various factors such as function, status, and class (Ministry of PUPR, 2020).

Similar research matrix

Research matrices related to road preservation are shown in the table below.

Table 1. Similar research matrix

No	Author/Journal Name	Conclusion	Recommendation
1.	Abdullah Albar, Nurmaiyasa Marsaoly, Abdul Gaus, 2023, Clapeyron: Jurnal Ilmiah Teknik Sipil 4(2);78-84.	10 factors influence project delays. The 10 factors have an average value of 3<X<3.5.	There are no recommendations related to this study.
2.	Eucharis D. Mongisidi, Joice E. Waani, Lucia I. R. Lefrandt, 2023, Jurnal Teknik Sipil Terapan, 5(2); 93-105.	The National Road Implementation Center/National Road Implementation Center or P2JN must conduct a quality test of the FWD value of the road pavement if the IRI value is high	There are no recommendations related to this study.
3.	Slamet Priyadi, 2022, Jurnal VORTEKS, 3(1); 204-208.	Road Reconstruction Preservation: carried out on severely damaged road sections, including landslides, improving road safety, handling road drainage, improving road structures without covers. To prevent damage before serious damage occurs, preventive measures are carried out such as thin asphalt coatings including fog seal chip seal, slurry seal, micro seal, and SAMI	There are no recommendations related to this study.
4.	Henri Siswanto, Harnen Sulistio, Ludfi Djakfar, Ahmad Wicaksono, 2016. Prosiding Seminar Nasional Aplikasi Teknologi Prasarana Wilayah IX (ATPW) Surabaya	With traffic that continues to grow, poor maintenance will increase cumulative transportation costs and general economic costs.	The results of the study identified the need for a description of the condition of district roads and strategic steps to improve the condition of the road.
5.	Benny Hamdi Rhoma Putra, M. Rilly Aka Yogi, Elianora, Rizqy Ridho Prakasa, 2022, Jurnal Konstruksi, 14(1); 8-17.	The RSL value along the 11.2 km of Jalan Pematang Reba Rengat varies. This difference in value results in different handling recommendations. The results of the RSL calculation can be divided into several segments based on the similarity of the type of handling.	There are no recommendations related to this study.
6.	Rivan Asnery, Andries Lionardo, Novita Wulandari, 2022, Jurnal Tanah Pilih, 2(2); 100-115.	The results of distributing questionnaires to see how effective road and bridge maintenance programs are using program effectiveness variable data	There are no recommendations related to this study.
7.	Akhmad Zadhi, Nashruddin, Cahya Buana, 2021, Jurnal Teknik ITS, 10(1); E27-E34.	The results of distributing questionnaires to see how effective road and bridge maintenance programs are using program effectiveness variable data	Road damage surveys should require more accurate accuracy, especially related to primary surveys because the results of the survey are further processed in calculations so that they greatly determine the final results.
8.	Firdausi Nuzula, Sofyan M. Saleh, Yusria Darma, 2023, Jurnal Arsip Rekayasa Sipil dan Perencanaan, 6(1); 12-21.	Factor analysis using PCA was conducted to see the factors that influence or are of concern to respondents regarding the implementation of SMKK at the work location	More supervision of the audit factor indicators and K3 evaluation, then communication factors and K3 training.

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No	Author/Journal Name	Conclusion	Recommendation
9.	Aria Hansen, M. Rafie Hamdi, 2021. HTJ Teknik Sipil, 1(2); 19-26.	Road maintenance or repair using preservation is carried out in different ways according to the condition of the road damage needed	Complete and accurate data, one of which is visual data regarding the condition of road damage.
10.	Punti Minesa, Hermanto Siregar, Manuwoto, 2014. Jurnal Manajemen Pembangunan Daerah, 6(2); 34-50.	Maintenance and repair management efforts on existing roads to condition existing roads to be in good condition are needed management efforts	It would be better if a study was conducted on a wider scale for the entire Bogor district.
11.	Mochammad Faisol, Akbar Khaqiqi, Diah Ayu Restuti Wulandari, 2019, Narotama Jurnl Teknik Sipil, 3(2); 19-24.	Routine maintenance needs to be carried out on priority road sections that have a high level of service function to maintain road conditions so that they remain prime.	There are no recommendations related to this study.

RESEARCH METHODS

This research was conducted by collecting data from both secondary and primary data. Secondary data is data obtained from literature, journals and information from mass media, both electronic and print. While primary data was taken directly in the field by checking the level of road damage, the level of congestion due to poor drainage. The research location is in Kemang sub-district and Bojonggede sub-district. The research time was taken for 6 days, namely Saturday-Monday/October 26-November 2, 2024. The following shows the Research Location, namely in Figure 1 below.

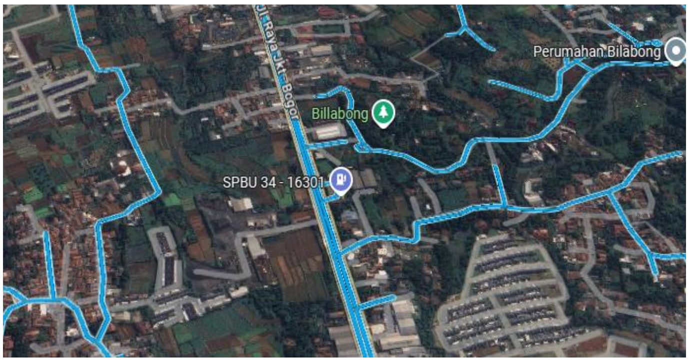

Figure 1. Map of research location on Parung-Bogor Road Source: Maps of Parung-Bogor Road

Object, population and sample

The object of the research is the drainage channel along the Salabenda-Tonjong intersection. The research location along Parung-Bogor Road is shown below.

Figure 2. Research point in front of the Ministry of Home Affairs Pol PP and Fire Department Training Center Source: Team Documentation, 2024

This research also involved experts in the field of road preservation consisting of: 3 (three) academics and 1 (one) person from the Bina Marga Service and Irrigation/Drainage Service and 1 (one) person from the Indonesian Transportation Society (MTI) so the total experts who participated in this study were 5 (five) people.

Research flowchart

Next, the author displays the research flowchart as the work steps for this research. Based on the flowchart display, it can be seen in Figure 3 below.

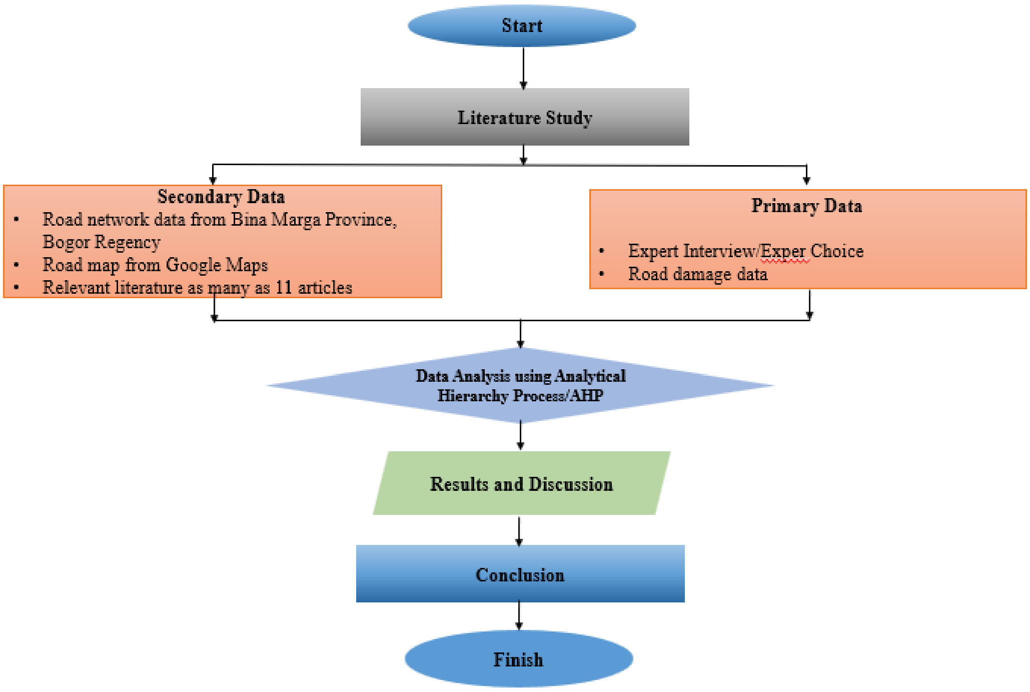

Figure 3. Research flowchart

DATA ANALYSIS AND ANALYSIS RESULTS

Research data analysis

Road preservation is an important process in infrastructure management to maintain optimal road conditions and extend service life. In the context of research, a literature review of road preservation aims to identify techniques that have been proven effective and explore the various factors that influence the success of preservation efforts. After establishing the objectives and research questions, the next step is to identify and collect relevant literature. This process involves searching

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Volume 14, Issue 1, February 2025, pp.0349-0365
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academic databases such as Scopus, Google Scholar, or ScienceDirect to find articles, reports, and studies that discuss road preservation. Keywords used in the search may include terms such as "road preservation", "pavement maintenance", "asphalt treatment", and "preventive maintenance". In addition, in selecting literature, inclusion and exclusion criteria are set to narrow the search. For example, articles published in the last five to ten years are preferred to ensure relevant data and reflect the latest methods used. Articles can also be selected based on geographic areas similar to the research location, especially if climate and road conditions have a major impact on the techniques used. After the literature has been collected, the next step is to classify and analyze the methods used in road preservation. The literature obtained is categorized based on the techniques or methods described, such as crack sealing, chip sealing, micro-surfacing, and hot recycling techniques. Crack sealing is a technique that involves covering cracks in the road surface with a covering material so that water and foreign materials do not enter, thereby preventing the spread of damage. Meanwhile, chip sealing is done by adding a thin layer of adhesive and aggregate to provide extra protection to the asphalt surface. Micro-surfacing is a technique by adding a layer of slurry consisting of a mixture of asphalt, fine aggregate, and additives that are useful in strengthening the surface and restoring friction resistance. Meanwhile, hot recycling is an asphalt recycling process that relies on heat to repair road structures at lower costs and with less environmental impact.

Results of analysis using the Analytical Hierarchy Process/AHP

Road preservation is the process of maintaining and repairing roads to ensure that their function remains optimal during the operational period. In conducting road preservation analysis using the Analytical Hierarchy Process (AHP) method, the main factors considered are technology, economy, and environment. The following is an explanation of the analysis steps using AHP which involve these three aspects.

Based on the study and analysis that has been done and the FGD conducted online, three types were obtained, namely 1) Technology criteria, 2) Economic criteria and 3) Environmental criteria. The form of the priority scale is by compiling a 3-level scale presented in the structure/hierarchy in Figure 4 below.

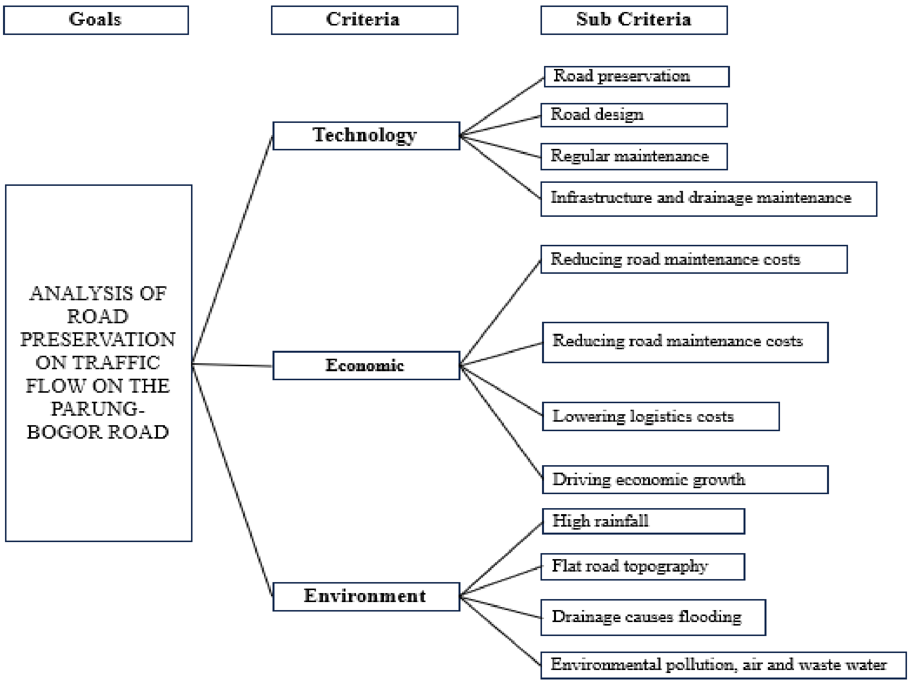

Figure 4. Priority scale of Objectives, Criteria and Sub-criteria

Next, the Matrix for the three criteria is displayed in table 2, technology criteria, economic criteria and environmental criteria as below.

Table 2. Matrix of technology, economic and environmental criteria

Criteria	Technology	Economic	Environment
Technology	**1,000**	5,966	5,305
Economy	0,168	**1,000**	6,346
Environment	0,189	0,158	**1,000**

Technology Criteria

The following is the technology criteria based on the concept of paired comparison based on the Analysis Hierarchy Process/AHP pattern. Furthermore, it can be displayed in the image below.

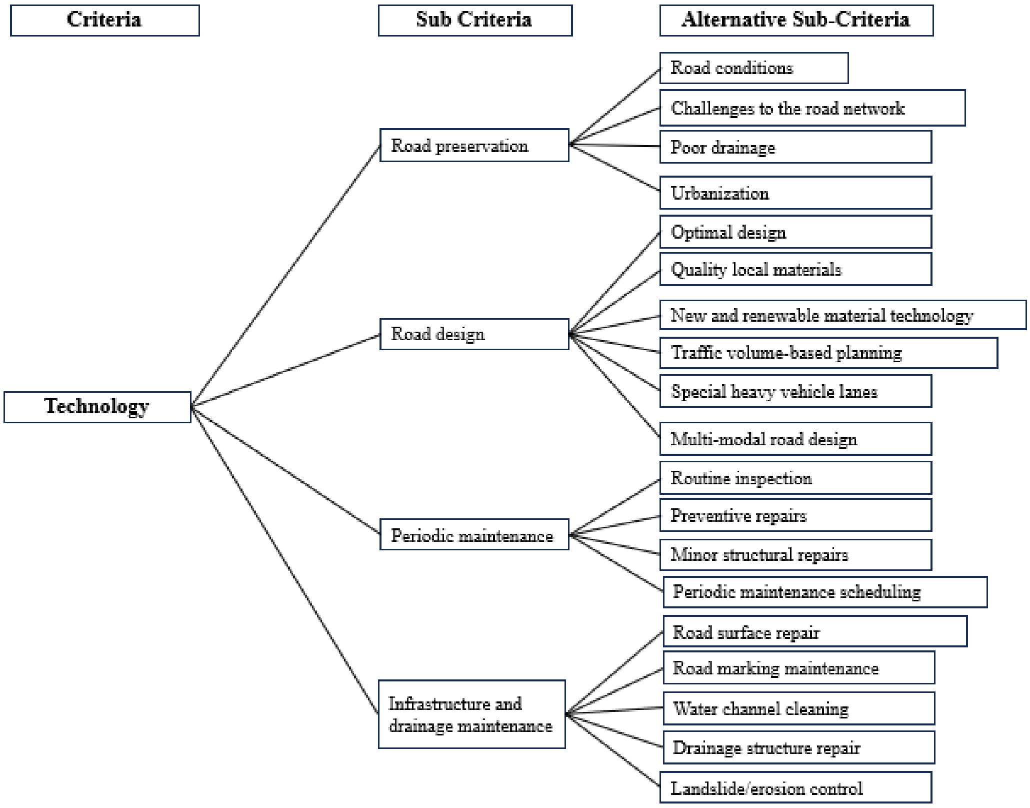

Figure 5. Priority scale of 3 dimensions with Technology criteria

Table 3. Technology Sub-Criteria Matrix

Sub Criteria	Road preservation	Road design	Periodic maintenance	Infrastructure and drainage maintenance
Road preservation	**1,000**	5,753	5,186	5,008
Road design	0,174	**1,000**	4,856	5,378
Periodic maintenance	0,193	0,206	**1,000**	6,581
Infrastructure and drainage maintenance	0,200	0,186	0,152	**1,000**

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Furthermore, with the AHP method, the results of the pairwise comparison of the Technology criteria for the road preservation sub-criteria with 4 alternative sub-criteria are obtained in the table below.

Table 4. Pairwise comparison matrix for road preservation sub-criteria

Sub criteria	Road conditions	Challenges to the road network	Poor drainage	Urbanization
Road conditions	**1,000**	4,317	4,478	5,144
Challenges to the road network	0,232	**1,000**	5,144	3,728
Poor drainage	0,223	0,194	**1,000**	4,782
Urbanization	0,194	0,268	0,209	**1,000**

Based on the table above, it can be seen that the four sub-criteria are compared with each other. This means that serious handling of road conditions at the research location is needed.

Economic Criteria

The following are economic criteria based on the concept of paired comparisons based on the Analysis Hierarchy Process/AHP pattern. Furthermore, it can be displayed in the image below.

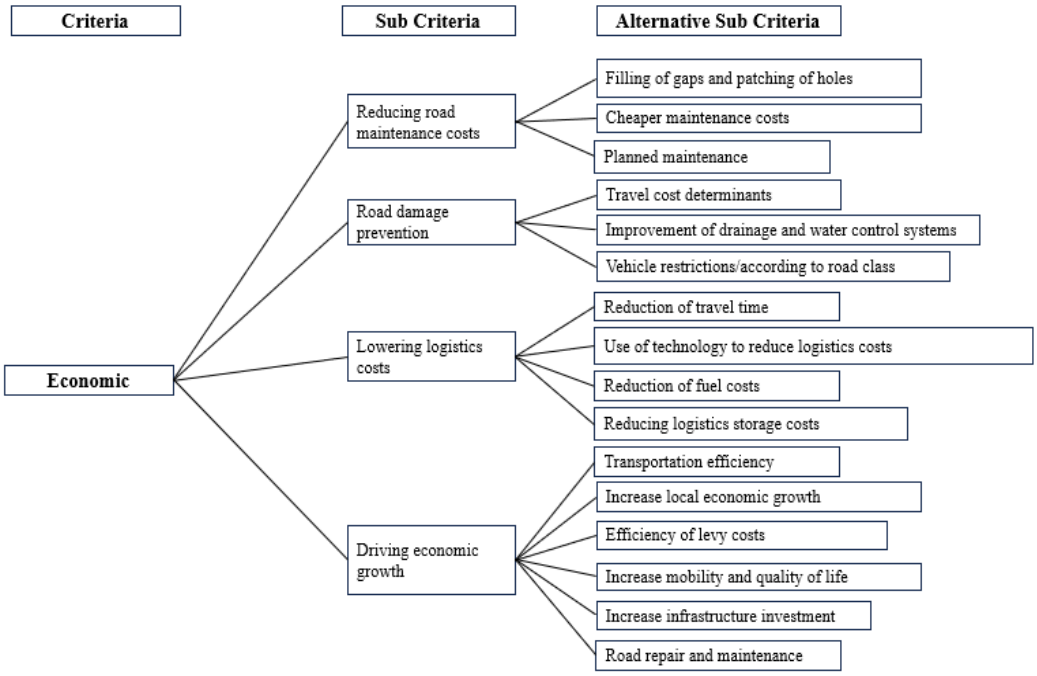

Figure 6. Priority scale of 3 dimensions with Economic criteria

Table 5. Economic Sub-Criteria Matrix

Sub criteria	Reducing road maintenance costs	Preventing road damage	Reducing logistics costs	Encouraging economic growth
Reducing road maintenance costs	**1,000**	4,573	5,305	4,193
Preventing road damage	0,219	**1,000**	4,129	4,682
Reducing logistics costs	0,189	0,242	**1,000**	4,704
Encouraging economic growth	0,238	0,214	0,213	**1,000**

Furthermore, with the AHP method, the results of the pairwise comparison of the Economic criteria sub-criteria for reducing road maintenance costs with 3 alternative sub-criteria are obtained in the table below.

Table 6. Pairwise comparison matrix for infrastructure and drainage maintenance sub-criteria

Sub criteria	Gap filling and hole patching	Lower maintenance costs	Planned maintenance
Filling of gaps and patching of holes	**1,000**	5,102	5,578
Cheaper maintenance costs	0,196	**1,000**	4,129
Planned maintenance	0,179	0,179	**1,000**

Environmental Criteria

The following are environmental criteria based on the concept of paired comparison based on the Analysis Hierarchy Process/AHP pattern. Furthermore, it can be displayed in the image below.

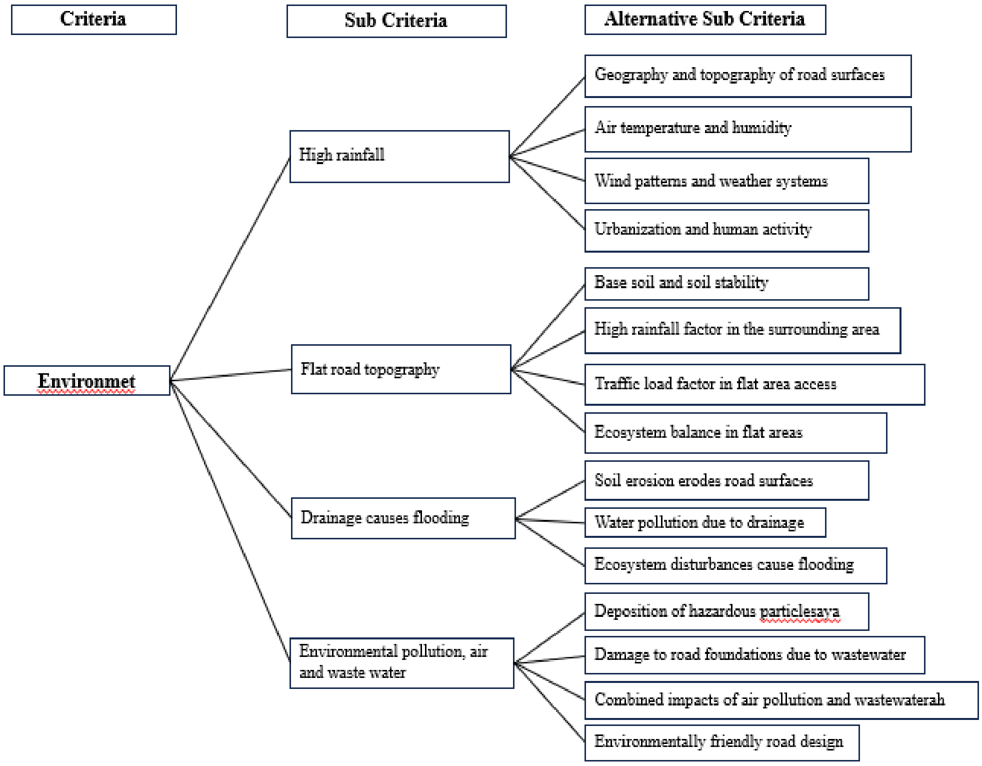

Figure 7. Priority scale of 4 dimensions with environmental criteria

Table 7. Pairwise comparison matrix of sub-criteria of high rainfall

Sub criteria	Geography and topography of road surfaces	Air temperature and humidity	Wind patterns and weather systems	Urbanization and human activity
Geography and topography of road surfaces	**1,000**	2,766	3,104	2,930
Air temperature and humidity	0,361	**1,000**	2,930	3,366
Wind patterns and weather systems	0,322	0,341	**1,000**	3,178

pISSN 2302-4240
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Urbanization and human activity	0,341	0,297	0,315	**1,000**

Discussion of the results of the debate using AHP

Discussing the results that have been processed through the Analysis Hierarchy Process (AHP) is one of the methods often used in multi-criteria decision making. This discussion is related to 3 (three) objectives, namely Technology, Economy, and Environment in the context of road preservation, AHP helps determine priorities based on the weight of each objective according to the preferences that have been analyzed.

Discussion of technological, economic and environmental objectives

Technological objectives usually include aspects such as the selection of innovative methods and materials, long-term durability, and efficiency in the construction or maintenance process of the road. In the context of AHP, if technology gets the highest weight, this indicates that stakeholders prioritize the use of advanced technology to achieve better road quality and operational efficiency. Focusing on technology requires a large initial investment, but can reduce long-term maintenance costs. In addition, technology also plays a role in improving road safety and infrastructure life. The results of the objectives with this technology criterion are in the image below.

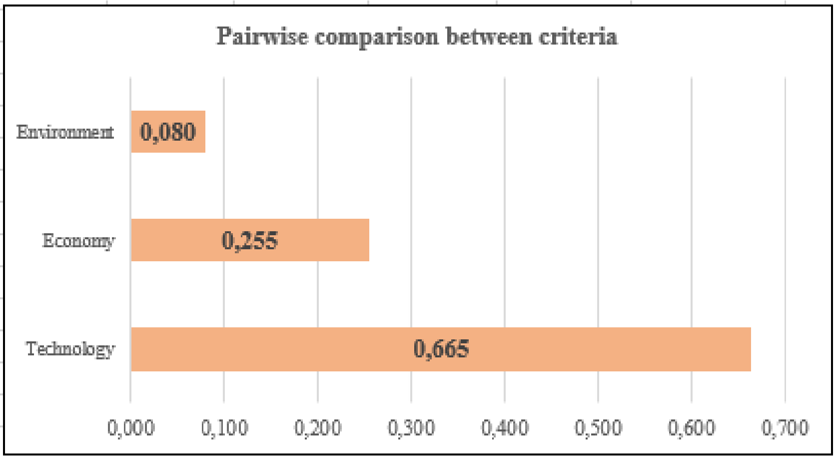

Figure 8. Pairwise comparison between criteria

The highest weight on technology indicates that stakeholders prioritize innovation and technical efficiency to ensure optimal road preservation quality. Technology is considered a key element in supporting the sustainability and durability of road infrastructure. The use of advanced materials, modern construction techniques, and automated monitoring systems are the main focus in this effort. On the other hand, the economic aspect, although having a lower weight than technology, is still considered important with a value of 0.225. This shows that cost efficiency and budget optimization remain a concern, although not as important as the application of technology. In practice, good budget management ensures that preservation projects run smoothly without sacrificing quality or sustainability. The environmental aspect is in last place with a weight of 0.080, reflecting a lower concern for ecological impacts in road preservation decisions. However, despite its small weight, the environmental aspect still needs to be considered, especially to ensure that the technology used does not have a significant negative impact on the surrounding ecosystem. Discussion of paired comparison of technology criteria

The following is a paired comparison of technology criteria based on 1) road preservation, 2) road design, 3) periodic maintenance and 4) infrastructure and drainage maintenance. The following is presented in the image below.

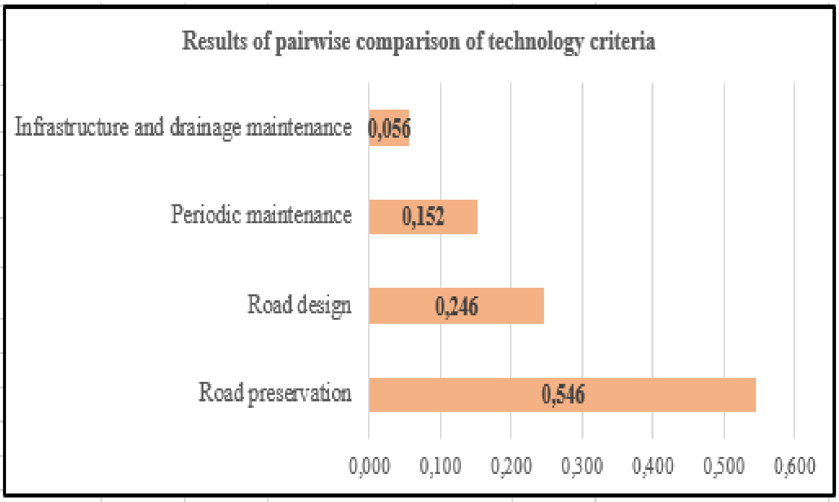

Figure 9. Pairwise comparison of Alternative technology sub-criteria

The high weight on road preservation emphasizes the importance of applying advanced technology in pavement management, improving material quality, and efficient road rehabilitation methods. This priority reflects the understanding that roads as the main element of transportation require maximum attention to ensure connectivity and comfort for users. In contrast, the low value on infrastructure and drainage maintenance shows that although supporting infrastructure is important, attention to this aspect is not as great as the focus on main roads. Good drainage contributes significantly to road longevity by preventing damage due to waterlogging.

Discussion of pairwise comparison of Alternative-road preservation sub-criteria

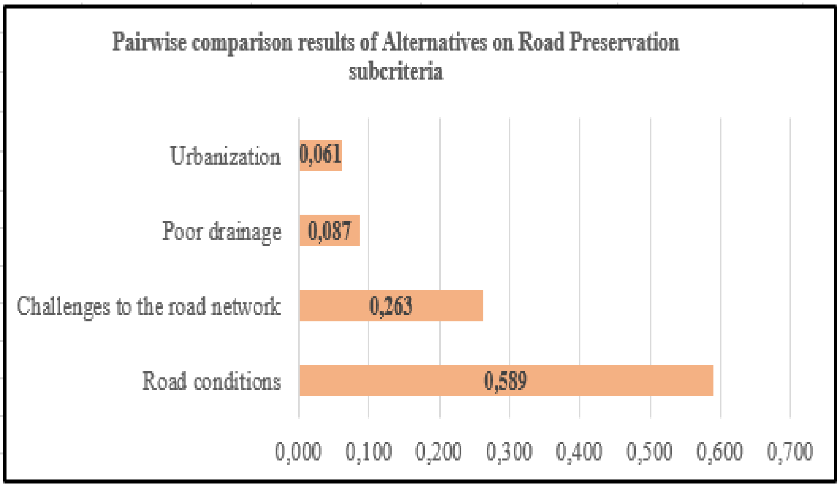

Figure 10. Pairwise comparison of alternative road preservation sub-criteria

In the analysis of road preservation sub-criteria using the AHP method, the results show that the road condition sub-criteria has the highest weight of 0.589, while urbanization has the lowest weight of 0.061. This reflects that the main concern in road preservation is to ensure that the road remains in good condition and is suitable for use. The focus on road conditions involves aspects such as structural strength, flat surfaces, and user safety, which are critical factors in supporting efficient mobility and transportation. In contrast, urbanization as the sub-criterion with the lowest weight indicates that the influence of urban area development on road preservation strategies is considered less significant than other factors. Although urbanization can increase traffic loads and the need for better roads, direct attention to road conditions is prioritized higher.

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Discussion of pairwise comparison of economic criteria

The following is a pairwise comparison of economic criteria based on 1) filling gaps and patching holes, 2) cheaper maintenance costs, 3) planned maintenance. The following is presented in the figure below.

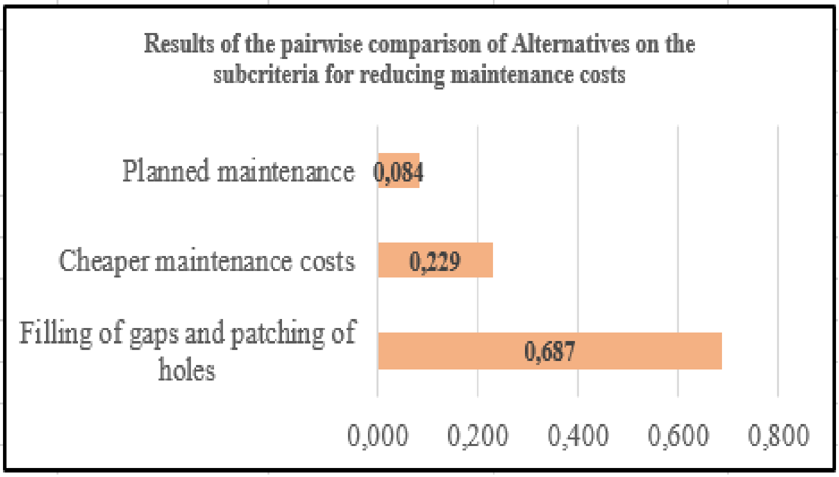

Figure 11. Pairwise comparison of Alternative economic sub-criteria

In the economic criteria, crack filling and pothole patching with an effectiveness value of 0.687 is the most efficient method. This technique has a relatively low cost but has a significant impact on preventing greater damage. By repairing small cracks and potholes quickly, the road can remain functional and safe without requiring more expensive major reconstruction. This method is suitable for roads with light to moderate damage levels. On the other hand, planned maintenance has the lowest economic effectiveness value, which is 0.084. This is because this approach often involves a fixed schedule without considering real-time road conditions, so that maintenance can be carried out even though it is not urgent. As a result, the budget can be absorbed for activities that are less priority.

Discussion of pairwise comparison of Alternative-road damage prevention sub-criteria

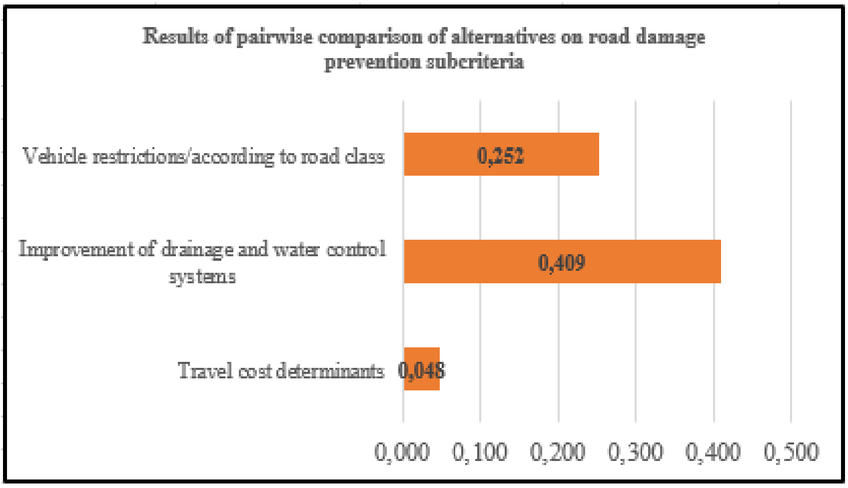

Figure 12. Pairwise comparison of Alternative sub-criteria for preventing road damage

In the economic criteria, drainage improvements and control systems with a value of 0.409 are quite effective methods in road preservation. A good drainage system prevents waterlogging that can accelerate road damage, such as cracks or holes due to water infiltration into the lower layers. This improvement has a significant economic impact because it extends the life of the road and reduces the need for more expensive major repairs in the future. In contrast, the travel cost determinant factor has the lowest value, namely 0.041, because it focuses more on the effect of road conditions on users than direct maintenance. Although important, this factor is only an indirect indicator and does not have a direct impact on saving preservation costs.

Discussion of pairwise comparison of environmental criteria

The following is a pairwise comparison of environmental criteria based on 1) Geography and topography of the road surface, 2) Temperature and humidity, 3) Wind patterns and weather systems, 4) Urbanization and human activities. The following is presented in the picture below.

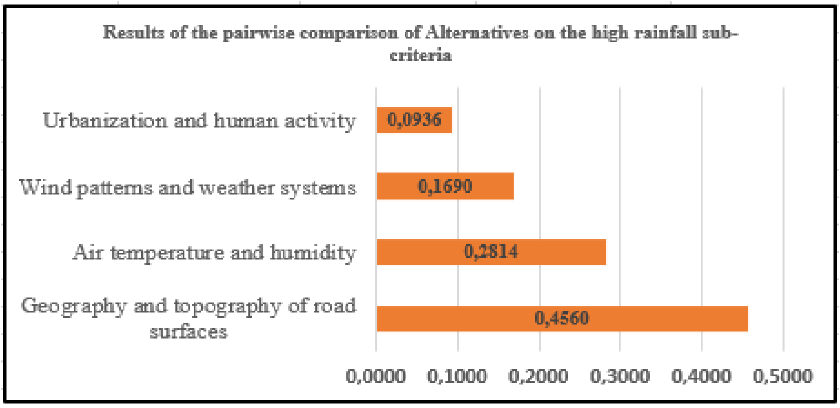

Figure 13. Pairwise comparison of Alternative environmental sub-criteria

Environmental criteria play an important role in the evaluation and management of an area, especially in the context of sustainable development and risk mitigation. Based on the weight value, geography and road surface topography have the highest weight of 0.456. This shows that geographical and topographic conditions greatly affect various environmental aspects, such as smooth transportation, disaster risk (floods or landslides), and regional accessibility. Supportive topography, such as stable road surfaces and good infrastructure, are essential to support economic activities, transportation, and daily life. In contrast, urbanization and human activities have the lowest weight of 0.0936. This shows that this factor is relatively less dominant than other criteria in the environmental analysis. Although urbanization and human activities affect landscape changes, land use, and environmental impacts, the impacts are more local and depend on resource management. Unplanned urbanization can put pressure on the environment, such as pollution and loss of biodiversity. Therefore, it is important to balance the rate of urbanization with environmental conservation efforts.

Discussion of pairwise comparison of Alternative flat road topography sub-criteria

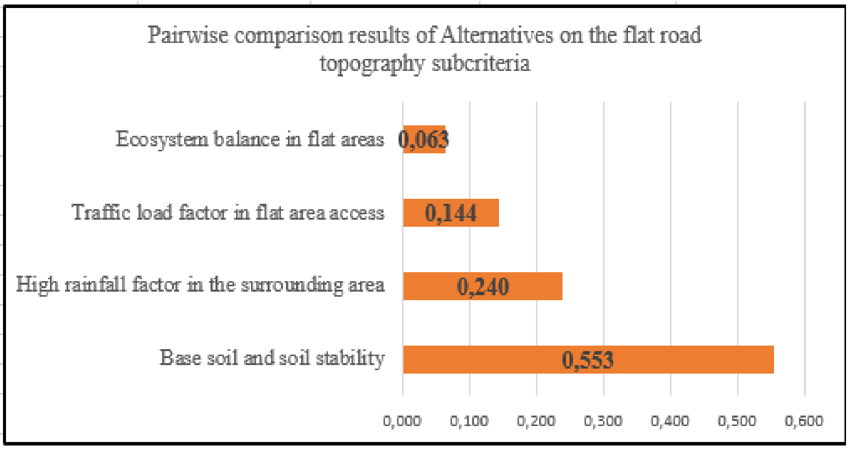

Figure 14. Pairwise comparison of Alternative sub-criteria of flat road topography

In the flat road topography criteria, the subgrade and soil stability have the highest weight of 0.553, indicating the importance of this factor in road planning and construction. Solid and stable subgrade is the main foundation for maintaining the strength and longevity of the road. Good soil stability reduces the risk of damage such as cracks, subsidence, or landslides, which often occur due to unfavorable soil conditions. Therefore, an in-depth analysis of soil type, density level, and drainage capacity is essential before constructing a flat road. Ecosystem balance in flat areas has the lowest weight of 0.063. This shows that although this aspect is important in an environmental context, its influence is relatively small on the function and sustainability of flat roads compared to other factors. However, ecosystem balance still needs to be considered to prevent environmental damage, such as loss of biodiversity or disturbance of natural habitats. Proper ecosystem management in flat areas, such as reforestation around roads and protection of local flora and fauna, can help minimize the negative impacts of development.

CONCLUSION

Based on the results of the analysis of criteria and sub-criteria and alternative criteria, the following conclusions can be drawn: 1) the existing condition of the Parung-Salabenda highway found that the condition of the drainage channel in the field is higher than the road surface, so that when it rains the road will flood, 2) based on the study that the technology criterion has a very large influence, namely 0.665. This means that technology plays a very important role compared to economic and environmental criteria, 3) the results of the paired comparison analysis of technology criteria with the highest road preservation sub-criteria of 0.546 and the economic criteria sub-criteria for reducing road maintenance costs of 0.538 and finally the environmental criteria sub-criteria for high rainfall of 0.630.

ACKNOWLEDGEMENTS

We would like to thank the Lecturer of the Road Preservation Course and for allowing us to submit this paper to the Sinta 3 Accredited Journal. We would like to express our gratitude to Mr. Dr. Adhi Muhtadi, S.T., S.E., M.Si., M.T. and Mr. Dr. Sapto Budi Wasono, S.T., M.T, for their motivation and support during this course.

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