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Road Damage Management Model Due to Overloading: AHP Priorities and Policy Implications (Case Study of Lampung Province)

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Abstract. Lampung Province serves as a vital gateway for Trans-Sumatra-Java land transportation, placing a heavy burden on its 1,298 km of national roads. Managed by the Lampung National Road Traffic Management Agency (BPJN), these roads face accelerated degradation primarily due to Over-Dimension and Over-Loading (ODOL) vehicles. This study aims to identify causal variables of road damage, analyze significant parameters, and prioritize road sections for maintenance. Data were gathered through interviews and questionnaires with key stakeholders. Using the Analytical Hierarchy Process (AHP), the results identify ODOL vehicles as the primary cause of damage (67%), with the International Roughness Index (IRI) as the most critical parameter (27%). Consequently, the BTS Sukamaju – Km 10 Panjang Bandar Lampung segment is identified as the highest maintenance priority. The study recommends stricter ODOL enforcement through functional weighbridges, legal sanctions, and cross-agency oversight. These measures are essential to extend road service life, ensure safety, and improve regional transportation efficiency.

Keywords: Overdimension/Overloading (ODOL), Analytic Hierarchy Process (AHP), International Roughness Index (IRI), Road Pavement Priority, Lampung Province, Road Asset Management

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1. Introduction

Land transportation costs are the largest component of logistics costs in Indonesia, accounting for 66.8%, with the remainder being administrative and inventory handling costs, as well as loading and unloading, parking, and extortion fees [1,2]. This situation poses a challenge to logistics sovereignty and national competitiveness, given that an integrated logistics network between ASEAN countries was implemented in 2015 and will be integrated into the global logistics network by 2020 [3]. Lampung

Province is located on the Trans-Sumatra-Java route, serving as the land gateway between the islands of Java and Sumatra [4–6]. The central government must support this important geographical position as a means of transportation, particularly on national roads. Road improvements and routine maintenance are key to maximizing the capacity of heavy vehicles from various origins and destinations [7]. National roads / state roads in Lampung province are calculated as 1298 km long [8] which are managed by the Lampung BPJN (National Road Implementation Center) which requires important attention in planning, implementation, supervision and maintenance as well as cooperation between relevant stakeholders in order to minimize damage to the level of road quality [9]. In the implementation of roads regulated in Law Number 20 of 2022 concerning roads, the authority of the central government in article 14 includes: a. Development of the Road Network System b. General road implementation, c. Implementation of national roads [10].

The presence of the toll road network is a positive impact in the solution to break the flow of vehicles on public roads, thereby reducing the increase in excess loads [11,12]. Poor road infrastructure severely hampers the development of the freight transportation industry in Indonesia and limits the ability of small business owners to reach profitable target markets. Poor road quality also hinders inter-regional trade and hinders efforts to integrate underdeveloped regions with larger markets. Poor road infrastructure is not only caused by low road quality but also by overloading of freight vehicles [13]. Overloading of freight vehicles is a complication of various problems, including a suboptimal freight transportation network, non-strategic locations of UPPKB (Motor Vehicle Weighing Implementation Unit) nodes, many inactive UPPKBs, and others [8,14]. Various freight transportation problems cannot be solved by any single party, not even the government alone.

The government plays a key role in solving freight transportation problems, but the community, business actors, transportation entrepreneurs, and road users can make significant contributions to solving freight transportation problems [15]. In the road damage parameter standards studied, a management model is needed, namely alternative policy solutions for these parameters [16,17]. The causes of road damage include road damage resulting from planning, implementation, supervision, and maintenance, and the causes of road damage due to vehicles. BLOOD that cross the road. The implementation of road maintenance is largely determined by funding sources [18]. The limited funding capacity of the central government means that road maintenance cannot be handled on the entire national road network, so it is necessary to determine the priorities and types of maintenance that must be carried out carefully and accurately according to the conditions. Determination of standard parameters and alternatives for road damage is based on theory and perspective in the form of a questionnaire distributed to stakeholder This determination was made at a national seminar entitled "Challenges and Solutions to the solution to overcome road damage from the existing standard parameters is called sub-criteria. The sub-criteria are used to minimize the value of road damage to road construction work and ODOL.

Over-Dimension and Over-Loading (ODOL) vehicles are a strategic issue in the national logistics system because they directly impact the efficiency, safety, and sustainability of transportation infrastructure. Within the context of the national supply chain, freight vehicles play a crucial role in ensuring timely and cost-efficient commodity distribution. However, the practice of overloading and modified vehicle dimensions (over-dimensioning) places excessive burdens on national roads that do not comply with pavement design standards. This condition results in accelerated road damage, increased maintenance costs, and disrupted logistics flow. Furthermore, the high intensity of ODOL vehicles increases the risk of accidents, reduces the quality of road services, and has the potential to cause overall logistics cost inefficiencies due to longer travel times, fleet damage, and disrupted distribution of goods. Therefore, controlling ODOL vehicles is a crucial step to maintain the reliability of the national road network, reduce logistics costs, and support sustainable national economic competitiveness.

Previous research by Arifin showed that overloading affects the increase in the IRI value. From an initial IRI of 2.37, if the road is used by vehicles with standard loads for 20 years, the IRI value increases to 10.42. Meanwhile, if the road is used by overloaded vehicles for 20 years, the IRI value increases from 2.37 to 16.88. With overloading, the IRI value increases sharply with an exponential model y=2.3583e0.0982x. Meanwhile, with standard loads, the exponential model y=2.3825e0.0739x is produced. The results of the exponential model show that overloading results in a significant increase in the IRI value with a growth rate of 0.0982. This compares with a normal load, which only experiences a growth rate of 0.0739. The modeling results indicate that overloading significantly increases the IRI value, with an exponential growth rate [18].

Another study by Abobaker found that overloaded vehicles significantly reduce the pavement's service life. Therefore, road users are expected to comply with existing regulations in carrying out transportation. Keywords: overloaded vehicles, damage factors, pavement service life, pavement thickness [18]. Previous studies, such as Arifin and Abobaker's research, have made important contributions in explaining the effect of overloading on increasing IRI values and decreasing pavement service life. The study emphasized technical indicator aspects, such as the exponential growth of IRI values, vehicle damage factors, and the relationship between overloading and pavement thickness. However, the study has not comprehensively accommodated policy indicators that play a role in controlling and mitigating the impact of road damage due to overloaded vehicles.

In this study, the case study that will be taken is a road that is the gateway to the Trans Sumatra - Java road, namely a road located in South Lampung Regency and Bandar Lampung City, on the Bakauheni road to the Tanjung Karang Soekarno Hatta Intersection [19,20]. This road is a road that is definitely passed by land transportation besides using alternative toll roads (toll lanes). The length of the section at the research location is 96.88 km, which is the largest road length for national roads in Lampung Province. It is expected that the studied road section will become a reference for national roads in Lampung Province [21–24]. Therefore, from the explanation above, a road damage management model is needed in research that is able to analyze excessive loads on roads caused by several factors, for example, lack of supervision at weighbridges regarding the load of vehicles passing through the road, reduction in transportation costs from industry and others [21]. The real impact caused by excessive loads (overloading) is road damage before the technical planning period is reached. Other negative impacts arising from overloading are decreased safety levels and decreased levels of traffic service [15,25]. This research can also answer the central government's budget policy for Lampung Province related to national roads, which not only formulates road length and level of road damage but also needs to be considered [26,27]. Variable-variable other factors such as LHR (Average Daily Traffic) and average vehicle load are due to Lampung Province being on the Trans Sumatra-Java route and having the highest economic income in the agricultural, plantation, industrial, and other sectors. It is hoped that the results of this study will be useful stakeholders related as a consideration in decision making [28]. This study aims to (1) identify causal variables and parameters contributing to road damage in Lampung Province, (2) analyze the most significant factors and parameters, and (3) determine priority road sections for maintenance based on the selected parameters. Data were collected through interviews, questionnaires, and road section assessments involving key stakeholders.

2. Methods

This research method uses a quantitative approach supported by AHP (Analytical Hierarchy Process) analysis to measure the priority of criteria, sub-criteria, and alternatives related to road damage caused by overloading. The research for this study consisted of three main parts: preparation, primary and secondary data collection, and data analysis. The research was conducted using the following flowchart:

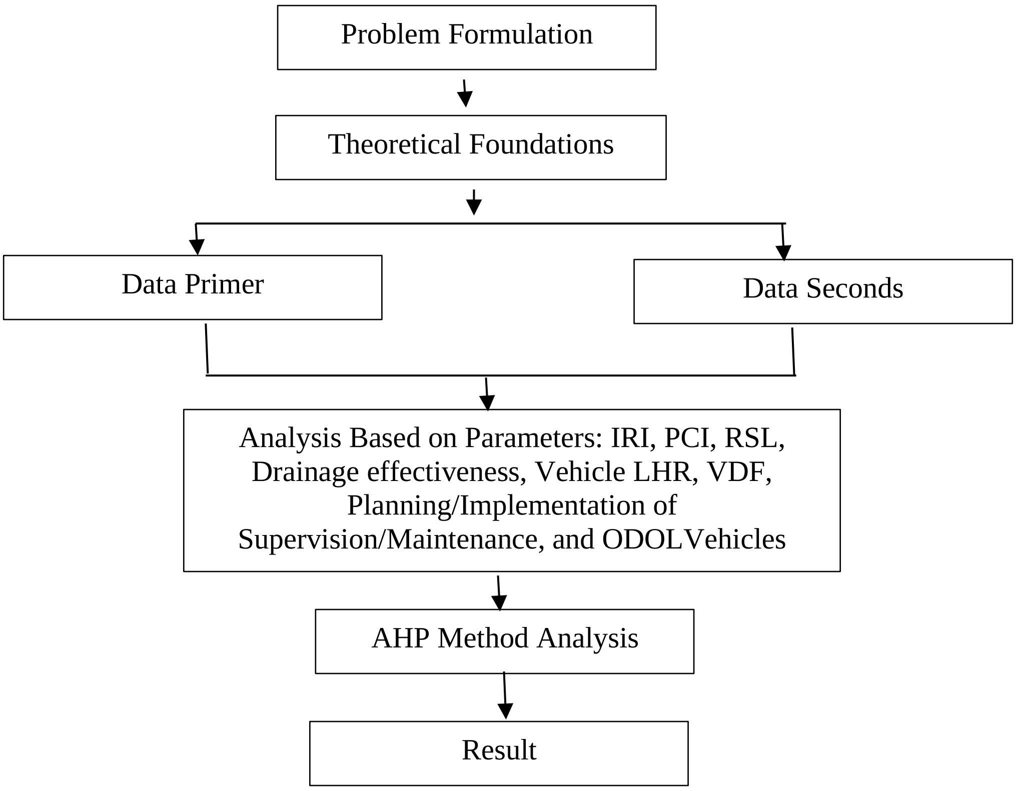

Figure 1. Research Flowchart

2.1 Data Objects and Data Types

The object of this study is the 96.88 km section of Jalan Soekarno–Hatta in the Bakauheni–Tugu Radin Intan corridor, Bandar Lampung. This section consists of five segments:

a. Bakauheni – Sp Kalianda (29.85 Km) is called B-SPK.
b. Sp Kalianda – Sukamaju (41.64 Km) is called SPK-SU.
c. Bts Sukamaju - Km 10 Bandar Lampung Length (5 Km) is called SU-KM.
d. Km 10 Length of Bandar Lampung – Sp Tiga Teluk Ambon (2.31 Km) is called KM-SPT.
e. Sp. Tiga Teluk Ambon – Sp. Tanjung Karang Soekarno Hatta Bandar Lampung (18.12 Km) is called SPT-SPTK.

The initial stage of the research began with a preliminary survey to understand the field conditions and formulate the needs for further surveys so that the research could run optimally. In this study, two types of data were collected, namely primary data and secondary data. Primary data was obtained through interviews and questionnaires with relevant stakeholders to assess the criteria and sub-criteria for road damage, including references from the Director General of Highways Letter No. 09/SE/Db/2021 in sub-chapter 2.10, which emphasizes the importance of the IRI, PCI, RSL, and drainage effectiveness parameters.

However, based on the results of national seminars and interviews with experts summarized in the expert judgment form, road damage management cannot rely solely on these four parameters because damage is often caused by overloaded vehicles, so vehicle LHR and VDF factors also need to be taken into account. LHR affects congestion and excessive static loads at a single point, which accelerates pavement damage, while VDF indicates the level of damage caused by vehicle axle loads compared to the standard load of 8.16 tons. Secondary data was collected from relevant agencies on road conditions, including IRI, PCI, RSL, drainage effectiveness, LHR, and VDF at the research site [29,30].

2.2 Data Collection Techniques

Data collection was carried out after the initial survey stage and the preparation of administration, personnel, logistics, and survey funding had been completed [31,32]. Respondents were selected using purposive sampling, targeting stakeholders with strong links to road planning, transportation, and professional institutions. Respondent requirements included a minimum education of a bachelor's degree in civil engineering or a related field, a minimum of five years of work experience, and a minimum SKK level of 7, if available. Each institution was required to send a minimum of five respondents [33–37]. The minimum number of respondents was calculated using the Slovin formula with a population of 2,204,344 [8] and an error rate of 0.1, resulting in a value of 9.95 or a minimum of 10 respondents. The final number of respondents was 50, as listed in the following table:

Table 1. List of Respondents

No	Respondent Group	Institution / Respondent Origin	Total (People)
1	Public Works	BPJN Lampung Region and Lampung Provincial Road and Bridge Agency	10
2	Transportation	BPTD Lampung Region and Lampung Provincial Transportation Agency	10
3	Experts	University of Lampung, Sumatera Institute of Technology (ITERA), and Sang Bumi Ruwa Jurai University	15
4	Organizations and Associations	National Road Developers Association (HPJI) Lampung Province, Indonesian Engineers Association (PII) Lampung Province, and Indonesian Transportation Society (MTI) Lampung Province	15
Total			**50**

Primary data from interviews and questionnaires were summarized in the Expert Judgment Form as the basis for determining the analysis weight.

2.3 AHP Method Analysis of Criteria, Sub-criteria, and Alternatives

The initial AHP analysis was conducted by compiling criteria, sub-criteria, and alternatives based on road damage parameters and causes of damage confirmed through sources and literature [38].

This model includes two main groups of causes, namely errors in planning/implementation/supervision/maintenance and the influence of ODOL vehicles. Meanwhile, the road damage parameters used include IRI, PCI, RSL, drainage effectiveness, vehicle LHR, and VDF as used in secondary data. Each parameter has a different unit, such as mm/m, a score of 0–100, or tons per day, so equalization or normalization is needed to enable consistent comparison. The values of each parameter are then converted to a scale of 1–9 based on expert assessment for use in the weighting stage [39,40].

The AHP method is used to break down complex problems into a hierarchy consisting of criteria, subcriteria, and alternatives by comparing the importance levels of each variable in pairs [41]. The assessments obtained from respondents are then averaged and entered into a comparison matrix to determine the relative weight of each variable. AHP allows researchers to evaluate various aspects simultaneously, involve various stakeholders, and determine which variables contribute most to influencing the research results [41]. The weighting results are used to prioritize the causes of damage, damage parameters, and the order of road sections that need to be addressed.

2.4 Data Processing

After the primary and secondary data were collected, processing was carried out using the AHP method assisted by Microsoft Excel. The resulting weighting values were used to determine the priority value of each road section based on the level of damage and its causes. Road sections are then ranked from highest to lowest weight value to determine the priority for handling. This data processing provides an objective basis for determining which sections require earlier intervention based on the IRI, PCI, RSL, drainage effectiveness, LHR, and VDF parameters.

2.5 Hypotheses

Based on the inter-variable relationship model, this study tests the following nine hypotheses:

H1: Negligence in planning/implementation/supervision/maintenance has a positive effect on the level of road damage.

H2: The effect of ODOL vehicles has a positive effect on the level of road damage.

H3: The IRI parameter has a positive effect on the level of road damage.

H4: The PCI parameter has a positive effect on the level of road damage.

H5: The RSL parameter has a positive effect on the level of road damage.

H6: Drainage effectiveness has a positive effect on the level of road damage.

H7: The LHR parameter has a positive effect on the level of road damage.

H8: The VDF parameter has a positive effect on the level of road damage.

H9: The selected parameters affect road section priorities.

The hypothesis is accepted if the significance level is within the range of 1%–5% (α).

3. Results and Discussion

This study examines the causes, parameters, and alternative treatments for damage to national roads in Lampung Province based on field background, interviews, and opinions from teams of experts, road users, and relevant stakeholders. Road damage is identified as being mainly caused by suboptimal planning, ineffective supervision and maintenance, and Over Dimension Over Load (ODOL) vehicle traffic passing through the road sections. The damage parameters assessed include IRI (International Roughness Index), PCI (Pavement Condition Index), RSL, drainage effectiveness, average daily traffic (ADT), and Vehicle Damage Factor (VDF). These parameters are interrelated with the causes of damage and serve as a reference in determining the priority of road repairs.

As a case study, this research selected five road sections to analyze the priority of their handling, namely Bakauheni - SP Kalianda (29.85 km, B-SPK), SP Kalianda - Sukamaju (41.64 km, SPK-SU), Sukamaju Border – Km 10 Panjang Bandar Lampung (5 km, SU-KM), Km 10 Panjang Bandar Lampung – SP Tiga Teluk Ambon (2.31 km, KM-SPT), and SP Tiga Teluk Ambon – SP Tanjung Karang Soekarno Hatta Bandar Lampung (18.12 km, SPT-SPTK). With this approach, the study can prioritize road sections that require immediate attention based on measurable conditions and levels of damage, thereby making national road management in Lampung Province more effective and efficient.

The model for comparing priorities for sub-criteria that form the basis for prioritization can be seen in the following table:

Table 2. Priorities for causes/parameters of road damage

No	Description	Priority	Priority (%)
1	P4	0,66	67%
	Kendaraan ODOL	0,33	33%
2	IRI	0,27	27%
	PCI	0,15	15%
	RSL	0,11	11%
	ED	0,11	11%
	DS	0,09	9%
	VDF	0,26	26%

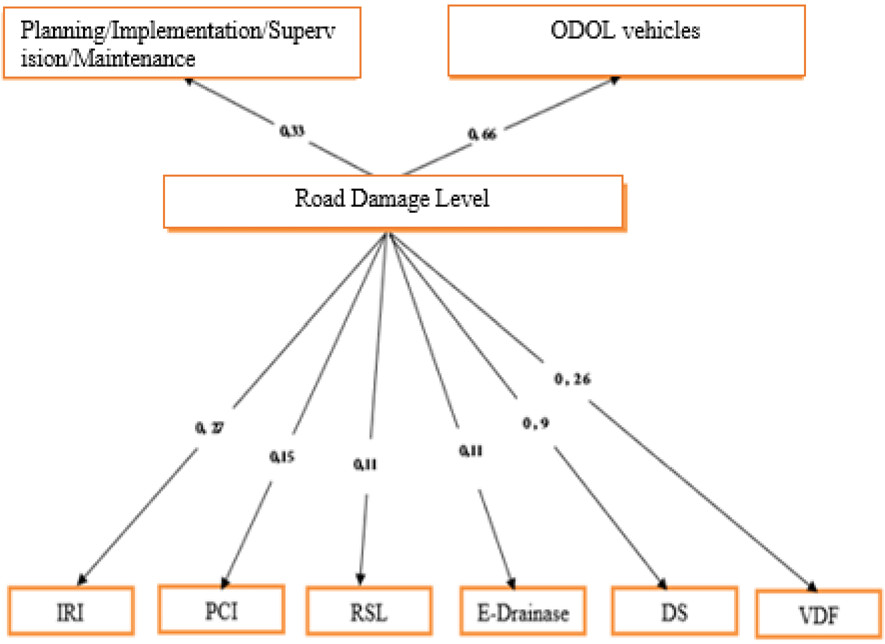

Figure 2. Model of Causes and Parameters of Road Damage Levels

From the above hypotheses, the following conclusions can be drawn:

1. H2: ODOL vehicles have a positive effect on road damage levels.
2. H3: The IRI parameter has a positive effect on road damage levels.
3. H8: The VDF parameter has a positive effect on road damage levels. (significance level less than 5% for the largest variable).
4. H9: Selected parameters have an effect on road section priority. (IRI and VDF parameters have an effect on road section priority).

The following are the results of the sub-criteria priority calculations for alternative priorities in Table 3.

Table 3. Results of Sub-Criteria Priority Calculations for Alternative Priorities

Road Sections	IRI	PCI	RSL	ED	DS	VDF	Total
B - SPK	0,03	0,02	0,02	0,02	0,01	0,03	**0,12**
SPK - SU	0,07	0,04	0,03	0,03	0,01	0,02	**0,19**
SU - KM	0,11	0,01	0,05	0,01	0,02	0,11	**0,32**
KM - SPT	0,02	0,06	0,01	0,05	0,04	0,07	**0,24**
SPT - SPTK	0,04	0,01	0,01	0,01	0,01	0,04	**0,12**

(Source: AHP Analysis)

Table 3. shows the results of calculating the priority of sub-criteria against the priority of alternatives, using formula 4.3. Y = 0.26979 (NP) + 0.15146 (NP) + 0.11345 (NP) + 0.11345 (NP) + 0.09266 (NP) + 0.25918 (NP). The higher the Y value, the higher the priority for road maintenance compared to other road sections.

The road damage priority model can be seen in Figure 3:

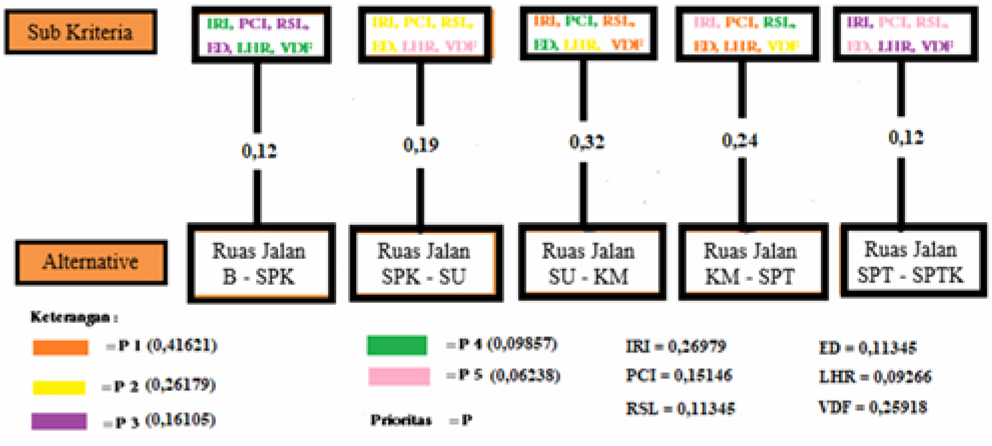

Figure 3. Road Damage Priority Model

In analyzing the causes, parameters, and alternatives, the researchers used the AHP method. The AHP method functions as a decision-making method used to organize and prioritize various options or alternatives based on several interrelated criteria. Based on stakeholder data related to the road sections studied, the following road damage parameters were obtained:

1. The lowest IRI value of 5.49 based on the IKP score 1 with a priority ranking of 1 (One) is the Sukamaju BTS – Km 10 Panjang Bandar Lampung (SU-KM) road section.
2. The lowest PCI value of 87.01 based on the IKP score 1 with a priority ranking of 1 (One) is the Km 10 Panjang Bandar Lampung – Sp Tiga Teluk Ambon (KM-SPT) road section.
3. The lowest RSL value of 8.51 based on an IKP score of 3 with a priority ranking of 1 (One) is the Sukamaju BTS – Km 10 Panjang Bandar Lampung (SU-KM) road section.
4. The lowest ED value of 87.01 based on the IKP score 1 with a priority ranking of 1 (One) is the Sukamaju BTS – Km 10 Panjang Bandar Lampung (SU-KM) road section.
5. The highest vehicle LHR value (smp/hour) is 1036 based on the smallest road section of 2.31 km with a priority ranking of 1 (One) which is the road section Km 10 Panjang Bandar Lampung – Sp Tiga Teluk Ambon (KM-SPT).
6. The highest total VDF value of 12.93 based on the smallest road section of 2.31 km with a priority ranking of 1 (One) is the road section Km 10 Panjang Bandar Lampung – Sp Tiga Teluk Ambon (KM-SPT).

The analysis results show that the Km 10 Panjang Bandar Lampung – Sp Tiga Teluk Ambon (KM–SPT) has the highest LHR value of 1,036 smp/hour and the highest total VDF value of 12.93, indicating that this section receives the most intense traffic pressure and the greatest damage load from heavy vehicles. Technically, a high LHR indicates a greater frequency of dynamic loading on the pavement, making it much more likely that the road's performance will deteriorate if maintenance is not carried out promptly. Meanwhile, a high VDF value indicates a significant contribution of heavy vehicles to structural damage, as each heavy vehicle can exert a load equivalent to tens to hundreds of times that of a light vehicle. The combination of these two indicators is an important basis for maintenance decision-making, particularly in determining the type of intervention (e.g., overlay or structural rehabilitation), the urgency of treatment, and budget allocation. Sections with high LHR and VDF generally require higher maintenance costs because they require high-resistance materials, more frequent maintenance, and stricter traffic supervision to prevent repeated damage.

Next, in the stage of determining the questionnaire weight, it is determined from the perspective of the groups, namely respondents from the Public Works Department, the Transportation Department, experts, organizations, and associations. In these 4 (four) groups, the weighting results are determined using analysis, *geometric mean* as seen in Table 4.16 of the total respondents, the analysis was continued with weighting using the AHP method. In its analysis, the AHP method uses a questionnaire with weighting values included in the process. In the process, the pairwise comparison weighting values are carried out in 4 (four) stages, namely:

1. Pairwise comparison of criteria (causes) to determine which criteria are the greater cause of road damage in Lampung province. The highest weighted criterion or the cause of road damage in Lampung province is ODOL Vehicles with a weight value of 67%.
2. Pairwise comparison of sub-criteria (parameters) to determine which sub-criterion has the greatest influence on road damage parameters in Lampung Province. The highest sub-criteria weight or the largest parameter for road damage in Lampung Province is IRI with a weight value of 27%.
3. Pairwise comparison of alternatives (road sections) to determine priority alternative road sections based on the parameter ranking values provided by the relevant stakeholders. The highest weighted alternative or the one that becomes priority road section 1 (one) with a value of 42%.
4. Comparison of sub-criteria and alternatives is to determine the value of the paired comparison between road damage parameters and road sections that will be prioritized in handling road damage. The highest priority value compared to road damage parameters is the Sukamaju BTS road section - Km 10, Bandar Lampung length (5 Km) called SU-KM with an AHP value of 32%.

The questionnaire included questions about two causes of road damage, which researchers studied to provide solutions. The following summarizes the respondents' answers:

1. Road damage due to planning/or implementation and supervision and/or maintenance of roads.
   a. Planning design with current conditions to obtain appropriate parameters and appropriate pavement types and quality.
   b. Implementation of work under good planning and supervision with technical specification standards.
   c. Routine, periodic maintenance and timely rehabilitation to ensure the planned lifespan is in accordance with the plans drawn up.
   d. Tightened control of road drainage supervision.
   e. The use of technology and programs in inspection and administration to speed up information and work.
   f. Using the latest materials and methods to simplify work so that it is on time, of the right quality, and saves budget.
   g. There is no kinship between the owner's *project* and service providers.
   h. Involve the public in reporting damaged roads in applications or programs appropriately and accurately.
2. Road Damage Due to ODOL Vehicles
   a. Firm action against ODOL vehicles, such as: on-the-spot ticketing, vehicle confiscation, and cutting of the vehicle bed.
   b. Supervision is tightened by the Ministry of Transportation in collaboration with the police and other relevant stakeholders.
   c. The implementation and enforcement of UPPKB (Motor Vehicle Weighing Implementation Unit) and weighbridges in areas prone to ODOL violations.
   d. Increased supervision of KIR test vehicles and firm action against fake KIR books.
   e. Socialization to users and companies that use medium vehicles and large trucks regarding regulations of the Law, Government Regulations, Regulations of the Minister of Transportation, Regulations of the Director General of HUBDAT, and others.
   f. Coal transportation is moved by rail mode.
   g. The fine is not the maximum but should be increased to prevent continued violations.
   h. Encourage the use of advanced automotive technology and comply with JBI (Total Weight Permit) regulations to overcome *overload* such as the consumption *multiple axles, air bag suspension* and others.
   i. Improve services to the community.
   j. Systematic and modern law enforcement such as *MEAT* and *WIM*.

Based on the segment priorities determined through AHP analysis, budget requirements and maintenance types can be mapped more effectively. For example, the Sukamaju BTS – Km 10 Panjang Bandar Lampung (SU–KM) segment, which has the lowest IRI, RSL, and ED values, requires a larger budget allocation for structural rehabilitation work because the low roughness and remaining service life indicate damage that has penetrated the pavement layer [42]. Conversely, the Km 10 Panjang Bandar Lampung – Sp Tiga Teluk Ambon (KM–SPT) segment, which has a relatively high PCI value but the highest LHR and VDF, is better prioritized for intensive routine maintenance and preventive maintenance to prevent accelerated damage due to heavy traffic loads [43,44]. The budgeting for these two segments will differ: the SU–KM segment requires rehabilitation investment with high-resistance materials, while the KM–SPT segment requires monitoring costs, periodic repairs, and stricter traffic management.

Recommendations for law enforcement measures also need to be mapped based on the characteristics of priority segments. In the KM-SPT segment, which bears the heaviest vehicle load, the placement of enforcement facilities such as UPPKB and Weight in Motion (WIM) is highly relevant to control ODOL at points that directly contribute to damage. Increased but still proportional fines can be applied as a deterrent, accompanied by vehicle body cutting and direct action against serious violators. In other segments with lower ODOL risks, supervision can focus on improving the quality of vehicle inspections and verifying the authenticity of vehicle eligibility documents to prevent unroadworthy vehicles from entering priority lanes. In addition, shifting certain modes of transportation, such as coal to rail, can help reduce pavement loads in segments with high VDF values.

However, all of these policy decisions still contain uncertainties that need to be considered. Uncertainties can arise from seasonal variations in traffic, changes in logistics distribution policies, inaccuracies in ODOL reporting, and regional budget constraints that cause maintenance delays. In addition, the effectiveness of law enforcement is highly dependent on the consistency of UPPKB operations and the ability of WIM to accurately record loads. Thus, even though priority segment mapping, maintenance needs, and law enforcement strategies have been developed in a targeted manner, the implementation process still requires flexibility, continuous data verification, and inter-agency coordination to ensure optimal and sustainable results.

From the results of the analysis above, a road damage management model was determined for research variables such as causes, parameters, and priority for selecting road sections which are expected to be a reference in making policies for *stakeholder* related. Although the AHP results provide a strong picture of the priorities for action, the external validity of these findings has certain limitations. Because respondents were selected purposively, the assessment results reflect the knowledge and experience of stakeholders who are indeed competent, but cannot be considered statistically representative of the entire population. Therefore, the application of the results outside Lampung Province needs to be done carefully and must take into account traffic conditions, pavement characteristics, and local policies in other regions. Nevertheless, the analytical approach used, which combines measurable data such as IRI, PCI, RSL, LHR, and VDF with multi-stakeholder assessment through AHP, can be replicated and adapted in other regions as long as equivalent technical data is available and the decision-making process follows the same hierarchical structure.

4. Conclusion

Based on the analysis, this study concluded that national road damage in Lampung Province is primarily caused by two main factors: weaknesses in planning, implementation, supervision, and maintenance, and the high activity of ODOL vehicles. Six technical parameters IRI, PCI, drainage effectiveness, remaining road life, vehicle LHR, and VDF are the main indicators influencing the level of damage. Using the AHP method, ODOL vehicles were identified as the most dominant cause of damage, with a weighting of 67%, while IRI parameters were the top priority in assessing pavement condition, with a weighting of 27%. Priority road segment management has also been established: five main road sections, from Sukamaju BTS Km 10 Panjang to Bakauheni Sp. Kalianda. Based on these findings, this study recommends three stages of structured policy management. In the short term, the focus will be on law enforcement against ODOL vehicles through weighbridge optimization, field inspections, integrated enforcement, and quick response maintenance on sections with the highest IRI scores. Medium-term goals include improving drainage effectiveness, adjusting pavement designs to reflect actual traffic loads, and strengthening cross-agency coordination for a digital-based vehicle monitoring system. Long-term goals include developing a sustainable road load management model, modernizing weighbridge infrastructure to Weigh-in-Motion (WIM), and integrating LHR, VDF, and IRI data into the national planning system. To ensure sustainable implementation, recommended monitoring indicators include a reduction in the annual IRI value, an increase in the PCI index, a reduction in the number of ODOL violations, increased drainage effectiveness on priority sections, and a reduction in the trend of premature deterioration based on the remaining road life assessment. This combination of strategies is expected to produce a comprehensive and effective road deterioration management model for the Lampung region and nationally.

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