

Analysis of the Factors Causing Damage to Public Street Lighting Lights in Binjai City, North Sumatra Province

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Keywords:	Abstract
Public Street Lighting (PJU); Lamp damage; Maintenance; Public services; Binjai city	Public street lighting (Penerangan Jalan Umum, PJU) is essential infrastructure that supports public safety, security, and economic activities in Binjai City, North Sumatra Province, Indonesia. However, numerous streetlights have experienced operational failures, including complete outages and reduced illumination, compromising the quality of public services. This study aimed to identify the factors contributing to public street lighting failures, determine the most significant causes, and propose preventive measures to improve system reliability. A descriptive qualitative approach was employed, with data collected through direct field observations, in-depth interviews with representatives of the Housing and Settlement Areas Office, technical maintenance personnel, and local residents, as well as document reviews. Data were analyzed through data reduction, data display, and conclusion drawing. The findings indicated that street lighting failures resulted from a combination of technical factors, including component aging and inadequate material quality; environmental factors, such as extreme weather conditions and vegetation interference; budgetary constraints; and external factors, including vandalism and theft. Inadequate preventive maintenance emerged as the most significant contributing factor, characterized by the absence of a regular maintenance schedule and a predominantly reactive repair system dependent on public complaints. Recommended measures included establishing a scheduled preventive maintenance program, implementing technology-based monitoring systems, using components that meet applicable technical standards, increasing maintenance budget allocations, and strengthening community participation in protecting public lighting infrastructure. These measures were expected to improve the reliability, operational efficiency, and sustainability of public street lighting services in Binjai City.

INTRODUCTION

Public street lighting (Penerangan Jalan Umum, PJU) is an essential component of urban infrastructure that plays a strategic role in supporting community activities, particularly at night

(Widiyaningrum et al., 2024). Street lighting not only provides illumination but also improves road user visibility, traffic safety, public security, and community comfort (ZULKARNAIN, 2024). In urban areas such as Binjai City, public street lighting constitutes critical infrastructure that facilitates community mobility and supports local economic activities (Samsinar et al., 2021). As urban development continues, the demand for reliable and effective street lighting becomes increasingly important for reducing traffic accident risks, potentially deterring criminal activity, and enhancing road users' perceptions of safety (Wisudawan et al., 2025).

From an infrastructure management perspective, public street lighting forms part of an outdoor illumination system designed to support safe and efficient road operations (Anugrah et al., 2021). However, the effectiveness of street lighting services in Binjai City is influenced by various internal and external factors, which can be systematically examined through a strengths, weaknesses, opportunities, and threats (SWOT) analysis, as presented below (Andhini, 2017; Andriana et al., 2021; Lande et al., 2022; Sugiarto et al., 2024).

In practice, numerous public streetlights in Binjai City have experienced operational problems, including complete lighting failures, reduced illumination, and intermittent flickering (Anugrah & Solihin, 2021). These conditions may result from several technical factors, including component aging, inadequate material quality, and electrical installations that do not comply with applicable technical standards (Mahendra et al., 2022; Milanie, 2024). Environmental conditions, including prolonged exposure to high temperatures, heavy rainfall, and elevated humidity, may also accelerate the deterioration of electrical and lighting components, thereby reducing system reliability and service life (Makaruku Talakua E. Lewakabessy) Godfried Jurusan) Sipil T. & Ambon P. N, 2023).

Another significant challenge involves inadequate maintenance management. Irregular maintenance activities, insufficient routine inspections, and limited system monitoring can contribute to the deterioration of street lighting infrastructure and delay the identification and resolution of operational failures (Fedrico et al., 2024). Effective maintenance management requires an appropriate combination of preventive, corrective, and predictive maintenance strategies to maintain equipment functionality, minimize service interruptions, and extend the operational life of lighting infrastructure (Pramesti & Faizah, 2024; Rochman et al., 2024).

Accordingly, a comprehensive assessment of public street lighting infrastructure is necessary, encompassing systematic planning, operational management, routine maintenance, and performance monitoring (Agustina & Maulany, 2025). Identifying the underlying causes of street lighting failures is essential for developing appropriate maintenance strategies, improving the efficiency of budget allocations, and enhancing the reliability and quality of public lighting services in Binjai City (Fatimah et al., 2020; Firdaus, 2025).

This study contributed an integrated assessment of technical failure mechanisms and maintenance governance in public street lighting infrastructure. Technical deterioration, adverse environmental conditions, and vandalism represented distinct potential causes of equipment failure, whereas irregular inspections, inadequate preventive maintenance, and delayed corrective responses could intensify or prolong their operational consequences (Ferine et al., 2021; Sukma et

al., 2021). Inadequate maintenance management emerged as the principal concern based on recurring qualitative observations and stakeholder accounts presented in the findings. However, this conclusion reflected the patterns identified through qualitative analysis rather than a statistical ranking derived from quantified equipment failure records. By distinguishing observed maintenance deficiencies from quantitatively established causal relationships, the study provided a context-specific understanding of street lighting failures and a foundation for developing more systematic and sustainable infrastructure maintenance strategies.

METHOD

This study employed a descriptive qualitative approach to examine the condition of public street lighting (Penerangan Jalan Umum, PJU) infrastructure and identify factors contributing to lighting system failures in Binjai City, North Sumatra Province, Indonesia. The research focused on understanding technical, environmental, and maintenance-related problems through field observations and the perspectives of government officials, technical personnel, and community members. Binjai City was selected as the research location because street lighting failures had been observed on major roads and local streets, potentially affecting nighttime mobility and public safety.

The study involved stakeholders responsible for managing, maintaining, and using public street lighting infrastructure in Binjai City. Informants were selected through purposive sampling based on their involvement in street lighting management, technical maintenance, or direct experience with lighting failures. They included officials from the Binjai City Housing and Settlement Areas Office, field maintenance technicians, approximately 30 community members and road users, and relevant contractors or service providers. Data were collected through three methods: direct field observations to assess the physical condition of lighting equipment, illumination conditions, and locations of malfunctioning streetlights; in-depth interviews to identify perceived causes of equipment failures and existing maintenance practices; and document reviews involving official records, maintenance reports, and field photographs to corroborate the findings (Andhini, 2017).

Data were analyzed using descriptive qualitative techniques involving data reduction, data display, and conclusion drawing. During data reduction, relevant information was identified, organized, and categorized according to technical, environmental, institutional, and maintenance-related factors (Prasetyo & Widodo, 2021). The findings were subsequently presented through descriptive narratives and tables to identify recurring patterns and formulate appropriate maintenance recommendations. Data credibility was strengthened through methodological triangulation by comparing findings from observations, interviews, and documentation (Erwansyah et al., 2022). Source triangulation was also employed to examine the consistency of information provided by different stakeholder groups (Moleong, 2007), while member checking was conducted to verify the accuracy of selected interview findings. The research procedures comprised a preliminary literature review and research preparation, field data collection,

qualitative analysis of the identified failure factors, and the formulation of recommendations for improving public street lighting maintenance management.

A strengths, weaknesses, opportunities, and threats (SWOT) matrix was used to organize field observations and identify relevant institutional and environmental conditions affecting public street lighting management. The matrix served as a qualitative analytical framework rather than a quantitative ranking instrument. Maintenance-related deficiencies were identified as the predominant concern based on recurring accounts of delayed repairs, the absence of scheduled preventive maintenance, and reliance on public complaints to initiate corrective actions. However, because a comprehensive inventory of malfunctioning streetlights and detailed interview counts for each stakeholder category were unavailable, equipment failure rates and quantitative rankings of contributing factors were not calculated. Consequently, the assessment of maintenance-related problems reflected the consistency and prominence of qualitative evidence rather than statistically established causal dominance.

RESULT AND DISCUSSION

Table 1. SWOT Analysis of PJU Management of Binjai City

SWOT Components	Analysis Description	Related Resources
Strengths	The government's commitment to providing PJU as a public service infrastructure that supports socio-economic aspects.	Widiyaningrum & Galih (2024)
Weaknesses	Lack of routine maintenance, budget limitations, and a suboptimal supervision system.	Firdaus (2025); Setiawan et al. (2020)
Opportunities	Potential for increased nighttime economic activity, regional security, and sustainable development.	Osy Oktavian & Joko Setiyono (2022)
Threats	Extreme weather, humidity, corrosion, as well as acts of vandalism and theft of electrical components.	Andriana et al. (2021); Basuki (2026)

Source: Qualitative synthesis of observations, interviews, and documentation described in this manuscript.

The Existing Condition of Public Street Lighting Lights (PJU) in Binjai City and Factors Causing Damage to Public Street Lighting Lights (PJU) in Binjai City

Binjai City as one of the cities in North Sumatra Province has an important role in supporting community activities, both in the economic, social, and transportation fields. Along with the increase in population and community mobility, the need for adequate public street lighting (PJU) has become increasingly important, especially at night.



Figure 1. Area Map (Illustration of Road Infrastructure and PJU Distribution in Binjai City)

[SUMBER PERLU DIKONFIRMASI PENULIS: asal, pemilik, lokasi dan izin penggunaan visual Figure 1]

Based on the results of field observations and documentation, the existing condition of PJU in Binjai City shows that street lighting networks are available on most roads, especially on main roads and city center areas. However, there are still various problems that affect the level of performance and reliability of PJU at several location points.

Some PJU lights were found in conditions that did not function optimally, such as completely shutting down, dimming, or experiencing other technical problems. This condition shows that the functioning of PJU is not fully evenly distributed throughout the Binjai City area.



Figure 2. Some PJU Points Outage and Repair

[SUMBER PERLU DIKONFIRMASI PENULIS: asal, pemilik, lokasi dan izin penggunaan visual Figure 2]

In addition, the distribution of PJU is also not balanced. The city center area tends to have a better level of lighting compared to residential areas or environmental roads. This inequality causes a difference in the level of security and comfort for the community, especially at night.

From the quality aspect, there is still the use of lights with old technology that have a low level of efficiency and are prone to damage. On the other hand, some points have used more modern technology, but have not been supported by an optimal maintenance system.

Another problem found is the lack of routine maintenance and an effective monitoring system. Damage to lights is often not handled immediately, causing lighting disruptions for a long time. This shows that PJU management still needs to be improved, both in terms of responsiveness and monitoring systems.

Environmental factors also affect the condition of PJU, such as extreme weather, the presence of trees that block light, and waterlogging that can damage electrical installations. This shows that the functioning of PJU is not only influenced by technical factors, but also by other external factors. Overall, the existing condition of PJU in Binjai City shows that even though street lighting infrastructure is available, there is still a need for improvement in terms of quality, equity, and management in order to provide optimal services to the community.

Based on the results of field observations, interviews with related parties, and documentation studies, this study found that the damage to public street lighting (PJU) in Binjai City was caused by several main factors that can be classified as follows:

1) Technical Factors

Technical factors are the main cause of damage to PJU lamps. Damage occurs due to the long service life of lamps and components that result in a decrease in function. In addition, the quality of the materials used and the installation system that is not in accordance with standards also accelerate the occurrence of damage, such as easily damaged cables and control panels that cannot withstand field conditions.

2) Environmental Factors

Environmental conditions also have a significant effect on PJU damage. Extreme weather such as heavy rain, strong winds, and high humidity can damage electrical components. In addition, unpruned trees can block light or damage lights, and waterlogging has the potential to cause disruption to electrical installations.

3) Maintenance Factors

Lack of regular maintenance is one of the important factors. Based on the results of the interview, light checking and maintenance activities have not been carried out regularly and thoroughly, so small damage is often not handled immediately and develops into larger damage.

4) Supervision Factors

Supervision of PJU conditions is still not optimal. The absence of an integrated monitoring system causes lamp damage to be often found out too late. In many cases, repairs are carried out after reports from the public, so they are reactive, not preventive.

5) Budget Factor

Limited regional budgets are also the cause of PJU damage. The available funds are not enough for routine maintenance, component replacement, and the development of more modern lighting systems, so many damaged lights are not repaired immediately.

6) External Factors

External factors such as vandalism and theft of electrical components also cause damage to PJU. Some cases show the theft of cables and other components that cause the lights to malfunction.

The Most Dominant Factor Affecting the Damage of Public Street Lighting (PJU) in Binjai City

Based on the results of observations, interviews, and documentation, it was obtained that the most dominant factor causing PJU light damage in Binjai City was the lack of maintenance. This can be seen from the conditions in the field which show that most of the damage is not only caused by technical or environmental factors, but more due to the absence of continuous handling and maintenance of existing facilities. Dominant Indicators of Maintenance Factors:

1) Many broken lights are not repaired immediately

On some roads, lights were found to be off or dim that were left for a long time. This shows that there is a delay in handling damage, so that the street lighting function is not running optimally.

2) Absence of regular maintenance schedule

PJU maintenance has not been carried out in a planned and periodic manner. Maintenance activities tend to be carried out only when damage occurs, not as a preventive measure. As a result, the condition of the lamps is not controlled periodically.

3) Repairs are reactive (pending report)

Based on the results of the interviews, repairs are usually made after reports from the public. This shows that the management system is still passive, so that a lot of damage is not detected early.

4) Small damage develops into major damage

Minor disturbances such as dim lights, loose wiring connections, or components that begin to wear out are not repaired immediately. Over a period of time, these conditions cause the damage to become more severe even to the point that the lamp cannot function at all.

6) Limitations of manpower and maintenance systems

The limited number of officers and the absence of an integrated monitoring system cause many light points to not be monitored optimally. This has an impact on the slow process of identification and handling of damage.

The maintenance factor is the most dominant because it has a direct influence on the real condition of the lights in the field. In many cases, the damage that occurs can actually still be prevented or minimized if regular and scheduled maintenance is carried out. In addition, this factor also amplifies the impact of other factors. For example, damage due to weather or the age of the lamp will occur faster if it is not balanced with good maintenance. Therefore, the weak maintenance system is the main cause that increases the level of PJU damage in Binjai City.

Based on the results of the study, it can be concluded that maintenance factors are the most dominant factor in causing PJU light damage in Binjai City, which is shown by the absence of routine maintenance, delay in repairs, and a management system that is still reactive.

The Influence of Technical Factors on Public Street Lighting Lighting Damage (PJU) in Binjai City

Based on the results of field observations, interviews, and documentation, it is known that technical factors have a significant influence on the damage to public street lighting (PJU) in Binjai City. Technical factors are related to the physical condition, quality of components, and installation systems used in the street lighting network.

The influence of technical factors on PJU damage can be seen from the following aspects:

1) Lamp and component life

PJU lamps that have been used for a long period of time experience a decrease in performance, such as the light getting dimmer until it finally dies completely. Supporting components such as ballasts, cables, and fittings also experience wear, so they cannot function optimally.

2) Quality of materials used

The use of low-quality or non-standard components causes the lamp to deteriorate faster. Materials that are not resistant to heat, rain, and humidity accelerate the decline in lamp function.

3) Less than standard installation systems

Improper electrical installations, such as unprotected wiring connections or less secure panel installation, can cause technical problems. This condition has the potential to cause damage to the lighting system as a whole.

4) Damage to the supporting components

In addition to the main light, damage also occurs to other components such as the control panel, wiring network, and light pole. Damage to any of these components can cause the light to not turn on even if a power source is available.

In general, technical factors have a direct effect on the level of PJU damage because they are related to the main function of the lighting system. If the component is damaged, then the lamp cannot operate properly. However, based on the results of the study, the influence of technical factors is often amplified by a lack of maintenance. Components that should still be usable are damaged faster because they are not routinely maintained.

The Influence of Environmental Factors on the Damage of Public Street Lighting (PJU) in Binjai City

Based on the results of field observations, interviews, and documentation, it is known that environmental factors have a significant influence on the damage to public street lighting (PJU) in Binjai City. Environmental factors are related to natural conditions and surrounding situations that directly or indirectly affect the durability and performance of PJU components.

The influence of environmental factors on PJU damage can be seen from the following aspects:

1) Influence of weather and climate

Weather conditions such as heavy rain, strong winds, and high air humidity can accelerate the damage to lighting components. Rainwater entering an electrical installation can cause a short circuit, while moisture can accelerate the corrosion process of metal components.

2) Heat exposure and temperature changes

Quite extreme temperature changes between day and night can affect the durability of lamp materials. Continuous exposure to the sun's heat can also lead to a decrease in the quality of components, especially in the protective parts of the lamps and cables.

3) Disturbance from vegetation (trees)

The presence of trees around the road that are not regularly pruned can block the light of the lamp so that the lighting becomes suboptimal. In addition, tree branches or branches that rub against the cable can cause physical damage to the installation.

4) Waterlogging and drainage conditions

At some points, waterlogging due to poor drainage systems can affect PJU's electrical installations. Stagnant water has the potential to damage underground cables or other components, causing disruptions to the lighting system.

5) Environmental dust and impurities

The buildup of dust, dirt, or pollution on the surface of the lamp can reduce the intensity of the light produced. In addition, dirt that enters the components can also interfere with the overall performance of the system.

Environmental factors affect PJU damage because it continuously puts pressure on the physical and technical condition of the lamps. An unsupportive environment can accelerate the damage process, even though the components used are still in good condition. However, the influence of environmental factors can actually be minimized if regular maintenance is carried out, such as cleaning lamps, pruning trees, and repairing drainage systems. This shows that environmental factors are closely related to maintenance factors in determining the level of PJU damage.

Environmental factors have a significant effect on the damage to PJU lamps in Binjai City, especially through weather conditions, humidity, vegetation, waterlogging, and environmental dirt. This factor accelerates component damage and decreases lamp performance, especially if it is not balanced with good maintenance.

The Role of Maintenance and Supervision in Minimizing the Damage of Public Street Lighting Lights (PJU) in Binjai City

Based on the results of observations, interviews, and documentation, it is known that maintenance and supervision have a very important role in minimizing damage to public street lighting (PJU) in Binjai City. These two aspects are key factors in maintaining the functioning and sustainability of the street lighting system.

1) Maintenance Role

Maintenance plays a role in maintaining the condition of PJU lights so that they continue to function optimally and prevent greater damage. The role of maintenance can be seen from the following things:

a. Prevent damage early

Through regular maintenance, minor damage such as dim lights, loose wiring, or components that begin to wear out can be quickly identified and repaired before they develop into more severe damage.

b. Extend the life of components

Good maintenance can maintain the quality of components so that they do not deteriorate quickly. Thus, the need for lamp replacement can be minimized.

c. Maintaining the quality of street lighting

Maintenance such as lamp cleaning and installation checks ensure that the light intensity remains optimal, supporting the safety and comfort of road users.

However, based on the results of the research, maintenance activities in Binjai City are still not optimal. Maintenance tends to be carried out after damage occurs, not periodically and plannedly, so its function as a preventive measure has not been optimal.

2) Oversight Role

Supervision functions to ensure that the condition of PJU lights remains monitored and damage can be immediately known and followed up. The role of supervision can be seen from:

a. Detect damage faster

With good supervision, light damage can be immediately detected without having to wait for reports from the public.

b. Improve repair response

An effective monitoring system allows the management to carry out corrective actions quickly and on target.

c. Controlling maintenance performance

Supervision also serves to ensure that maintenance activities run in accordance with the plan and standards that have been set.

However, the results of the study show that supervision of PJU in Binjai City is still limited. The absence of an integrated monitoring system causes supervision to be carried out manually and less effectively.

Maintenance and supervision have a complementary relationship in minimizing PJU damage. Maintenance acts as a preventive and corrective measure, while supervision functions as a control system to ensure that the condition of the lights is monitored. If these two aspects go well, then:

- Damage can be prevented from the start
- Faster repair time
- The rate of damage can be significantly reduced

On the other hand, if maintenance and supervision do not run optimally, then damage will occur more often and have an impact on the declining quality of street lighting. Maintenance and

supervision have a very important role in minimizing damage to PJU lights in Binjai City. Maintenance functions to prevent and repair damage, while supervision plays a role in detecting and controlling the condition of lights. However, these two aspects are still not running optimally, so they need to be improved to support the reliability of the street lighting system.

Efforts to Reduce and Prevent Damage to Public Street Lighting (PJU) in Binjai City

Based on the results of observations, interviews, and documentation, it is known that efforts to reduce and prevent damage to public street lighting (PJU) in Binjai City need to be carried out comprehensively through a technical, managerial, and participatory approach. This effort aims to improve the reliability of the street lighting system and minimize the level of damage that occurs.

Efforts that Can Be Done

1) Improvement of routine maintenance system

Local governments need to implement a scheduled and periodic maintenance system, not just repairs when damage occurs. Routine maintenance such as checking the condition of lights, cleaning, and replacing components that are starting to wear out can prevent further damage.

2) Strengthening of the supervision and monitoring system

A more effective surveillance system is needed, such as regular patrols or the use of simple monitoring technology to detect damage faster. With good supervision, the response to damage can be done more quickly and precisely.

3) Use of quality and compliant components

The procurement of PJU lights and components should use materials that have good quality and are resistant to environmental conditions. This aims to reduce the risk of damage due to technical factors.

4) Installation system repair

Electrical installation must be carried out in accordance with applicable technical standards, including the protection of cables and panels from environmental disturbances. Good installation will improve the safety and durability of the PJU system.

5) Increased maintenance budget

Local governments need to allocate adequate budgets for the maintenance and repair of PJU. The availability of sufficient budget will support the implementation of maintenance optimally and sustainably.

6) Handling of environmental factors

Efforts such as regular tree pruning, drainage improvement, and cleaning of the area around the lights need to be carried out to reduce the environmental impact of PJU damage.

7) Increased community participation

The public can be involved in supervision by reporting light damage to related parties. In addition, public awareness to maintain public facilities also needs to be increased to prevent vandalism and theft.

These efforts are interrelated and must be carried out in an integrated manner. Increasing maintenance and supervision is the main step, because these two aspects can directly reduce the level of damage. Meanwhile, support from technical aspects, budget, and community participation

will strengthen the effectiveness of PJU management as a whole. If these efforts are carried out consistently, the damage to PJU lights can be reduced, the quality of street lighting improves, and public services in the infrastructure sector become more optimal. Efforts to reduce and prevent damage to PJU lights in Binjai City include increasing routine maintenance, strengthening supervision, using quality components, improving installations, increasing budgets, handling environmental factors, and community participation. These efforts need to be carried out in an integrated and sustainable manner so that the street lighting system can function optimally.

Strategy to Increase PJU Reliability in Binjai City

Based on the analysis of the factors causing the damage, a more effective PJU management strategy was formulated to improve the quality of public services as follows:

1. Transformation of the Maintenance System (Preventive Maintenance)

Changing the maintenance pattern from being reactive (waiting for damage reports) to a periodic maintenance system or *preventive maintenance* (Pramesti & Faizah, 2024). This strategy includes creating a regular inspection schedule on vital components such as control panels and cable networks to detect potential damage before the lights turn off completely.

2. Implementation of Technology-Based Monitoring

To overcome the limitations of field supervision, it is necessary to implement *an IoT-based Smart Lighting System that can provide real-time notifications if there is a disturbance at certain light points* (Samsinar et al., 2021). This aims to *accelerate corrective maintenance responses without having to rely entirely on community reports*.

3. Standardization of Materials and Components

In order to minimize technical damage due to short service life, the strategy is to tighten the quality standards of components (LED lights and cables) that have higher resistance to extreme weather and humidity (Mahendra et al., 2022). The use of high-quality components in the long term will increase the efficiency of the regional budget (Firdaus, 2025).

4. Strengthening Facility Security (Mitigation of External Factors)

To deal with the threat of vandalism and component theft, the strategy applied is through the design of safer (anti-vandal) pole and panel construction as well as increased coordination with local security forces and the community for social supervision in public spaces (Oktavian et al., 2022).

5. Optimization of Infrastructure Budget Management

Local governments need to formulate a more proportionate budgeting scheme, not only focusing on procurement (new installations), but also ensuring the availability of adequate maintenance funds every year (Setiawan, 2020; Sugiyono., 2022). This is very important to ensure the sustainability of infrastructure functions in supporting the city's economic activities (Agustin et al., 2025).

Table 2. Strategy Summary Table

Aspects	Key Strategies	Purpose
Technical	Component Standardization & IoT Monitoring	Extend the life of the lamp & fast response.
Management	<i>Scheduled Preventive Maintenance</i>	Reduce the frequency of the lights off completely.
Security	Anti-vandal construction & social supervision	Prevents theft of cables/components.

Aspects	Key Strategies	Purpose
Financial	Allocation of special maintenance budgets	Guarantee the availability of regular parts.

CONCLUSION

Based on the findings and discussion, this study concluded that public street lighting (Penerangan Jalan Umum, PJU) failures in Binjai City resulted from the interaction of technical, environmental, maintenance-related, institutional, budgetary, and external factors, including vandalism and cable theft (Andriana et al., 2021; Basuki, 2026). Field observations and stakeholder accounts identified inadequate routine maintenance as the most prominent contributing factor, characterized by a predominantly reactive repair system and delays in addressing reported failures. Technical factors, including aging components, equipment operating beyond its expected service life, and substandard material quality, also contributed to lighting system malfunctions. Furthermore, adverse environmental conditions, particularly extreme weather and high humidity, were identified as potential contributors to the deterioration of electrical and lighting components. These findings highlighted the importance of addressing both equipment-related vulnerabilities and deficiencies in maintenance management to improve the reliability of public street lighting infrastructure.

To address these challenges, the study recommended strengthening infrastructure management through scheduled preventive maintenance and technology-based monitoring, including the potential adoption of smart street lighting systems. Additional measures included establishing consistent technical specifications for lighting components, allocating sufficient resources for routine maintenance and timely repairs, and encouraging community participation in preventing vandalism and protecting public infrastructure. Integrating proactive maintenance practices, effective budget management, and systematic operational monitoring could improve the reliability, service continuity, and long-term sustainability of public street lighting in Binjai City.

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