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ANALYSIS OF TRAFFIC LIGHTING ON ROAD USERS: CASE STUDY OF SILIWANGI ROAD KADIPATEN - MAJALENGKA

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ABSTRACT

A well-lit and safe roadway is a crucial factor in ensuring the safety and comfort of road users. This research presents an in-depth analysis of traffic lighting on Jalan Siliwangi Kadipaten-Majalengka through a comprehensive case study. The main focus of the study was to understand the impact of lighting levels on road user behavior concerning infrastructure conditions and lighting aspects. The research methodology involved a field survey that included measuring light intensity, monitoring the type of lights used, and evaluating infrastructure conditions related to street lighting. In addition, a questionnaire from road users was also conducted to obtain their perceptions and experiences regarding traffic lighting along the road. The results show that there are variations in the level of illumination on different parts of the road, which may affect the level of alertness of road users. The analysis of road user behavior also provides insights into the direct impact of lighting conditions on speed, distance judgments, and responses to traffic situations. Based on these findings, the research provides recommendations for the improvement of the street lighting system by considering more efficient use of lights, regular maintenance, and adequate infrastructure adjustments. This research is expected to contribute significantly to the development of strategies that can improve road user safety and comfort on Jalan Siliwangi Kadipaten-Majalengka, as well as provide a foundation for further research in the traffic lighting domain.

1. Introduction

Traffic is an important issue in traffic management worldwide. In an era of increasingly rapid globalization, rapid economic growth and urbanization have led to inevitable population mobility and traffic volume. Most highly populated countries have experienced a massive increase in motorized vehicles, triggering major challenges in managing traffic and safeguarding road users. Poor traffic conditions in some countries have given rise to an urgent need for further analysis of street lighting systems and their effects on traffic safety. It is, therefore, identified that active traffic management is a necessity [1].

Regionally, Asia is one of the regions most affected by traffic and road safety issues. Asia itself, with its large population and rapid economic growth, is facing the issue of severe traffic congestion and increasing accident rates. Due to this unplanned growth of infrastructure and increased private vehicles,

traffic congestion becomes an unbearable daily life problem [2]. Many factors contribute to these problems, including the ever-increasing volume of vehicles, inadequate road infrastructure, and lack of efficient street lighting have made traffic in Asia more complicated and dangerous. One underrated aspect of daily life that potentially influences comfort in an urban environment is street lighting in public spaces [3].

At the national level, Indonesia is a country facing similar challenges in managing traffic and ensuring road user safety. The archipelago has experienced significant vehicle growth, especially in major cities. The issue of road lighting about traffic safety has become more pressing and needs to be addressed. Indonesia has one of the highest traffic accident rates in Southeast Asia, and efficient street lighting has become a major concern for the government. Road accidents pose a serious problem for the economy, especially in low and middle-income countries, where the death rates due to road injuries are three times higher than in high-income countries [4].

Majalengka district in West Java is also not immune to worsening traffic problems. In a study conducted in this region, researchers found that the lack of adequate street lighting on most roads in Majalengka has caused various problems, including a high rate of nighttime accidents and a lack of security for road users. Thus, a comprehensive analysis of all factors contributing to road traffic accident occurrence is necessary to define the real needs of people in road traffic while detailed background circumstances need to be taken into account [5]. Most accident-cause classification systems only focus on the faults and actions of the perpetrators that directly cause conflicts. To improve road safety, insight is needed into preventable causes of road accidents [6].

Therefore, the objective of this study is to conduct a comprehensive analysis of traffic lighting on Siliwangi Road, Kadipaten-Majalengka, which includes an evaluation of lighting effectiveness, its impact on road user safety, as well as recommendations for improvement. As part of a broader effort to improve traffic conditions in the region, this study aims to provide valuable insights that can be used in transportation planning and policy at local, national, and regional levels. Proper analysis of street lighting can have a positive impact on traffic safety, better mobility, and a higher quality of life for the community. Based on this, researchers are interested in writing a journal entitled Analysis of Street Lighting for Road Users: Case Study of Jalan Siliwangi, Kadipaten-Majalengka.

2. Literature Review

2.1 Traffic Lighting

Traffic lighting plays a crucial role in securing and optimizing traffic on roads, and has been the subject of much research in the literature. The presence of adequate lighting is an important aspect studied by many researchers, especially in the context of traffic safety. This research highlights the positive impact of lighting on the visibility of roads and surrounding objects at night. Thus, the provision of light at night is designed to allow the visual system to function to some degree and this brings with it benefits [7]. The study showed that adequate lighting can reduce the risk of accidents by giving drivers the ability to see more clearly and respond more effectively to situations.

Traffic lighting is a broad topic. Traffic regulation and control aspects are also a major focus in the traffic lighting literature. An efficient traffic light system and bright road signs not only help drivers navigate better at intersections and crossings but also contribute to the overall smooth flow of traffic. The fixed programs set the traffic signals to equal time duration in every cycle, or different time duration based on historical information [8]. Several studies have explored how proper lighting can minimize driver confusion, optimize vehicle flow, and reduce the risk of congestion on congested road sections. One of the critical benefits of TMSs is their ability to improve road safety [9].
From a psychological perspective, the literature shows that traffic lighting affects driver behavior. According to the global status report on road safety conducted by the World Health Organization (WHO)

in 2015, 1.25 million traffic-related fatalities occur annually worldwide, with millions more sustaining serious injuries and living with long-term adverse health consequences; road traffic injuries are currently estimated to be the leading cause of death among young people, and the main cause of death among those aged 15–29 years [10]. This research highlights the relationship between adequate lighting and driver alertness levels, which in turn can improve driving safety. A well-lit road environment was also associated with higher levels of driver compliance with traffic rules, suggesting that psychological aspects play an important role in creating safe driving conditions.

Finally, in this literature, the importance of traffic lighting in preventing road crime has been the focus of attention. Good lighting on roadways can create a less favorable environment for criminal activity, providing an additional layer of protection for road users and pedestrians. However, adding new approaches and responding to changing urban circumstances is costly for the agencies involved, and difficult choices have to be made between forms of crime prevention [11]. Therefore, this literature research provides a solid foundation for understanding how important traffic lighting is not only in the context of driving safety but also in creating an overall safe and comfortable roadway environment.

2.2 Environmental and Energy Aspects

Environmental and energy aspects in the context of traffic lighting have been a major focus in recent literature. The measured biological responses occur at intensities and spectra of artificial light that are currently encountered in the environment, and the global distribution of night-time lighting means that it is likely already having widespread impacts in marine, freshwater, and terrestrial habitats around the world [12]. This research highlights the importance of developing lighting solutions that are not only effective in providing visibility and safety on roadways but are also environmentally and energy-sustainable. One approach that continues to be studied is the use of LED lights which are more energy efficient than conventional lights. Simultaneously, the costs of LED packages have decreased to the point where LED lighting products can be competitive with conventional lighting products on a first-cost basis while offering a significantly lower cost of ownership (initial cost plus cost of electricity cost) during its life cycle [13]. The literature shows that LED technology can significantly reduce energy consumption, extend lamp life, and reduce environmental impact due to less e-waste generated. While new lighting technologies hold promise for higher efficiency, it is critical to examine the potential for an unintended waste burden rebound effect caused by impacts at the end of the product lifecycle [14].

The integration of renewable energy in traffic lighting systems has also been a major focus in the research literature. These studies include the use of solar panels and wind turbines as alternative energy sources to power streetlights. The sustainability of these energy sources provides an environmentally friendly solution and can reduce dependence on conventional energy resources. Although it is difficult to find alternative energy resources with the same efficiency and reliability as compared to conventional energy, it is also challenging to generate energy that is not involved in changing our climate [15]. In addition, the latest energy storage technologies are also a significant topic of study, enabling the storage of power generated from renewable energy sources for use when needed, even at night or in adverse weather conditions.

In this literature, research also includes smart energy management strategies that can dynamically optimize energy use based on traffic conditions and required lighting. The traffic authorities in most countries tend to control the traffic to reduce traffic accidents using several techniques such as: optimizing traffic-light management, improving cycling infrastructure, enforcing existing road traffic laws, improving perceptions of buses, extending residents' parking zones, using CCTV to monitor road conditions, charge for workplace parking, improve bus services, etc [16]. Smart sensor technology and automatic control systems enable the adjustment of lighting levels as needed, reducing unnecessary energy consumption and contributing to overall energy efficiency. In a smart city, technology is placed in the serve of society in order to achieve the smart objectives of every living factor that motivates

society, such as the administration, citizens and industry [17]. Awareness of the environmental impact of traffic lighting infrastructure and efforts to reduce the carbon footprint are important issues in designing environmentally friendly and sustainable solutions.

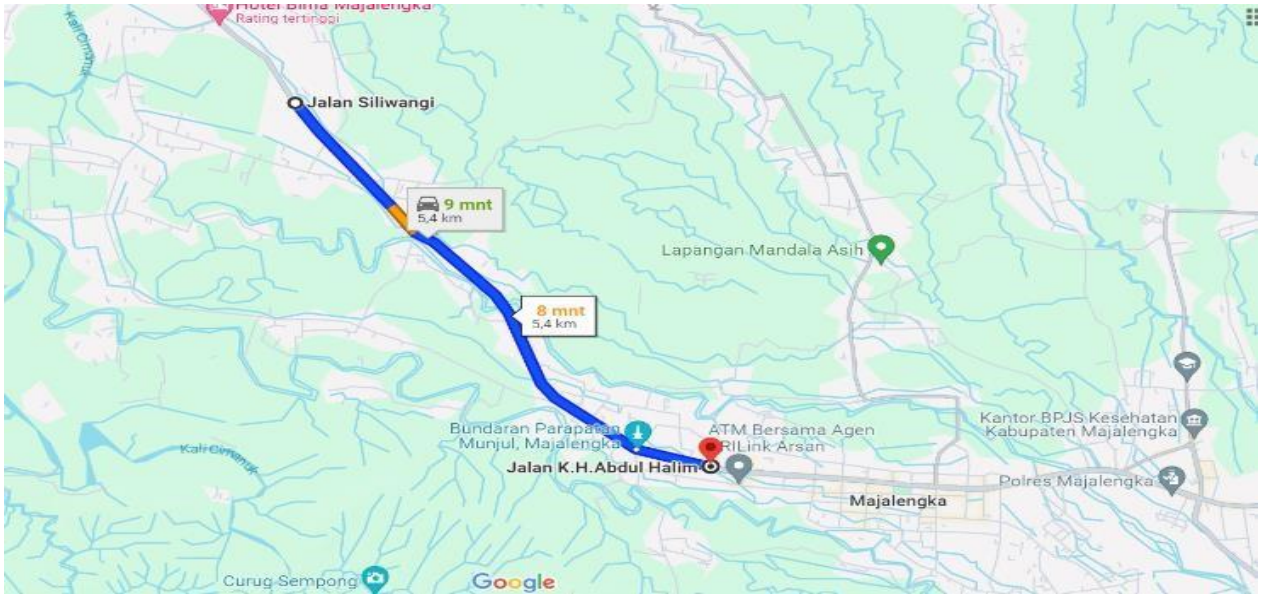
2.3 Local geographical and environmental conditions

Literature studies that focus on traffic lighting specifically often recognize the important role of local geography and environmental conditions in the design of effective lighting systems. Research into the ecological and evolutionary impacts of artificial night-time lighting, and how these can best be minimised, has focused almost exclusively on emissions from streetlights [18]. These factors have a direct impact on the lighting needs of an area and influence the successful implementation of appropriate lighting solutions. With the continuous improvement of motorization degree, freeway travel demand is increasing, and the freeway has become an important part of the world's highway transportation system [19].

Geographical conditions, such as topography and road structure, are key considerations in research related to traffic lighting. Some studies have shown that topographic nonuniformity can create shadow zones or dark spots on the road, requiring additional lighting to ensure optimal visibility. Light is examined as a code and a unit of information that produces an identity as the result of a linguistic outcome [20]. In addition, weather and climate factors, which are part of the geographical conditions, also play an important role in designing lighting systems that can withstand changing environmental conditions.

The local environment, including factors such as population density, urban development, and economic activities, can affect traffic intensity and the need for different lighting. Street lighting has been proven as an effective countermeasure to prevent road traffic accidents and severities on both rural and urban roads [21]. Literature research highlights that areas with high traffic density or locations with busy economic activities may require stronger lighting to ensure safe and smooth traffic flow. Similarly, aspects of the local environment such as the presence of shopping centers, entertainment venues, or pedestrian zones require special consideration in lighting to meet the needs of diverse road users. In some literature, research has also highlighted the importance of understanding the characteristics of the local environment in a social and cultural context. These factors can influence people's preferences for the type of lighting used, as well as compliance with traffic rules and signs. Therefore, the integration of social and cultural aspects in the design of traffic lighting systems is relevant to creating solutions that are more acceptable and effective in local communities.

3. Method



Picture 1 Location plan

The location of this research was carried out in Majalengka Regency, Jalan Siliwangi, Kadipaten to Majalengka. Researchers chose this location because the road is still lacking in lighting, this road is a road to get to the center of Majalengka city from Kadipaten and its surroundings, so this road is a road that is quite busy for motorists. This research focuses more on the lighting system in Jalan Siliwangi, Kadipaten-Majalengka for road users which is carried out through questionnaires and also through direct observation to the field. Primary data is data from the results of questionnaires sourced from users of Jalan Siliwangi, Kadipaten-Majalengka, and the results of observations of the road.

Importance of street lighting on driver safety	A1
Importance of street lighting on driver comfort	A2
The importance of street lighting in avoiding the risk of road damage	A3
Importance of street lighting on road crossings	A4
Importance of street lighting to the driver's view	A5
Importance of street lighting to pedestrians	A6
Importance of road lighting at intersections	A7
Importance of road lighting to vehicles from the opposite direction	A8
Importance of road lighting to traffic signs	A9
Importance of road lighting to bridges	A10

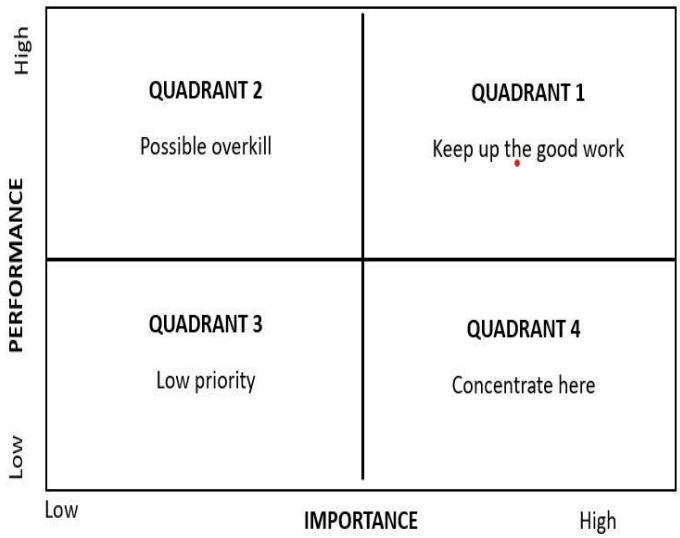
Table 2 Indicators of Importance

Satisfaction of street lighting on driver safety	B1
Satisfaction of street lighting on driver comfort	B2
Satisfaction of street lighting in avoiding the risk of road damage	B3
Satisfaction of street lighting on road crossing	B4

Satisfaction of street lighting on driver's vision	B5
Satisfaction of street lighting on pedestrians	B6
Road lighting satisfaction at intersections	B7
Satisfaction of road lighting on vehicles from the opposite direction	B8
Satisfaction of road lighting on traffic signs	B9
Road lighting satisfaction with bridges	B10

Table 3 Satisfaction Level Indicators

This study obtained data from the perceptions of 20 respondents through a questionnaire with the parameters used in the form of importance and satisfaction with lighting to users on Jalan Siliwangi, Kadipaten-Majalengka on a scale of 1-10 from very unimportant to very important and from very dissatisfied to very satisfied. Furthermore, the data is processed using the Importance Performance Analysis (IPA) method which uses cartesian quadrants with 4 quadrants. Quadrant 1 (High Interest and High Satisfaction) variables are recommended to continue its performance. Quadrant 2 (Low Interest and High Satisfaction), means excessive performance. Quadrant 3 (Low Interest and Low Satisfaction), means low priority. Quadrant 4 (High Interest and Low Satisfaction) means that it needs more concentration [22]



Picture 4 The IPA Method Quadrant

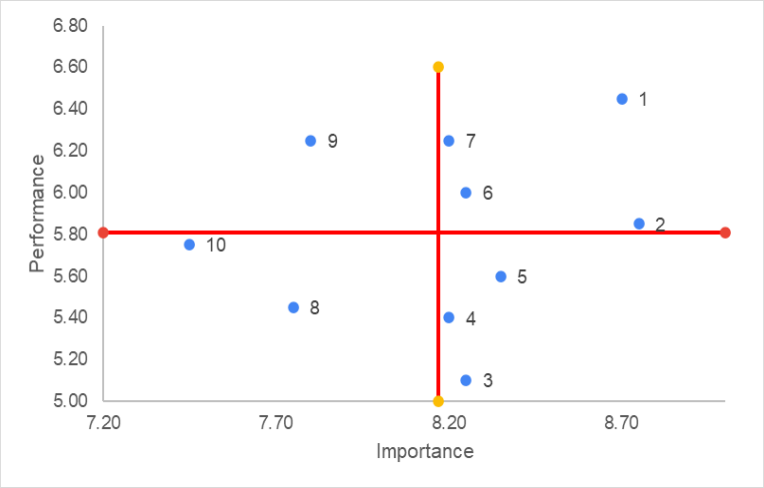
4. Result and Discussion

Indikator	Importance	Performance	Gap
Road lighting on driver safety	8.70	6.45	-2.25
Road lighting in driver comfort	8.75	5.85	-2.90
Road lighting in avoiding the risk of road damage	8.25	5.10	-3.15
Road lighting on road crossings	8.20	5.40	-2.80
Road lighting for driver visibility	8.35	5.60	-2.75
Road lighting for pedestrians	8.25	6.00	-2.25
Road lighting at intersections	8.20	6.25	-1.95

Road lighting for vehicles traveling in the opposite direction	7.75	5.45	-2.30
Road lighting for traffic signs	7.80	6.25	-1.55
Road lighting on bridges	7.45	5.75	-1.70

Importance and Satisfaction Questionnaire Data of Traffic Lighting Analysis for Road Users

From the above data taken from the results of the questionnaire, from the data on the importance of street lighting to users on Jalan Siliwangi, Kadipaten-Majalengka, the value of the highest indicator is street lighting on rider comfort with a score of 8.75 and the lowest value data is street lighting on bridges with a score of 7.45. Meanwhile, the satisfaction of road lighting for users on Jalan Siliwangi, Kadipaten-Majalengka, the data value of the highest indicator is road lighting on driver safety with a score of 6.45, and the lowest value data is road lighting in avoiding the risk of road damage with a score of 5.10. From the results of the data above the level of importance has an average value of 8.17, the average value of satisfaction is 5.81 and the average value of the gap is -2.36.



Picture 3 IPA Method Diagram

The table above shows the value of the level of satisfaction and importance in each quadrant. quadrant I is a quadrant that has a high level of satisfaction and importance so it needs to be maintained. There are 4, namely 1,2,6,7. Quadrant II is a quadrant that has a high level of satisfaction and low importance so this is excessive, there is 1 indicator included, namely 9. Quadrant III is a quadrant that has the same low level of satisfaction and priority importance. There are 2 indicators included in quadrant III, namely 8 and 10. Quadrant IV is a quadrant that has a very high level of satisfaction and top priority importance. There are 3 indicators included in quadrant IV, namely 3, 4, and 5.

5. Conclusion

From the data on the results of road lighting research on road users, it is obtained that the average value of importance has a score of 8.17. Meanwhile, the average value of satisfaction with a score of 5.81, which means that the value of importance is higher than the value of satisfaction so it has an average gap value of -2.36, the sign of negative indicates that road user satisfaction with lighting cannot be fulfilled, so respondents expect improvements to road lighting on Jalan Siliwangi, Kadipaten-Majalengka. Among them are road lighting to avoid the risk of road damage, road lighting on road crossings, and road lighting to the driver's view. In addition, with the parameter of high importance value, namely lighting on the comfort of motorists, and the highest satisfaction value, namely road lighting on the safety of motorists.

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