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WildAlert: A Sustainable Solar-Powered Infrared Sensor-System for Animal Roadkill Hotspots

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ABSTRACT

Animal-vehicle collisions are a significant nationwide concern in Malaysia, particularly during low-light hours when visibility is severely limited. Recent statistics reveal that between 2016 and 2021, Malaysia recorded approximately 2562 wildlife roadkill incidents, with a high frequency of Malayan tapir deaths occurring at night. These incidents often lead to severe human casualties and property damage. WildAlert aims to reduce these collisions and protect biodiversity in line with SDG 15: Life on Land by providing a sustainable, solar-powered warning system. The project utilizes a Passive Infrared (PIR) sensor for motion detection and a Light Dependent Resistor (LDR) to ensure the system only activates in low-light conditions. The system triggers visual (LED) and audio (buzzer) alerts, powered by solar panels with battery storage for remote operation. Secondary findings indicate that similar detection systems can reduce vehicle speeds by 3.82 km/h to 4.80 km/h, significantly decreasing accident rates. WildAlert holds strong commercial potential through proposed IoT integration for real-time monitoring and collaborations with navigation apps like Waze to provide instant road hazard notifications for stakeholders such as JKR and PERHILITAN.

Keywords: roadkill prevention, PIR sensor, solar-powered system, nighttime detection, IoT integration

1. INTRODUCTION

The rising numbers of roadkill in Malaysia is a nationwide concern, as it not only affects animals; it also has caused casualties among the citizens. Malaysia's Department of Wildlife and National Parks (PERHILITAN) reported that 115 Malayan tapirs were killed in Peninsular Malaysia from 2006 to 2019 and 2,444 wild animals died due to roadkill between 2012 and 2017. In fact, most of the Malayan tapir roadkill occurred at night. (Magintan et al. 2021 & Shabuddin et al., 2025). Another study also mentioned that a total of 36 road users were killed in collisions with water buffaloes; 12 were seriously injured; and 22 were slightly injured. Additionally, collisions between wild boars and motorists have caused 34 deaths (Jantan et al., 2020).

In alignment with UN SDG 15, WildAlert is designed to mitigate these human-wildlife collisions during low-light periods. WildAlert offers a solar-powered, motion-activated

solution for remote roadkill hotspots. The system uses solar panels to charge a battery for nighttime use, ensuring it remains operational without external power infrastructure. By integrating an LDR to gate the PIR sensor's activation, the device maintains extreme energy efficiency. Research on Roadside Animal Detecting Systems (RADS) suggests that these automated warnings effectively encourage earlier braking and lower speeds, providing a scalable and cost-effective method to protect Malaysia's local ecosystems.

2. METHODOLOGY

2.1 Research Question and Framework

The primary research question of this study investigates how a low-cost, solar-powered autonomous sensor system can effectively reduce nighttime wildlife-vehicle collisions while maintaining energy efficiency in remote hotspots. This research follows a framework that integrates technical hardware development with a comparative analysis of secondary behavioral datasets. The framework is designed to bridge the gap between affordable technology and practical road safety applications.

The study is structured into two phases: the development of a functional electronic prototype and the evaluation of its potential impact using established research on Roadside Animal Detecting Systems (RADS). This approach allows for validation of the system's logic and its projected effectiveness in real-world scenarios without requiring immediate, large-scale field trials.

2.2 Technical Design and Methods Applied

The WildAlert system uses a multi-sensor circuit designed to prioritize energy conservation. A Passive Infrared (PIR) sensor serves as the primary detection unit, identifying animal movement via infrared radiation, while a Light Dependent Resistor (LDR) ensures the system only operates in low-light conditions.

The circuit logic uses a potential divider configuration made of resistors to manage power based on ambient light. During the day, the LDR maintains low resistance to keep the circuit in a dormant state. In darkness, the increased resistance allows the PIR sensor to trigger a visual alert via a high-intensity LED and an audio alert through a buzzer. To remain sustainable in remote hotspots, a solar panel charges a battery during the day to provide independent power throughout the night.

2.3 Relevance and Suitability of Chosen Methods

The research question is highly relevant to both theory and practice as it addresses the limitations of current road safety infrastructure. Theoretically, it explores the application of low-power sensor logic in environmental conservation. Practically, it offers a scalable solution for authorities like the Public Works Department (JKR) and PERHILITAN to reduce both wildlife loss and human casualties.

The chosen methods are uniquely suited for the problem for several reasons. First, the use

of solar energy eliminates the high costs and environmental impact associated with constructing perpetual street lighting in remote areas. Second, the LDR-gated logic ensures that the system does not waste power or distract drivers during daylight hours when visibility is already sufficient. Finally, the inclusion of a buzzer provides a necessary redundant alert mechanism, ensuring the system remains effective even if visual components fail. This combination of renewable power and smart sensing provides a durable tool for long-term roadkill prevention.

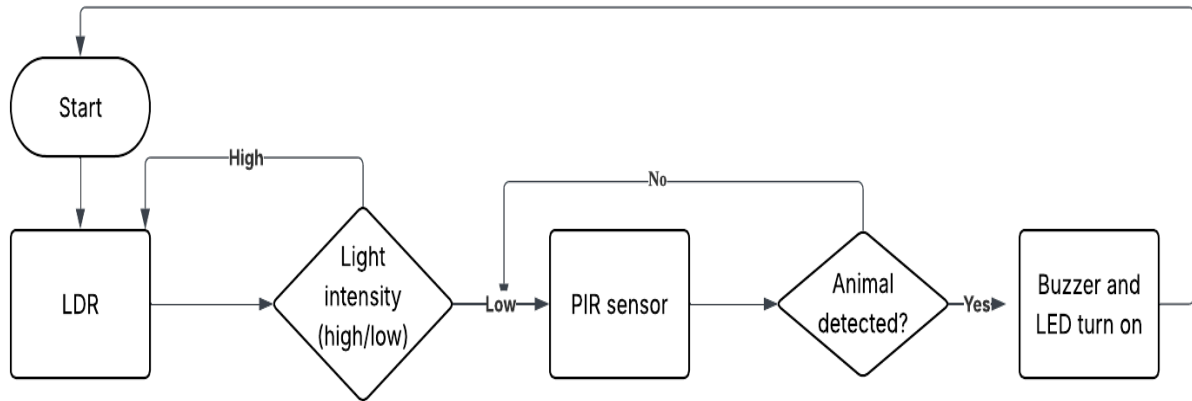


Figure 1. Logic Flowchart

3. RESULTS AND DISCUSSION

3.1 Analysis of Secondary Data

The effectiveness of WildAlert is supported by secondary research on Roadside Animal Detection Systems (RADS). Data indicates that these systems successfully change driver behavior by providing real-time warnings. The table below summarizes speed changes observed when detection systems are active, particularly during peak tourist seasons when traffic volume is higher.

Table 1. Average Vehicle Speeds with and without RADS Activation (Grace et al., 2017)

Condition	RADS Off (km/h)	RADS On (km/h)
Twilight	96.4	91.6
Night	89.7	87.2

These findings show that even small reductions in speed, such as 2.5 km/h to 4.8 km/h, are significant. Research suggests that a 1.6 km/h decrease in speed corresponds to a 5% decrease in the crash rate (Taylor et al., 2000). This proves that the visual and audio alerts used in WildAlert can effectively lower the probability of collisions by giving drivers more time to react.

4. CONCLUSION

The WildAlert system provides a practical and low-cost solution to the national problem of wildlife roadkill in Malaysia. Through the integration of PIR and LDR sensors, the system successfully detects movement and provides targeted alerts during high-risk nighttime hours. Our analysis of secondary data confirms that these types of automated warnings lead to significant speed reductions and lower crash probabilities. For future recommendations, we suggest the implementation of IoT modules to allow for centralized monitoring and real-time data sharing with national transport authorities. Collaboration with navigation apps like Waze is also recommended to extend the reach of the alerts directly to drivers beyond the physical device. The commercial potential for WildAlert is high, as it offers a sustainable alternative to expensive road infrastructure. By targeting stakeholders such as JKR, PERHILITAN, and highway concessionaires, WildAlert can be deployed across various ecological hotspots to protect Malaysia's biodiversity while keeping road users safe. Beyond that, WildAlert can also be exported to countries with high roadkill rates.

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