Advances in Consumer Research
https://acr-journal.com/
Volume-2 | Issue-6 | Dec: 2025

Original Researcher Article

Stored Grain Protection & Spoilage Alert System

Mrs. R. Lakshmi [1], K. Kavimadhu [2], K. Kesiha [3], S. Mariyamma[4], K. Kaviyaa [5], Mahathi Meignana Moorthy [6]
[1]Assistant Professor , Department of Electronics and Communication Engineering, Karur - 639111 K. Kavimadhu
[2]Department of Electronics and communication Engineering, V.S.B Engineering College, Karur & 639111
Email ID : kavimadhu2895@gmail.com
[3]Department of Electronics and communication Engineering, V.S.B Engineering College, Karur & 639111
Email ID : kesihakaruppusamy@gmail.com
[4]Department of Electronics and communication Engineering, V.S.B Engineering College, Karur & 639111
Email ID : smariyamma867@gmail.com
[5]Department of Electronics and communication Engineering, V.S.B Engineering College, Karur & 639111
Email ID : kkaviyaa41@gmail.com
[6]Department of Electronics and Communication Engineering V.S.B Engineering College Karur & 639111
Email ID : mahathimeignanamoorthy@gmail.com

ABSTRACT
Grain preservation is essential for global food security, yet post-harvest losses remain high due to poor storage conditions such as excessive temperature, humidity, and gas accumulation. This paper presents a Hybrid Grain Monitoring and Alert System that provides a low-cost, energy-efficient, and sustainable solution for real-time environmental monitoring in grain storage. The system, built around an ESP32 microcontroller and DHT22 sensor, continuously tracks temperature and humidity, comparing them with predefined safety thresholds. When abnormal conditions are detected, it triggers both a local buzzer alert for offline notification and a real-time mobile alert via the Blynk IoT platform. Powered partially by solar energy, the system ensures continuous, eco-friendly operation. Experimental results confirm its effectiveness in reducing spoilage risks and improving reliability compared to traditional manual or high-cost automated systems

Keywords: Grain Monitoring Systems, Internet of Things, ESP32, DHT22 Sensor, Solar Power, Hybrid Monitoring, Blynk App.
.

1. INTRODUCTION:

The global demand for food security places immense pressure on minimizing post-harvest losses, particularly concerning staple commodities like stored grains. The financial stability of farming communities and the stability of national food reserves depend heavily on maintaining optimal conditions within storage facilities. The primary threat to stored grain

To overcome these significant limitations, this paper introduces a Stored Grain Protection and Spoilage Alert System based on a simple, low-cost, and robust Internet of Things (IoT) architecture. The proposed system is centered around the ESP32 microcontroller, chosen for its excellent balance of processing capability, integrated Wi-Fi functionality, and low power demand. Environmental sensing is performed by the DHT22 sensor, which provides accurate and stable digital measurements of both temperature and relative humidity with minimal interfacing complexity. The core novelty of the system lies in its hybrid alert strategy: utilizing a local buzzer/LED for immediate auditory/visual feedback at the site and leveraging the Blynk platform to send instant, remote mobile notifications to the owner.

This work provides several distinct contributions to the field of agricultural IoT systems. First, we establish a truly cost-effective and simple hardware solution that drastically lowers the economic barrier to entry for automated grain storage monitoring. Second, we implement a hybrid alert mechanism that ensures reliability whether or not cloud connectivity is maintained. Third, by incorporating a solar panel power supply, the system achieves unparalleled energy efficiency and operational reliability, minimizing the need for external grid power and making it an environmentally sustainable choice. Finally, the system design emphasizes scalability and ease of use, ensuring automatic operation and requiring minimal training for end-users. This research provides a valuable framework for deploying smart, sustainable, and reliable solutions in agricultural inventory management.

The remainder of this paper is organized as follows. Section II details the related work, examining previous smart storage solutions and their constraints. In Section III, we describe the complete system architecture, including the hardware configuration and software implementation using the ESP32 and Blynk platform. Section IV presents the detailed working principle and the technical approach to data collection and processing. Results, performance metrics, and a discussion of the system's viability are provided in Section V. Finally, Section VI concludes the paper and outlines areas for future work.

II. RELATED WORK

The development of intelligent systems for post-harvest grain monitoring has been an active area

alert mechanism. This creates two distinct vulnerabilities: a reliance on uninterrupted grid power and a failure to provide local, offline alerts if the internet connection is temporarily lost. The complexity of handling large data streams and the need for dedicated server infrastructure in some solutions further increase operational complexity.

C. The Current Gap in Monitoring Solutions

Existing methodologies, while demonstrating the technical feasibility of automated grain monitoring, consistently fall short in three critical areas that are essential for widespread adoption by diverse agricultural stakeholders:

Cost and Simplicity: Many prior systems required advanced components and complex circuitry, leading to high deployment costs and increased risk of component damage, whereas a low-cost, simple, and easily replicable solution is preferred.

Energy Sustainability: The power-consuming nature of previous prevention methods presents a significant barrier, highlighting the need for energy-efficient or self-sustaining systems suitable for remote or off-grid locations.

Alert Robustness: Most real-time alert systems rely solely on cloud connectivity. A robust solution must offer a hybrid alert mechanism—providing an immediate, local (offline) auditory alert (via a buzzer) alongside the remote IoT notification (via the Blynk app).

The proposed Stored Grain Protection and Spoilage Alert System directly addresses this gap. By utilizing the low-power ESP32 and simple DHT22 sensor, and integrating a solar-powered element with a dual-redundant alert mechanism, our solution offers a technically, economically, and socially sustainable platform for grain preservation.

III. PROPOSED METHODOLOGY

The proposed system adopts a Hybrid Monitoring Architecture explicitly engineered for simplicity, affordability, and energy efficiency, making it highly suitable for agricultural grain storage environments. This architecture integrates a local alert mechanism with a cloud-based IoT monitoring layer, ensuring continuous protection of stored grains even under unstable network conditions. The system operates based on four functional modules Sensing, Processing, Alerting, and Sustainable Power.

farmers or warehouse managers. For power efficiency and sustainability, the system incorporates solar-based power management, allowing continuous operation with minimal environmental impact.

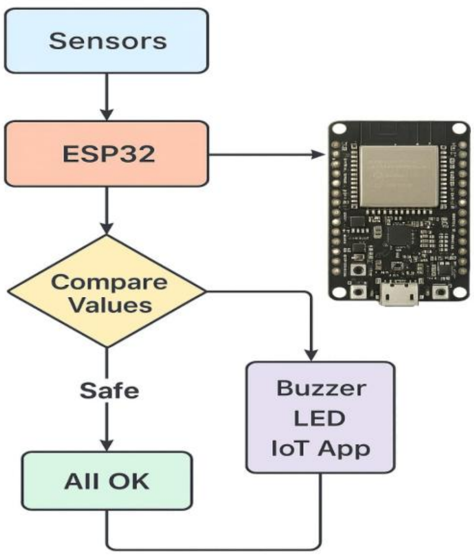

Figure : Block Diagram

D. System Summary

The integration of IoT connectivity, local fallback mechanisms, and energy-efficient hardware results in a robust, cost-effective, and scalable monitoring system for grain storage. This hybrid model minimizes post-harvest losses, promotes eco-friendly operation, and ensures real-time supervision of critical storage conditions such as temperature and humidity.

IV. RESULT AND DISCUSSION

This section evaluates the performance and practical implications of the proposed Hybrid Grain Monitoring and Alert System, demonstrating its technical validity, superior economic feasibility, and significant advantages in terms of reliability and sustainability over conventional monitoring systems.

A. Performance Validation and Alert Reliability

The experimental validation confirms that the system achieves its primary objective of real-time grain monitoring with high fidelity. The DHT22 sensor provided stable and accurate digital readings, which the ESP32 microcontroller processed instantaneously against the predefined critical thresholds for temperature and humidity. The core performance

energy-efficient solution for post-harvest grain preservation. The core objective of mitigating significant losses caused by adverse environmental conditions (high temperature and humidity) was achieved through the intelligent integration of the ESP32 microcontroller and the DHT22 sensor. The system's key architectural strength lies in its dual-channel alert mechanism, which ensures redundant notification: an instantaneous, offline alert via a local buzzer/LED, coupled with a real-time remote alert through the Blynk mobile application. This approach guarantees continuous protection, irrespective of network availability. Furthermore, the system's reliance on a partially solar-powered supply establishes a new benchmark for sustainability and operational efficiency, making it an ideal and accessible technology for remote or resource-constrained agricultural settings. The design is simple, utilizes low-cost components, and provides a scalable, automatic, and socially beneficial alternative to expensive, power-intensive conventional systems. For future enhancements, the system can be expanded to incorporate additional gas sensors to detect early stages of pest infestation or anaerobic respiration more accurately. Integrating a predictive analytics module, possibly utilizing machine learning on the historical sensor data, could allow the system to forecast potential spoilage events before they occur. Finally, exploring the integration of low-power wide-area network (LPWAN) technologies like LoRaWAN could extend the monitoring range, making the solution viable for large-scale, geographically dispersed warehouse complexes without relying heavily on local Wi-Fi infrastructure.

REFERENCES

1. Ajisegiri, E. A. (2025). "Development of a Smart Grain Storage Silo Using the Internet of Things (IoT) Technology."
2. Wanyonyi, E. N. (2025). "A Smart IoT-Based Real-Time System for Monitoring Storage Conditions of Maize Grains."
3. Lydia, J. (2022). "Automated food grain monitoring system for warehouse storage. "Order, Author(s) & Year, Title, Focus & Relevance to Your Project
4. Ajisegiri, E. A. (2025). "Development of a Smart Grain Storage Silo Using the Internet of Things (IoT) Technology."
5. Wanyonyi, E. N. (2025). "A Smart IoT-Based Real-Time System for Monitoring Storage Conditions of Maize Grains."
6. Lydia, J. (2022). "Automated food grain monitoring system for warehouse storage. "Order, Author(s) & Year, Title, Focus & Relevance to Your Project