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Rice Initiative: Rapid Income For Crop Entrepreneurs

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Abstract : Paddy farming remains a cornerstone of rural agriculture, yet farmers often face delayed payments and opaque pricing when selling their produce through traditional channels. The Rice Initiative addresses these critical challenges by introducing an automated, real-time paddy procurement system that ensures immediate cash disbursement based on current market rates. The proposed solution utilizes a load cell integrated with an HX711 ADC module and an ATmega328P microcontroller to accurately weigh the paddy and compute its value. A servo motor controlled cash dispenser delivers instant payment to the farmer, thereby eliminating middlemen, reducing transactional delays, and improving financial transparency. This paper details the system's architecture, methodology, and potential socioeconomic impact, demonstrating a scalable and cost-effective approach to support farmer livelihoods and promote inclusive agricultural commerce.

IndexTerms - Paddy procurement, Agricultural automation, Instant payment system, Load cell, Rural fintech, Smart farming.

I. INTRODUCTION

Paddy farming remains a vital component of the agricultural economy in many developing regions. Despite its importance, farmers engaged in this sector frequently face significant financial challenges, particularly due to delayed payments, price opacity, and reliance on intermediaries. Traditional paddy procurement methods often involve prolonged waiting periods for payment, inconsistent pricing based on subjective evaluations, and vulnerability to exploitation by middlemen. These issues not only hinder the immediate financial liquidity of farmers but also limit their capacity to invest in subsequent crop cycles.

A. BACKGROUND

Several initiatives have been implemented globally and nationally to improve transparency, efficiency, and financial inclusion in agricultural markets. These efforts align closely with the objectives of the Rice Initiative proposed in this paper. A. Unified Market Platform (UMP) – Karnataka, India. The Unified Market Platform (UMP) is an electronic trading solution developed by Rashtriya e-Market Services (ReMS) to modernize agricultural trade across Karnataka. UMP facilitates price discovery, online bidding, and near-instant payments to farmers by integrating digital weighing systems and electronic auction modules. Farmers receive real-time pricing updates and are paid shortly after their produce is electronically weighed and traded. UMP has significantly minimized dependency on middlemen and enhanced farmer earnings through competitive bidding and reduced delays [7].

B. NATIONAL AGRICULTURE MARKET (ENAM) – India eNAM is a pan-India electronic trading platform that connects Agricultural Produce Market Committees (APMCs) to a centralized network. It enables online buying and selling of produce, standardizes grading and quality checks, and streamlines payments via electronic channels. eNAM empowers farmers by ensuring better price realization and improved access to markets, though it often still relies on market-level intermediaries and thirdparty logistics[4].

C. DIGITAL AGRICULTURE TECHNOLOGIES: The rise of mobile technology and IoT has contributed to the advancement of digital agriculture, including mobile apps that provide live price data, demand forecasting, and online marketplaces. Digital payment systems integrated into these platforms offer secure and near instant payouts to farmers. These innovations have enhanced transparency, reduced transaction costs, and promoted financial inclusion—particularly in remote rural areas [1].

II. LITERATURE REVIEW

Literature Survey Agricultural automation and digital payment systems have been the focus of various research and development initiatives aimed at improving farmer welfare, market efficiency, and transparency in crop procurement. This section reviews existing work in the domains of reverse vending systems, digital weighing mechanisms, and agri-fintech platforms, which form the technical and conceptual foundation for the proposed solution.

A. Reverse Vending and Automated Collection Systems

Reverse vending machines (RVMs) have been widely studied for their ability to automate item collection and compensation. In [3], Gaur et al. developed an RVM using capacitive proximity sensors and strain gauges to accept plastic waste and reward users accordingly. Similarly, Patil et al.[6] designed a plastic bottle vending machine using infrared sensors and force sensors to identify

and weigh input materials, triggering a servo motor-based reward system. These projects demonstrate the feasibility of integrating sensors and microcontrollers to build automated, user-centric platforms.

B. Load Cell-Based Weighing Systems

The use of strain gauge-based load cells in conjunction with analog-to-digital converters like HX711 has been explored in various microcontroller projects. Anju Latha et al.[5] proposed a cost-effective Arduino-based weighing scale that accurately converts strain into digital weight data using the HX711 module. These approaches validate the reliability and affordability of such components for rural and small-scale applications.

C. Digital Agriculture and Real-Time Market Access

Digital agriculture frameworks have integrated mobile apps and IoT to give farmers access to real-time market data, enabling better decision-making. However, these systems typically do not combine automatic weighing and real-time cash dispensing. This creates an opportunity for integrated systems that offer both physical validation (e.g., quantity assessment) and financial disbursement in one seamless platform.

III. METHODOLOGY

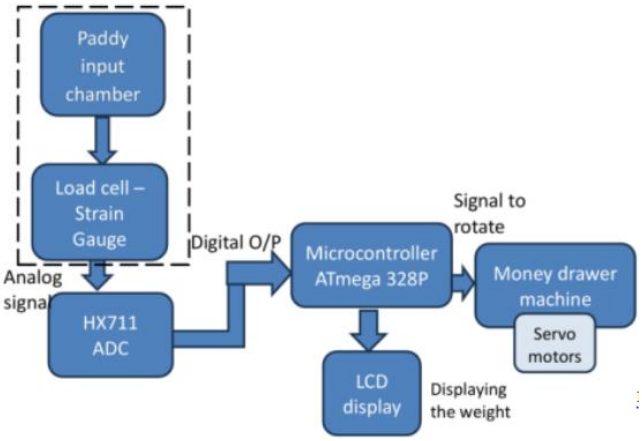


Fig.1. Methodology

The proposed system is designed to enable automated paddy weighing and real-time monetary disbursement, leveraging an embedded hardware setup. The architecture begins with the Paddy Input Chamber, which serves as the primary interface for the farmer to deposit harvested paddy. This chamber is mechanically mounted on a strain gauge-based Load Cell (5 kg rated), which converts the mechanical deformation caused by the paddy's weight into a low-voltage analog signal proportional to the applied force.

This analog signal is transmitted to the HX711 Analog to-Digital Converter (ADC), a 24-bit precision ADC specifically designed for weigh scale applications. The HX711 performs signal amplification and digitization, converting the low-voltage analog input from the load cell into a stable digital output that can be interpreted by the microcontroller.

The digital output from the HX711 is fed into the ATmega328P microcontroller, which serves as the central control unit for the system. The microcontroller executes calibration routines to convert the raw digital values into accurate weight measurements using a pre-defined scale factor. Once the weight is calculated, it is multiplied by a pre-configured unit price per kilogram to compute the total monetary value of the paddy deposited.

The calculated weight and payment amount are communicated to the user via a 16x2 LCD Display, ensuring transparency in the transaction. Upon confirmation, the ATmega328P generates a control signal to drive a servo motor connected to a cash dispensing module or money drawer. The servo motor precisely actuates the dispensing mechanism to release the appropriate amount of currency, proportional to the computed payment value.

IV. MATHEMATICAL MODELING AND EQUATIONS

The proposed system performs real-time measurement and monetization of paddy weight using a sensor-based architecture. The mathematical foundation for each stage of the system is presented below

A. Load Cell Output

The load cell produces an analog voltage output V_{out} proportional to the applied weight

$$W : V_{out} = S \cdot W \quad (1)$$

where S is the load cell sensitivity in mV/V and W is the weight in kilograms.

B. Analog-to-Digital Conversion (HX711)

The HX711 module converts the analog signal into a 24-bit digital value D, using the reference voltage Vref :

$$D = (Vout/ Vref) \cdot 2n \quad (2)$$

where n = 24 is the resolution of the ADC.



Fig.2. Algorithm Process

C. Weight Calibration

The raw digital reading is converted into real-world weight using a calibration equation:

$W = \alpha \cdot D + \beta$ (3)

where α is the scale factor, and β is the offset or zero-load correction.

D. Payment Calculation

The total payment P to be dispensed is computed by multiplying the measured weight with the unit price R:

$P = W \cdot R$ where R is the price per kilogram of paddy in INR (). (4)

E. Servo Motor Control

The cash dispensing operation is proportional to the computed payment. It can be defined either in terms of servo angle θ or operation time $T_{dispense}$:

$\theta = k \cdot P$ (5)

$T_{dispense} = \gamma \cdot P$ (6)

where k and γ are system constants that define motor response behavior.

F. Summary

These equations enable the system to convert mechanical weight into digital signals and eventually into automated cash disbursements, ensuring fairness, accuracy, and real-time compensation for farmers.

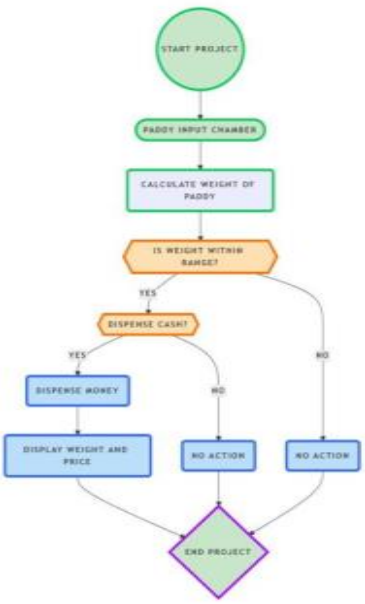


Fig. 3. System operation flowchart for automated paddy procurement and payment dispensing

V. FLOWCHART DESCRIPTION

The flowchart illustrated in Fig. 3 represents the operational logic of the proposed embedded system for paddy procurement and automated cash dispensing. The system workflow can be described as follows:

1) Start Project: Initialization of all system components such as the microcontroller (ATmega328P), load cell, HX711 analog-to-digital converter (ADC), LCD display, and the servo motor for the cash drawer.

2) Paddy Input Chamber: The user places paddy into the input chamber connected to a strain gauge-based load cell that measures the mass of the input produce.

3) Calculate Weight of Paddy: The analog weight signal is acquired by the load cell and digitized using the HX711 ADC module. This digital data is processed by the microcontroller to compute the exact weight.

4) Is Weight Within Range? A conditional check evaluates whether the weight of the input paddy falls within a pre-configured acceptable range. This ensures validation of legitimate entries and prevents under/overweight anomalies.

- If No: The system executes no further operation and awaits the next valid input.
- If Yes: The process proceeds to the next stage for cash dispensing.

5) Dispense Cash? An optional verification may be applied based on user eligibility or transaction history

If Yes: A signal is sent to the servo motor controlling the money drawer, which releases the appropriate amount of cash.

If No: No action is performed.

6) Display Weight and Price: The computed weight and the corresponding price (calculated using preset rates) are shown on an LCD display for user acknowledgment.

7) End Project: The system resets to its initial state and is ready to handle the next input.

This flowchart-based logic ensures real-time, automated, and secure handling of agricultural produce with direct monetary return, eliminating manual intervention and reducing latency in payments.

VI. EXPERIMENTAL VALIDATION AND ERROR ANALYSIS

To evaluate the accuracy of the proposed system, a set of known weights was measured, and the results were compared to the actual values. The percentage error was computed using:

$$\text{Percentage Error} = ((|\text{Actual Weight} - \text{Measured Weight})/(\text{Actual Weight}))\times 100 \quad (7)$$

TABLE 1
Weight measurement accuracy

Actual Weight	Measured Weight	% Error
1 kg	946 g	6.0%
2 kg	1800 g	8.3%
240 g	220 g	6.7%
1240 g	1160 g	6.3%

The results indicate that the system exhibits a measurement error within the range of 6% to 8.3%. The highest deviation was observed for a 2 kg sample, likely due to limitations in sensor linearity and calibration at higher loads. Despite this, the system achieves a satisfactory level of accuracy suitable for real-time agricultural procurement systems. Further refinement using advanced filtering or digital compensation can improve this performance. Table 1 Validates results for 4 weight samples: Actual vs. measured weights (e.g., 2 kg → 1.8 kg) and percentage errors (6.0–8.3%). Demonstrates system accuracy within acceptable margins for procurement use, with higher deviations under heavy loads

VII. COMPARISON WITH EXISTING WORK

Several existing systems have explored automation in agricultural procurement and supply chain management. Table II presents a comparative analysis of related works with respect to the proposed solution.

TABLE 2
Comparison of existing systems with the proposed work

Study / Work	Focus Area	Technology Used	Key Features	Limitations Addressed in Our Work
Soni et al. (2012) [10]	Digital paddy procurement and payment monitoring	Web-based interface	Centralized transaction record-keeping; improved transparency in Chhattisgarh	No real-time cash handling or embedded automation at procurement site
CSM Technologies (2022) [2]	Automated paddy procurement (Odisha)	Web portal, mobile app	Backend processing, farmer registration, tracking	Relies on centralized infrastructure; not offline-capable or instantcash enabled
Shahinuzzaman et al. (2023) [8]	Sustainable procurement model in Bangladesh	Survey data, analytics	Emphasis on policy modeling and awareness	Lacks hardware system or embedded real-time solutions
Sharma et al. (2024) [9]	Blockchain-based agriculture supply chain	IoT, Blockchain	High security, traceability	High-cost, not designed for direct farmer payments
Velmurugan et al. (2023) [11]	Real-time grain storage monitoring	IoT, wireless communication	Quality control during storage	Not related to procurement or real time payout

Proposed Work (Rice Initiative)	Real-time procurement and instant cash payment	Load cell, HX711, ATmega328P, servo motor	End-to-end automation at procurement site; cost-effective and field deployable	Eliminates intermediaries, ensures real-time cash-out, works offline

Table 2 provides Prior works lack real-time cash dispensing (e.g., eNAM, blockchain systems) or field automation. Emphasizes this prototype's cost-effective hardware, offline operation, and instant farmer payout. Fig. 4 is the actual prototype snaps.

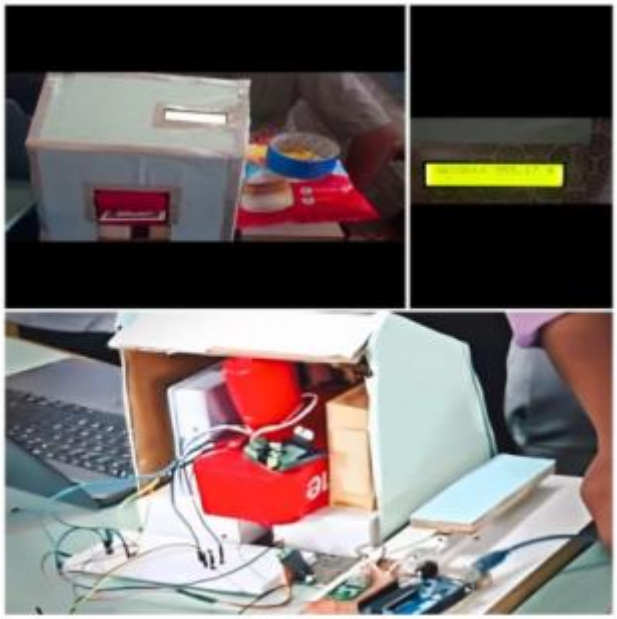


Fig. 4. Prototype Snaps

Fig. 5 compares measurement errors across test weights (0.24–2 kg). Shows consistent 6–8.3% deviation, with highest error at 2 kg. Confirms system accuracy limitations at higher loads and guides calibration improvements.

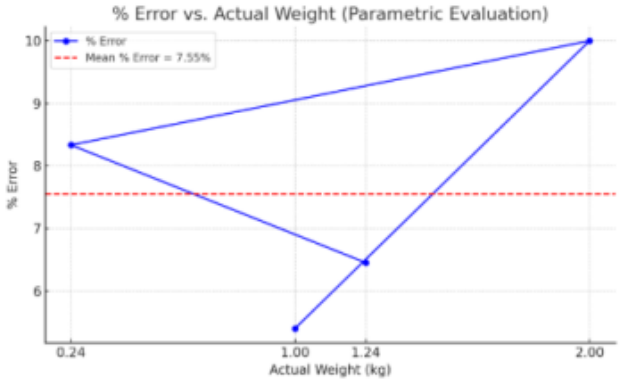


Fig. 5. Graph of Error vs Actual Weights

VIII. Conclusion

The Rice Initiative pioneers a scalable, low-cost solution to transform agricultural commerce. By integrating precision weighing, automated payment computation, and cash dispensing, it addresses systemic flaws in traditional procurement—price opacity, delayed payments, and intermediary exploitation. While sensor calibration requires refinement to reduce measurement errors below 5%, the system's socioeconomic impact is profound: it empowers farmers through financial transparency, immediate income access, and reduced market dependency. Future iterations will explore IoT connectivity for dynamic pricing and expanded crop support. This work underscores the viability of embedded technology in driving equitable agricultural innovation across rural economies.

IX. Acknowledgements

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