Research Trends International Journal of Technology and Innovation
An International Peer-Reviewed, Refereed & Open-Access Journal
ISSN : 3144-3273
Available Online at : https://rtijti.com/
doi : https://doi.org/10.5281/zenodo.23561464

Survey on IoT-Based Smart Ration Dispensing System Using RFID Authentication and STM32-Controlled Weight-Verified Dispensing

Prof. R. A. Sawant[1], H. H. Shinde[2], R. V. Talekar[3], A. A. Shinde[4]
[1, 2, 3, 4] Department of Electronics and Telecommunication Engineering, S. B. Patil College of Engineering, Indapur, Maharashtra, India
sawantrupali203@gmail.com, harshadashinde778@gmail.com, rutuvt09@gmail.com, abhijitashinde5006@gmail.com

ARTICLE INFO

Article History:
Received : 13-10-2026
Accepted : 14-10-2026
Published : 21-10-2026

Publication Issue
Volume 1, Issue 4
October – December 2026

Page Number
01-06

ABSTRACT

The Public Distribution System (PDS) supplies subsidised food grains to millions of households through Fair Price Shops, but its last-mile operation still depends heavily on manual registers, manual weighing, and human judgement. These weaknesses allow duplicate collection, under-dispensing, diversion of stock, and records that are difficult to audit. The Internet of Things (IoT) offers a practical way to address these problems by combining low-cost microcontrollers, identification devices, weight sensors, and cloud databases.

This survey paper reviews ten research studies on smart ration distribution, with a particular focus on RFID-based beneficiary authentication, GSM and OTP-based verification, biometric (Aadhaar-based) authentication, motor-driven and load-cell-based automatic dispensing, cloud-based monitoring, machine learning-assisted verification, and blockchain-based record keeping for the PDS supply chain. The reviewed studies show that automation can reduce manual errors and leakage, but they also show that strict authentication can exclude genuine beneficiaries when it is poorly implemented.

The survey derives the hardware, software, and mathematical requirements of an STM32-based ration dispensing system, identifies the major open issues such as authentication reliability, network dependence, weighing accuracy, data security, cost, and scalability, and outlines applications and future research directions for an integrated, weight-verified, and transparent ration dispensing system.

Index Terms - Internet of Things, Public Distribution System, RFID, STM32, Load Cell, HX711, Smart Ration Dispensing, Blockchain, Biometric Authentication

I. INTRODUCTION

India's Public Distribution System (PDS) is one of the largest food welfare networks in the world. It supplies subsidised wheat, rice, and other commodities to eligible households through a large network of Fair Price Shops. The efficient working of this network directly affects the food security of economically weaker families, and even small losses at each shop add up to a large loss at the national level [4], [5].

In many shops, ration distribution still relies on physical ration cards, paper registers, and manual weighing scales. This manual approach is slow and prone to error. It also creates opportunities for fictitious entries, diversion of stock, and issue of less than the entitled quantity, while beneficiaries have no reliable way to check what has been recorded against their card. Higher authorities also find it difficult to audit stock movement in real time [1], [6].

Recent research has tried to automate this process using IoT. Low-cost microcontrollers, RFID readers,

Copyright © 2026 The Author(s) : This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/)

fingerprint sensors, GSM modules, load cells with HX711 amplifiers, and cloud databases can be combined to authenticate a beneficiary, check monthly eligibility, dispense the correct quantity, and log every transaction centrally [6]-[9]. Other studies have focused on the back end of the supply chain and have proposed blockchain-based ledgers to make PDS records tamper-resistant [3]-[5].

1.1 Background and Motivation

Existing smart ration systems can be grouped into three broad categories, namely authentication of beneficiaries, automated dispensing and monitoring, and data integrity and transparency, as shown in Figure 1. However, most studies address only one part of the problem, such as authentication, dispensing, or record keeping, rather than providing an end-to-end solution.

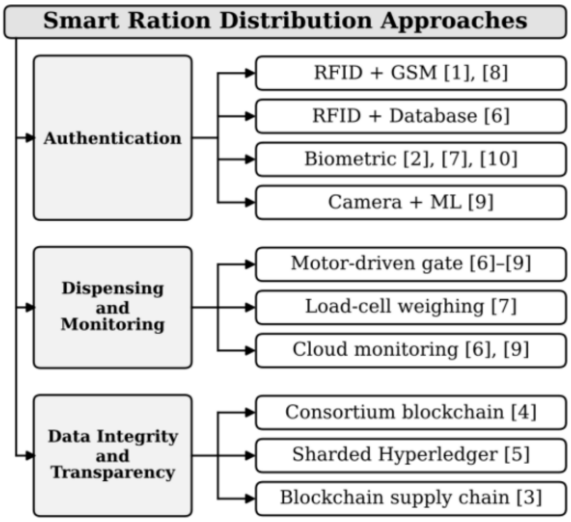


Figure 1. Classification of the reviewed smart ration distribution approaches.

Field studies of biometric authentication have also shown that technology which reduces fraud can unintentionally deny rations to genuine beneficiaries [2], [10]. The motivation for this survey is therefore to understand how authentication, accurate weighing, duplicate-collection control, and transparent record keeping can be brought together in a single low-cost device that is fair to beneficiaries and easy for authorities to audit.

1.2 Review of Existing Studies

A. Smart Ration Card Using RFID and GSM: Agarwal et al. proposed a smart ration card system in which RFID tags store family information of the cardholder. When the card is presented to the RFID reader, a microcontroller authenticates the user and calculates the ration quantity based on the size of the household. A GSM module then sends the delivery details automatically to the concerned government authorities, which removes manual data entry and reduces the chance of a dealer misreporting the distributed quantity. However, weight-verified dispensing and a central queryable database are not part of the design [1].

B. Aadhaar-Based Biometric Authentication for PDS: Menon studied the implementation of mandatory Aadhaar-based biometric authentication for PDS in Ranchi district of Jharkhand. The exploratory field study found that only about 52 percent of ration-card-holding households in the district were able to buy their ration in August 2016. The main reasons identified were incomplete seeding of Aadhaar data, biometric authentication failures, and weak administrative backup arrangements. The study shows that authentication technology must be designed with inclusion in mind [2].

C. Blockchain in PDS Supply Chain Operations: Pillai et al. carried out a systematic literature review of technologies used in supply chain management, with a particular focus on the use of blockchain in the public distribution system. The authors compared conventional supply chains with blockchain-enabled supply chains and discussed how a shared ledger can support smooth and transparent transactions among participants. However, the work is a conceptual review and does not address shop-level authentication and dispensing [3].

D. Consortium Blockchain Model for Indian PDS: Singh et al. analysed the operations of the Indian PDS to identify transactions that require information exchange, storage, and verification. They proposed a conceptual model using smart contracts and a consortium-based ecosystem, combining on-chain blockchain data with off-chain big data analytics, and discussed implementation using Hyperledger Fabric. However, the model focuses on the information layer, without covering the physical dispensing process at the Fair Price Shop [4].

E. Scalable Blockchain Solution for TPDS: Raghunandan et al. built a blockchain-based ledger for the Targeted Public Distribution System (TPDS) on Hyperledger Fabric. Scalability was handled by splitting the network into shards, each an independent chain holding its own data, while channels linked these shards into one inter-state workflow. However, the data entering the ledger from the shop is not verified by sensors such as RFID readers or load cells [5].

F. IoT-Enabled Authentic Ration Distribution: Singh and Singh presented an IoT-enabled ration and material distribution system using RFID smart cards

that contain user authentication data. The system uses an RFID reader, a microcontroller, and a DC motor with a motor driver to automate verification and distribution, while a database maintains stock and transaction records. However, closed-loop weight verification using a load cell is not part of the described component set [6].

G. Automated Ration Distribution Using RFID, Biometrics and Load Cells: Ravi et al. designed a two-step verification scheme in which a uniquely numbered RFID card serves as the ration card and the holder's fingerprint must also match the card. Once both checks pass, the allotted commodities are released by motorised mechanisms, the issued portion is weighed using load cells, and a confirmation message is produced. However, dependence on fingerprint matching can cause exclusion when biometric verification fails [7].

H. IoT Ration Dispensing with RFID and OTP: Machikuri et al. proposed an IoT-based government ration dispensing system that uses RFID cards for cardholder authentication. A GSM module sends a one-time password (OTP) to the registered mobile number before dispensing, and an alarm is triggered if an incorrect OTP is entered. However, OTP-based verification depends on mobile phone access and network coverage, and weight confirmation of the dispensed grain is not described [8].

I. Secure Ration Distribution Using Machine Learning: Waje et al. built a ration dispenser around an ESP-CAM, an RFID reader and cards, a microcontroller, a keypad, an LCD, and a DC motor with its driver. Machine learning is applied, together with a password, to verify the consumer, and transaction data is stored in a cloud-linked database so that shortfalls in supply can be detected. However, camera- and ML-based modules increase cost and require reliable connectivity [9].

J. Identity Verification Standards in Welfare Programs: Muralidharan et al. used randomised and natural experiments to evaluate biometric identity verification reforms in India's food security programme. Corruption fell after the reform, but about 1.5 to 2 million legitimate beneficiaries lost access during implementation, mostly because of how the transition was managed. The study shows that verification rules and fallback options matter as much as the technology [10].

A comparison of the reviewed studies is given in Table 1, arranged from the most recent study to the oldest.

Table 1. Comparative analysis of reviewed studies

Ref.	Year	Technique	Key Finding	Limitation
[10]	2025	Randomised experiments	Corruption fell but genuine users lost access	No system design
[9]	2024	ESP-CAM + RFID + ML + Cloud	Cloud logs track shortages	Higher cost; needs network
[8]	2024	RFID + GSM OTP	OTP adds second check	No weight confirmation
[7]	2024	RFID + Fingerprint + Load Cell	Weighed dispensing with message	Biometric failure excludes users
[6]	2023	RFID + MCU + Database	Stock records made public	No load-cell feedback
[5]	2021	Sharded Hyperledger	Scalable inter-state ledger	No sensor-verified data
[4]	2021	Smart contracts + off-chain	Trusted PDS data model	Conceptual only
[3]	2020	Literature review	Blockchain aids transparency	Not implemented
[2]	2017	Field survey	About half got ration	One district only
[1]	2014	RFID + GSM + MCU	Auto reporting to authorities	No weighing

1.3 Organisation of the Paper

Section II presents the general system architecture along with the hardware, mathematical, and software requirements. Section III discusses the open issues and challenges, and Section IV lists the applications. Section V gives the conclusion of the survey, and Section VI outlines future enhancements and research directions.

II. SYSTEM ARCHITECTURE

Based on the reviewed studies, the general architecture of an STM32-based smart ration dispensing system is shown in Figure 2. The beneficiary presents an RFID ration card, an optional OTP or fingerprint check provides a second factor, the STM32 controls a motor-driven gate while a load cell measures the dispensed grain, and every transaction is stored in a cloud database that authorities can view on a web dashboard [1], [6]-[8].

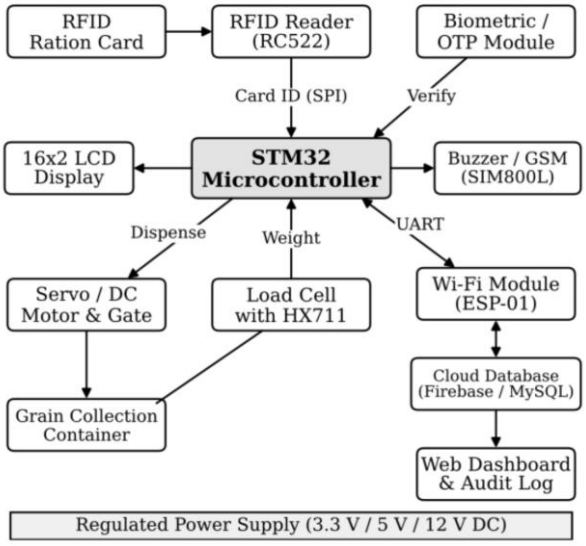


Figure 2. General architecture of an STM32-based smart ration dispensing system.

2.1 Hardware Requirements

The hardware requirements are derived from the components used in the reviewed systems [1], [6]-[9], with the STM32 used as the main controller.

- **STM32 Microcontroller:** A 32-bit ARM Cortex-M controller (for example, STM32F103) with hardware timers for motor control and SPI, I2C, and UART interfaces for the peripherals. It gives fast, real-time response for the weighing loop.
- **RFID Reader (RC522) and Cards:** Reads the unique ID of the ration card over SPI and identifies the beneficiary [1], [6].
- **Load Cell with HX711:** A 24-bit amplifier and ADC that converts the load-cell signal into a weight value used to stop dispensing at the authorised quantity [7].
- **Servo / DC Motor with Driver:** Opens the grain gate or drives a screw conveyor to release grain [6], [8].
- **Wi-Fi Module (ESP-01) / GSM Module (SIM800L):** The STM32 has no on-chip wireless connectivity, so an external module connected over UART is used to reach the cloud database and to send SMS or OTP messages [1], [8].
- **Display and Alert:** A 16x2 LCD shows the beneficiary name and issued quantity, and a buzzer signals errors.
- **Power Supply:** A regulated 3.3 V / 5 V / 12 V supply, preferably with battery backup for shops with unreliable electricity.

2.2 Mathematical Calculations

The following basic relations are used for computing the entitled quantity, measuring weight, and sizing the power supply.

Entitled quantity: the monthly quantity for a card depends on household size. The idea of computing quantity from household size is used in [1].

$$Q = N_m \times q_p \quad (1)$$

where N_m is the number of family members and q_p is the per-person allocation (kg/month).

Weight from HX711: the raw reading is converted to weight as

$$W = (D - D_0) / K \quad (2)$$

where D is the raw ADC reading, D_0 is the tare (empty) reading, and K is the calibration factor obtained with a known reference weight.

Stop condition: the motor is stopped when

$$W \geq Q - W_f \quad (3)$$

where W_f is the in-flight grain that still falls after the gate closes.

Dispensing time: the expected time to issue the full quantity is

$$t = Q / \dot{m} \quad (4)$$

where $\dot{m}$ is the grain flow rate of the gate (kg/s).

Duplicate check: dispensing is allowed only if

$$C(\text{card, month}) = 0 \quad (5)$$

where C is the number of collections recorded for that card in the current month.

Power calculation: the supply is sized from

$$P = V \times I \quad (6)$$

summed over the controller, motor, and communication module.

2.3 Software Requirements

The STM32 firmware can be developed in STM32CubeIDE or Keil µVision using the HAL drivers, with libraries for the MFRC522 reader and the HX711 amplifier. The Wi-Fi or GSM module is controlled through AT commands over UART. On the server side, a cloud database such as Firebase or MySQL stores beneficiaries, stock, and transactions, and a web dashboard lets authorities view stock and collection history, in line with the cloud monitoring used in [6] and [9]. The working flow of the system is shown in Figure 3.

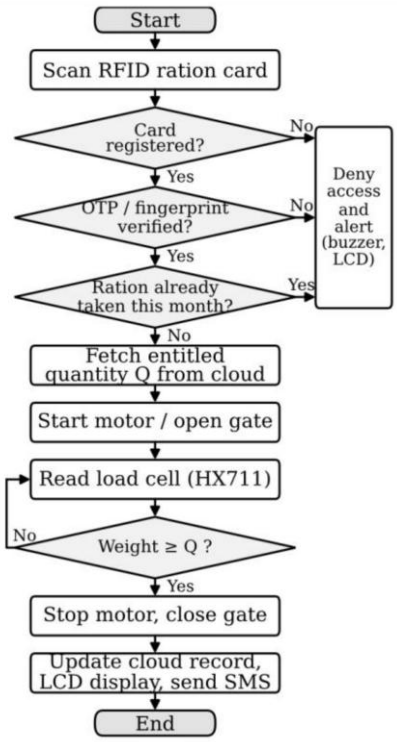


Figure 3. Working flow of the proposed ration dispensing system.

When a card is scanned, the STM32 reads its ID and checks it against the registered beneficiaries. If an OTP or fingerprint check is enabled, it must also succeed. The controller then checks whether the card has already been used in the current month, which blocks duplicate collection. If all checks pass, the entitled quantity Q is fetched, the motor opens the gate, and the HX711 is read in a loop. As soon as the measured weight reaches Q, the motor stops and the gate closes. Finally, the transaction is stored in the cloud database, the issued quantity is shown on the LCD, and an SMS is sent to the registered mobile number. If any check fails, access is denied and the buzzer and LCD alert the operator.

III. OPEN ISSUES AND CHALLENGES

3.1 Authentication and Inclusion

RFID cards can be lost or shared, fingerprints can fail for manual labourers and elderly users, and OTP needs a working mobile phone. Strict verification without a fallback can deny rations to eligible families [2], [7], [8], [10].

3.2 Weighing Accuracy

Many prototypes run the motor for a fixed time. Load cells need regular calibration, and grain flow, vibration, and moisture can affect the measured weight [7].

3.3 Duplicate Collection Control

Checking whether a beneficiary has already collected the current month's ration is rarely a separate verification step in existing designs [1], [6].

3.4 Network Dependence

Unreliable Wi-Fi or GSM coverage in rural areas can stop eligibility checks and record updates, and offline operation with later synchronisation is less explored [8], [9].

3.5 Link Between Device Data and Ledger

Blockchain studies secure the back-end records, but the data entering the ledger is still reported by humans rather than by sensors [3]-[5].

3.6 Data Security and Tamper Resistance

Beneficiary data must be protected, and the hardware, firmware, and records must resist manipulation by operators [4], [5].

3.7 Cost, Power, and Scalability

The device must stay low-cost, work with unstable electricity, and the back end must handle transactions from a very large number of shops [5], [9].

IV. APPLICATIONS

1. **Fair Price Shops:** automated, weight-verified issue of rice, wheat, and sugar under PDS.
2. **Relief camps and disaster zones:** controlled distribution of food packets to registered families [9].
3. **Mid-day meal and school stores:** accurate issue of grain stock with digital records [9].
4. **Anganwadi and community kitchens:** tracking of take-home ration and supplies.
5. **Cooperative and hostel stores:** card-based issue of fixed monthly quotas.
6. **Government audit:** real-time view of stock movement for supply officers [5], [6].

V. CONCLUSION

This survey reviewed research on IoT-based smart ration distribution, covering RFID-based authentication, GSM and OTP verification, biometric authentication, automated motor-driven and load-cell-based dispensing, cloud monitoring, machine learning-based verification, and blockchain-based record keeping. The reviewed studies show that automation can reduce manual errors, fraud, and leakage, but most approaches address only one part of the process and are tested as small prototypes. An integrated STM32-based

system that combines RFID authentication, monthly duplicate checking, load-cell-based weight-verified dispensing, and a cloud database with a monitoring dashboard can improve the transparency, accuracy, and accountability of the Public Distribution System.

VI. FUTURE ENHANCEMENT AND DIRECTIONS

- Multi-factor authentication with an inclusive fallback, such as RFID plus OTP or a supervisor override.
- Offline storage on the device with automatic synchronisation when the network returns.
- Linking sensor-verified transaction data to a tamper-resistant blockchain ledger.
- Automatic load-cell calibration and compensation for vibration and moisture.
- SMS and app-based receipts so beneficiaries can check their own collection history.
- Solar or battery backup for shops with unreliable electricity.
- Large-scale field testing with real beneficiaries and real shop conditions.

REFERENCES

[1] M. Agarwal, M. Sharma, B. Singh, and Shantanu, "Smart ration card using RFID and GSM technique," in Proc. 5th Int. Conf. Confluence: The Next Generation Information Technology Summit, 2014, pp. 485-489, doi: 10.1109/CONFLUENCE.2014.6949353.

[2] S. Menon, "Aadhaar-based biometric authentication for PDS and food security: Observations on implementation in Jharkhand's Ranchi district," Indian Journal of Human Development, vol. 11, no. 3, pp. 387-401, 2017, doi: 10.1177/0973703017748384.

[3] S. V. Pillai, Vipin H., A. Mohan, and Shruthi Dileep A., "Infusing blockchain in supply chain operations of a public distribution system," Journal of Supply Chain Management Systems, vol. 9, no. 2&3, pp. 1-7, 2020. [Online]. Available: https://www.publishingindia.com/archive/jscms/infusing-blockchain-in-supply-chain-operations-of-a-public-distribution-system

[4] S. K. Singh, M. Jenamani, D. Dasgupta, and S. Das, "A conceptual model for Indian public distribution system using consortium blockchain with on-chain and off-chain trusted data," Information Technology for Development, vol. 27, no. 3, pp. 499-523, 2021, doi: 10.1080/02681102.2020.1847024.

[5] A. Raghunandan, A. Priyadarsini, Vaibhav G, and Kiran M, "Scalable blockchain solution for targeted public distribution system (TPDS) in India," in Proc. 5th Int. Conf. Intelligent Computing and Control Systems (ICICCS), 2021, pp. 344-351, doi: 10.1109/ICICCS51141.2021.9432338.

[6] I. V. Singh and B. Singh, "IoT-enabled authentic ration and material distribution systems," International Journal of Solid State Innovations & Research, vol. 1, no. 1, pp. 26-34, 2023. [Online]. Available: https://journals.stmjournals.com/ijssir/article=2024/view=135475/

[7] G. Ravi, K. S. S. Sivamuthukumar, and S. P. Ramachandran, "Automated ration distribution: Addressing challenges in food distribution system," in Proc. 6th Int. Conf. Smart Systems and Inventive Technology (ICSSIT), Kalpa Publications in Computing, vol. 19, 2024. [Online]. Available: https://easychair.org/publications/paper/WcCM

[8] S. K. Machikuri et al., "Advanced interdisciplinary techniques for revolutionized government ration dispensing system using IoT," E3S Web of Conferences, vol. 507, Art. no. 01028, 2024, doi: 10.1051/e3sconf/202450701028.

[9] S. Waje, V. S. Baste, O. Shende, and A. Rupnawar, "Innovative secure public ration distribution using machine learning," Research & Reviews: A Journal of Embedded System & Applications, vol. 12, no. 3, pp. 25-30, 2024. [Online]. Available: https://journals.stmjournals.com/rrjoesa/article=2024/view=180684/

[10] K. Muralidharan, P. Niehaus, and S. Sukhtankar, "Identity verification standards in welfare programs: Experimental evidence from India," The Review of Economics and Statistics, vol. 107, no. 2, pp. 372-392, 2025, doi: 10.1162/rest_a_01296.