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# Smart Ration Tracking and FIFO Management

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**Abstract**

Conventional ration distribution systems exhibit certain limitations, including stock outages and poor management of stocks, which result in wastage of resources and unequal distribution. This paper suggests implementing an AI-based Smart Ration Tracking System enriched with blockchain technology to enhance the transparency, security, and effectiveness of public distribution. Through the use of smart contracts, the system manages the distribution of rations directly to the beneficiaries, thus reducing cases of fraud and false claims. FIFO (First In, First Out) is a stock control strategy that helps to reduce goods waste and increase the efficiency of the supply chain by using the older inventory before the new one. The AI-based analytics help in the correct identification of demand patterns to avoid shortages or overstocking situations. The decentralized and immutable ledger of blockchain increases stock accountability by providing accurate information about all transactions made. With this system enhanced by AI, the rations can be delivered to the beneficiaries properly and on time, with no possibility of interference or undue delay.

**Keywords:** AI-based Smart Ration Tracking System, Blockchain Technology, Smart contracts, First in first out (FIFO) stock management.

## 1. Introduction

The Public Distribution System (PDS) is vital for providing food security for millions, yet it has major problems such as stock mismanagement, transit theft, and discriminatory


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distribution. There is no effective FIFO (First-In-First-Out) procedure for clearing stocks, which results in spoilage and financial loss. Theft and pilferage in transit, weak tracking of dispatched and received stocks, and corruption in recording are major issues. To solve these problems, our Smart Ration Tracking and FIFO Management System utilizes automated tracking, AI, and Blockchain to maximize transparency and efficiency. It provides FIFO-based inventory management by sending out older inventory first, facilitates real-time shop inventory tracking, identifies theft by comparing sent and received inventory, and offers tamper-proof transaction records through Blockchain, guaranteeing secure and transparent ration distribution. The challenge is to develop a structured, transparent, and automated system to track ration stock at godowns and PDS shops, ensuring FIFO-based dispatch and identifying discrepancies in ration distribution using AI and Blockchain.

The Smart Ration Tracking System combines various innovative technologies to provide greater efficiency, transparency, and security in the distribution of rations and supply chain management. Artificial Intelligence (AI) for Supply Chain Management is significant for process optimization by examining data patterns, anticipating demand, and detecting inefficiencies while highlighting prevailing methodologies, potential uses, and knowledge gaps in the discipline [1]. The E-Ration Management System integrates AI and Blockchain for secure tracking, automated ration distribution, and theft control with an immutable and transparent transaction record [2]. The RFID and IoT-powered Smart Ration Card System allows ration transactions to be tracked in real-time, ensures secure and automated release, and protects against fraud by guaranteeing that ration-free goods reach legitimate beneficiaries only [3]. The Automatic Ration Material Distribution System, which uses GSM and RFID technology, provides accurate and automatic delivery of rations, significantly reducing human interference while avoiding fraud and lessening government revenue loss [4]. Similarly, the Automated Ration Distribution System enhances the process of commodity distribution by incorporating technology to prevent corruption, human error, and inefficiency in ration supply [5]. Lastly, IoT-based Livestock Monitoring and Management Systems utilize sensor technology for instantaneous tracking and data acquisition in farm and dairy operations to enable smart decisions and effective livestock management [6].

The Smart Ration Tracking and FIFO Management System is developed using a combination of frontend, backend, database, AI, and blockchain technologies to ensure effective and secure ration distribution. The frontend is created using HTML, CSS, and

JavaScript for a web interface. The backend is established using PHP and Python, where PHP is used for database operations and Python (using Flask API) for AI-based theft detection. MySQL is the database that stores transaction and stock records [21-23]. The AI system employs anomaly detection to identify imbalances in the movement of stocks and theft, which is incorporated using a Flask API. Secure tracking of the stock is carried out using Solidity smart contracts placed on the blockchain, with the Web3.js providing interaction between the blockchain network and the system.

## 2. Related Works

Mamun Habib et al. [7] suggest an in-depth analysis of Supply Chain Management (SCM) and its future relevance in manufacturing and service sectors with emphasis on its development over time and resolving the confusion over its definition despite its extensive usage. The research underlines the importance of SCM in providing sustainable profitability and growth in competitive settings and develops Educational Supply Chain Management (ESCM) as an application of SCM concepts in the service industry. One of the contributions is the Integrated Tertiary Educational Supply Chain Management (ITESCM) model, developed to maximize the performance of academic institutions by assessing stakeholders' inputs, validated via Structural Equation Modeling (SEM) methods. The model is intended to increase graduate quality and research contribution to benefit society in terms of greater education and innovation. Furthermore, the research offers a strategic model for the application of SCM to education while proposing that the same models may be applied to other service sectors. Further research can concentrate on empirical implementations of ITESCM, comparing key performance indices across institutions and developing the model based on empirical results. Md. Ashraful Babu et al. [8] suggest a heuristic method of managing risks in freight transportation by meeting challenges like delay and damage that can lead to financial sanctions and lower company reputation. The study pinpoints recurrent risk factors common to all types of transport channels, such as highways, waterways, airways, and railways, laying stress on the use of secure and cost-effective routing. To enhance transportation planning, the authors present a technique of obtaining multiple optimal solutions with the use of the Modified Distribution Method (MODI) in transportation problems. By utilizing a multi-optimality approach, the research reduces transportation risks through fewer possible routes while guaranteeing efficient delivery. This method offers a strategic framework for improving reliability and efficiency in supply chain logistics, and future studies could be based on real-world applications of the proposed risk management model in various industries. Internal data, like reported cases of gas theft and customer assets, and external data, like demographics, are combined in the research to boost predictive ability. Applying Hotspot analysis, Ordinary Least Squares regression (OLS), and Geographically Weighted Regression (GWR) using ArcGIS tools, the study determines that gas theft is a non-random phenomenon driven by underlying factors. The hotspot map technique identifies dense clusters of risk, and regression analysis verifies the importance of exogenous variables. From these outcomes, the research suggests a conceptual GIS framework to choose high-risk locations to advance meter data analysis. The findings are useful for proactive analytics in gas theft detection and can be used as a basis for future GIS-based studies in urban energy management. Nikolaos Vagiokas et al. [10] conduct a research work on risk assessment in the carriage of hazardous substances by road with a focus on the high level of danger arising from accidents that can affect not only truck drivers but also neighboring populations. The study is based on creating a computerized tool for risk management using actual traffic flows and weather conditions in an effort to maximize transportation security. Through the incorporation of an online interface connected to the Global Positioning System (GPS), the system facilitates real-time risk evaluation and decision-making to choose routes. The research makes use of the Dangerous Goods Quantitative Risk Assessment Model (QRAM) for quantifying risk and comparing findings through F/N curves and Expected Value (EV) measures. The conclusion drawn from the findings is that real-time analysis of data impacts route choice and risk reduction more greatly, providing a more dynamic and precise risk evaluation than the conventional annual statistical models. The conventional ration distribution is dependent on manual intervention, and thus it results in inefficiencies and malpractices. The paper presents an embedded system that mechanizes the process, where customers are able to enter the amount of commodities needed, which are automatically measured and dispensed. This innovation minimizes human intervention, improves transparency, and reduces errors. By incorporating automation, the suggested system provides efficiency, accuracy, and equality in ration distribution, which marks it as a major upgrade from traditional methods. Adrian France [12] The research purpose is to discover customer peak hours in terms of stock shortage, to reduce stock-out during customer peak hours and to research procedures/processes on how to access the supply of raw materials. Qualitative approach is applied in order to access information by means of informal discussion among the personnel. In an effort to ensure a better supply chain, all businesses wish to possess superior raw materials. Raw material management is activities such as acquiring, buying, refining, creating, and providing the correct quantity at the correct time. If waves in raw materials, then the company should adapt accordingly. Raw material fluctuation impacts performance, i.e., customer satisfaction. Stock shortage can result in delays and costs. Stock management can offer tracking to reduce issues and increases more profit. Absence of planning and material inspection results in delayed deliveries. Mikko O. Lehtonen et al. [13] uses RFID for product authentication systems, to detect counterfeit products and keeping them from entering official channels of distribution. Mikko O. Lehtonen, Florian Michahelles, and Elgar Fleisch's work derives a general chain of trust as well as functional and non-functional requirements for security. In contrast to most literature, which is limited to cryptographic tag authentication, this paper discusses more comprehensive methods, such as location-based authentication. Through misuse case analysis, the authors evaluate RFID-based authentication mechanisms in terms of how well they meet security needs. The research also examines current EPC standards in satisfying these security needs and proposes improvements to cover unmet requirements, especially the deployment of network-level services to identify cloned tags, thus making RFID-based product authentication systems more secure. Mazin Debe et al. [14] suggest a blockchain-enabled decentralized system to monitor and authenticate the return and resale of unused medication, thereby reducing drug wastage caused by misprescription, over-buying, and intolerance. Mazin Debe, Khaled Salah, Raja Jayaraman, and Junaid Arshad have created a system using blockchain, smart contracts, and decentralized storage (IPFS) to allow pharmacies and consumers to return reusable medicines for resale or donation. It provides transparency by monitoring drug manufacture from manufacturers to buyers while enabling authorized parties to authenticate and validate returned drugs prior to redistribution. A prototype built on Ethereum affirms the process, with reviews measuring functionality, execution cost, security, and smart contract strength, supporting pharmaceutical supply chain integrity. Thomas Kelepouris et al. [15] investigate RFID-based traceability in the food supply chain, focusing on its ability to maintain food safety, quality, and regulatory compliance. The research study by Thomas Kelepouris, Katerina Pramatari, and Georgios Doukidis pinpoints critical traceability needs and examines how RFID technology can efficiently meet these needs. The authors advance a system architecture and an information data model aimed at improving tracking and monitoring throughout the supply chain. The research brings into perspective the effect that technology choices have on the costs and effectiveness of implementation and emphasizes real-world testing as key to successful deployment. D. Malathi et al. [16] suggests a smart ration shop using blockchain technology in order to increase transparency and stop corruption in the Public Distribution System (PDS). The present manual system of data management generates inefficiencies and the scope for black-market operations. The new method uses secure immutable smart contracts for transactions and incorporates IoT for real-time asset tracking, ensuring no malpractices occur while distributing food. The local-language voice and text-based interfaces enhance accessibility as well. The performance of the blockchain network is measured in the study, which illustrates its potential for minimizing fraud and guaranteeing traceability while distributing rations. Fabrizio Dabbene et. al. [17] explains the significance of traceability for maximizing food supply chain management, food safety, and quality assurance. It focuses on critical traceability requirements, system performance measures, and current tracking methods of bulk and liquid foods. The research also delves into incorporating traceability and risk assessment, identity preservation, and anti-counterfeiting processes and reviews extant literature in an attempt to ascertain research lacunas and lines of future work in enhancing traceability within the food supply chains. The research also delves into incorporating traceability and risk assessment, identity preservation, and anti-counterfeiting processes and reviews extant literature in an attempt to ascertain research lacunas and lines of future work in enhancing traceability within the food supply chains.

## 3. Proposed Work

The Ration Stock Tracking System suggested here aims to combat ration commodity theft during delivery from godowns to shops of the Public Distribution System (PDS). The system has an electronic storage for maintaining stock records, following the flow of products from warehouses to distribution points. It implements MySQL for database management for proper stock insertion, dispatch, and receipt records. The mechanism of theft detection calculates dispatched inventory and received inventory at stores and detects discrepancies. Artificial Intelligence is integrated for detecting anomalies, which automatically marks irregularities. Blockchain (Solidity smart contracts) is used to provide secure and transparent tracking of inventory, so data falsification is avoided. Our system includes a web interface with PHP so that shop managers and shop owners can track movements of stock in real time, as indicated in Figure 1. The process starts with stock arrival notifications, where the newly arrived stock is added to the godown database. Then, in the case of stock dispatch, products are allocated to shops using a FIFO (First In, First Out) method so that older stock is dispatched first. Individual stock tables are kept by shops, with received goods recorded. The theft detection module cross-checks expected and actual stock at shops and reports mismatches. If there is any mismatch, it is immediately reported to the admin for further action. The AI-based model, trained on patterns of stock flow, detects abnormal dispatch or receipt activities. Blockchain adoption makes transactional records secure through an immutable ledger for transparency and verification. Subsequent upgrades may involve real-time GPS tracking and RFID-based authentication of stock. The system presents an effective, automated, and tamper-free method of ration stock monitoring with fair distribution and loss prevention.

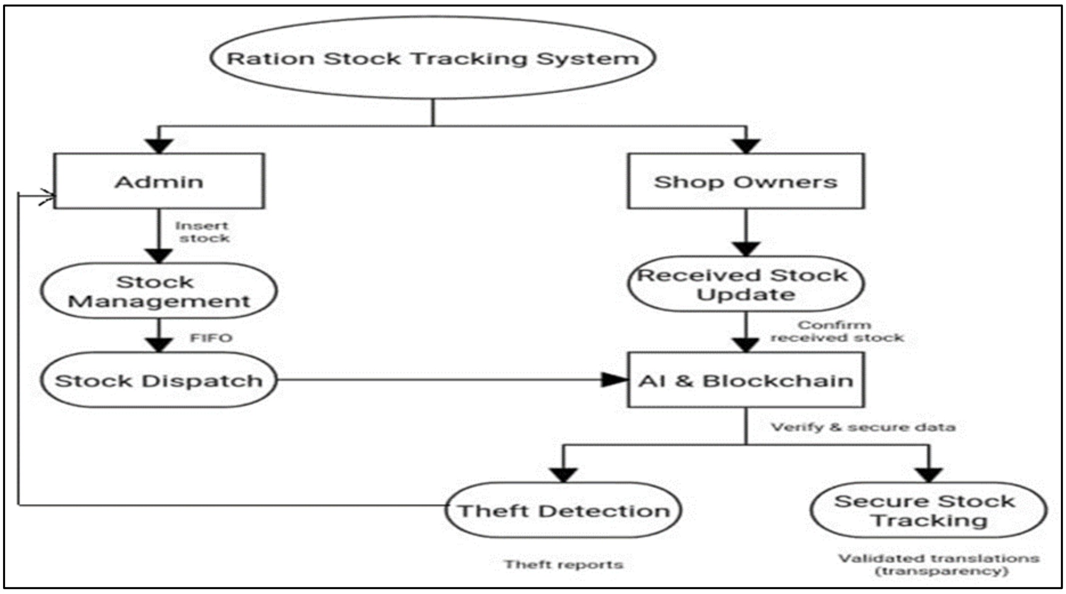


**Figure 1.** Overview

In actual implementation, the Ration Stock Tracking System has a systematic workflow to provide effective stock management, FIFO-based dispatch, theft detection, and blockchain integration for secure tracking. The system starts with the admin logging into the dashboard, where they enter new stock information, such as type, quantity, and expiry date. The system checks the details and updates the Godown Database to provide correct stock records. For dispatch, the system adopts a FIFO-based mechanism, verifying the oldest available inventory in the database, creating a dispatch order, and adjusting stock records appropriately. Dispatched stock information is subsequently transmitted to shop owners for monitoring. When receiving stock, shops notify the system of received amounts, and the system verifies dispatched and received stock information. Any difference is identified, and the AI Module detects discrepancies, issuing a theft report if discrepancies exist. Furthermore, integration with blockchain ensures transparency by logging each stock movement, both dispatch and receipt, on an irreversible ledger, making the data tamper-proof and increasing security within the supply chain, as indicated in figure.2.

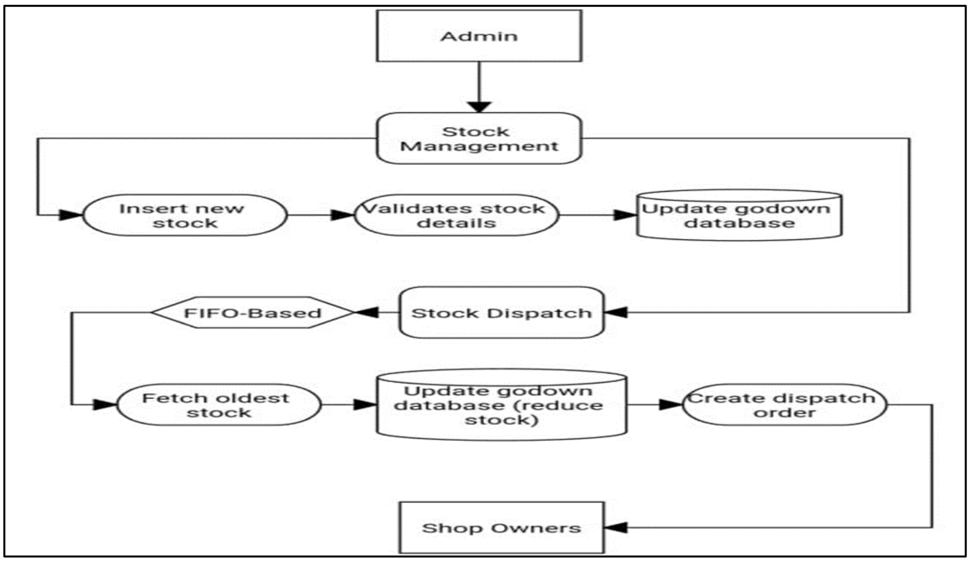


**Figure 2.** Admin Module

The owner of the shop verifies the stock received at their shop by logging in to their dashboard to begin the Stock Receipt Workflow. The quantity is verified in the system after confirming the received stock, and then the received stock information is entered into the Shop Inventory Database. The AI component analyzes the sent and received stock for any differences. The system generates a discrepancy report when there is a discrepancy, and it is stored in the Theft Reports Database for further analysis by the admin. An immutable Blockchain Ledger is employed for storing confirmed stock transactions to enhance security and transparency. This protects all stock movement by ensuring it is stored securely and -cannot be tampered with, as illustrated in figure.3.

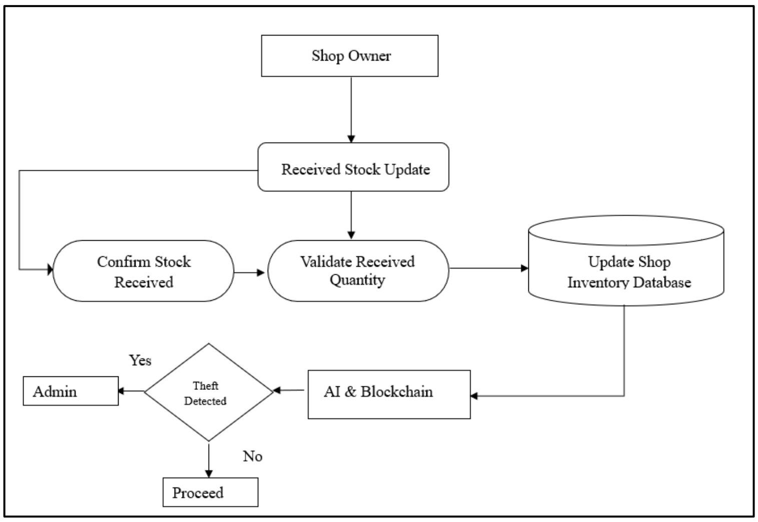


**Figure 3.** Shop Owner Module

The AI-Based Theft Detection module uses machine learning models like Random Forest and Decision Trees to detect anomalies in stock flow, and the Flask API in Python facilitates seamless integration. The system stores dispatched and received stock data in MySQL, and libraries like NumPy, Pandas, and Scikit-Learn facilitate data processing and model training. At the same time, the Blockchain-Based Secure Stock Tracking component uses Solidity Smart Contracts deployed on the Ethereum Testnet to ensure tamper-proof transaction records. Web3.js makes it easier for the blockchain and the frontend to communicate, while IPFS provides decentralized storage for transaction logs.

The AI model continuously monitors on stock transactions in real-time as part of the Theft Detection Workflow. If it notices that the difference between dispatched and received quantities exceeding a predefined threshold it flags the transaction as suspicious and sends an alert to the administrator with a Theft Report. At the same time, the Blockchain Integration Workflow logs every stock movement in a Smart Contract. This means that all transactions are verified by blockchain nodes before they get added to the Blockchain Ledger. as illustrated in figure 4.

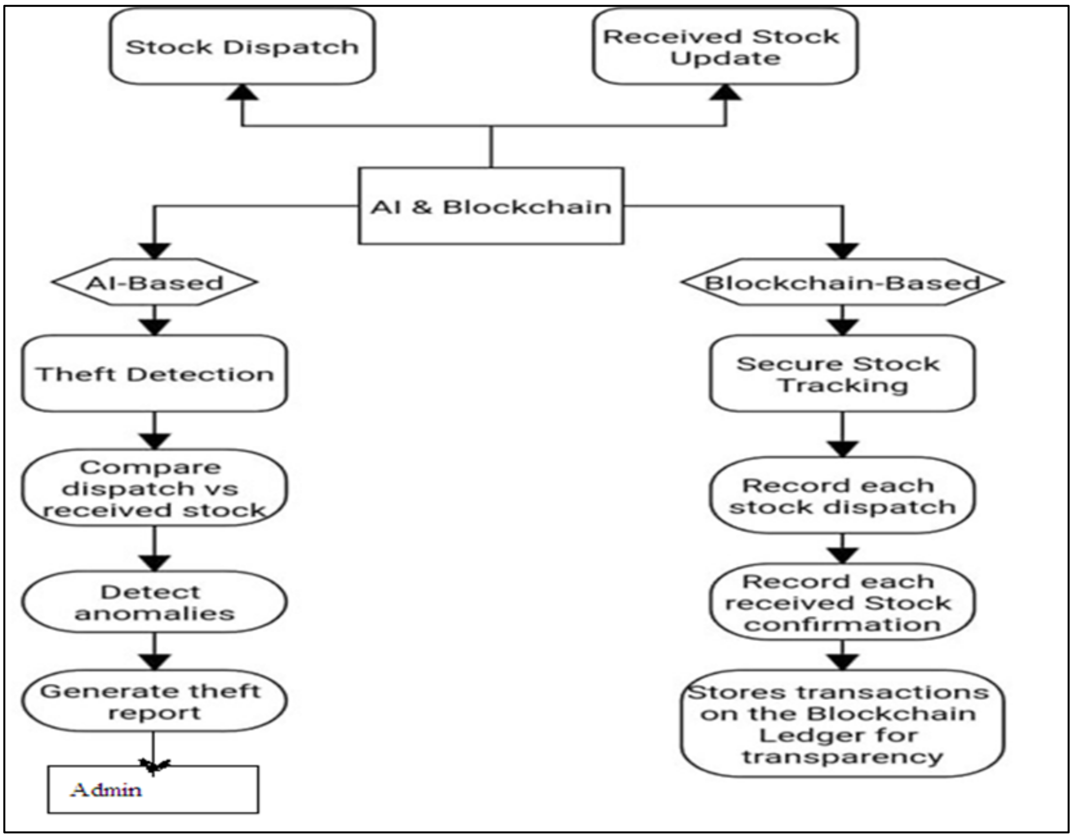


**Figure 4.** AI & Blockchain Module

## 4. Results and Discussion

### 4.1 Workflow

Our godown database is updated with new entries as soon as the new goods arrive. To focus on waste goods and preserve freshness, First-in-First-out is used in the dispatch process. When the goods reach the retailers, inventory records are updated, and a receipt is produced for the same. With the help of Artificial Intelligence, theft detection analysis is performed, and if any such suspicious event occurs, it is immediately reported to the admin for further action. Finally, all transactions are recorded in the blockchain distributed ledger for future investigations.

### 4.2 Software Requirements

**Frontend:** HTML, CSS, JavaScript, and Bootstrap for crafting a responsive and interactive user interface.

**Backend:** PHP for server-side scripting and managing authentication, database operations, and business rules.

**Database:** MySQL for retaining stock information, transaction history, and user records.

**Development Tools:** Visual Studio Code, Sublime Text, or PHPStorm for coding and debugging.

**Server:** XAMPP for testing and deployment purposes, consisting of Apache and MySQL.

**Version Control:** Git and GitHub for keeping track of modifications and collaboration.

**Testing & Deployment:** Microsoft Edge, Google Chrome, and Mozilla Firefox for testing, and a PHP and MySQL enabled cloud hosting service or shared hosting for deployment.

### 4.3 Hardware Requirements

**Hardware Components:** Intel i5/i7 or AMD Ryzen powered development machine, 8GB RAM minimum, 256GB SSD, and user machines like desktop, laptop, or mobile phone for accessing the platforms.

**Network Requirements:** Reliable internet connectivity for database synchronization, cloud hosting, and real-time stock monitoring.

The Landing Page is the initial screen view for users when they log in to the Smart Ration Tracking & FIFO Stock Management System. It offers a clean and user-friendly interface with two login alternatives: one for Godown Managers (Admins) and another for PDS Shop Owners. This will guide users to the correct portal according to their roles, thus ensuring easy and secure navigation, as shown in Fig.5.

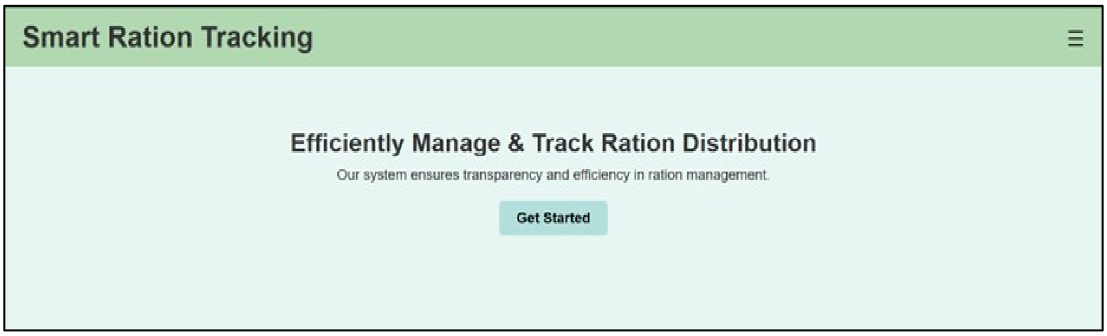


**Figure 5.** Landing Page

The Admin Login Page enables the Godown Manager to log in using their credentials. When the username or password entered is invalid, an error message is prompted, ensuring that no unauthorized access is allowed. This guarantees that only approved staff members manage with stock at the godown level, as shown in Fig.6.

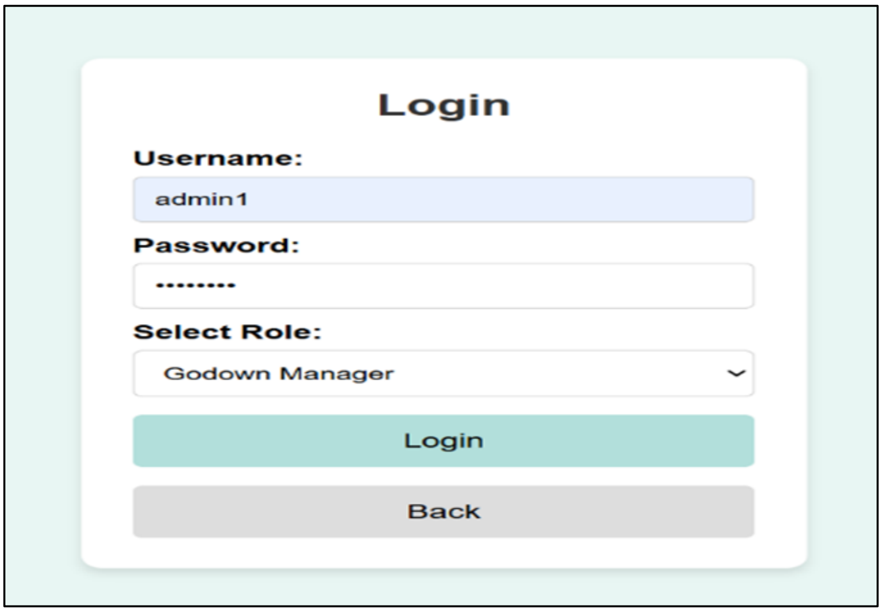


**Figure 6.** Admin Login Page

Once logged in, the Admin Dashboard is the hub of control for the Godown Manager. From here, they can easily access various functions such as new stock addition, stock dispatch

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to PDS shops, and discrepancy monitoring. The dashboard provides a clear picture of stock movement and ensures well-organized inventory records as shown in Fig.7.

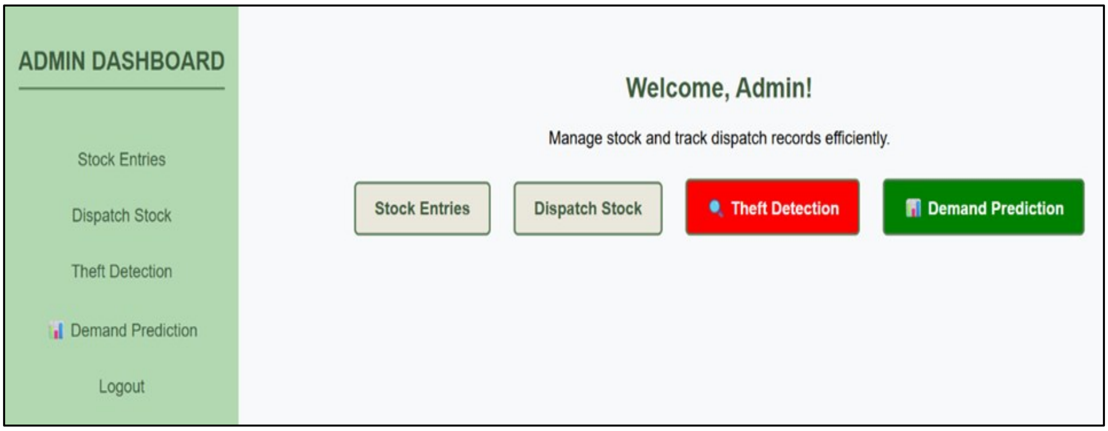



**Figure 7.** Admin Dashboard

This is the page where the Godown Manager enters the new stock information, such as the item name, quantity, entry date, and expiry date. This data is recorded automatically by the system to ensure that the stock is accounted for. As the system uses a FIFO (First-In-First-Out) strategy, older stock takes precedence in being dispatched, saving wastage and providing equal distribution, as shown in Fig.8

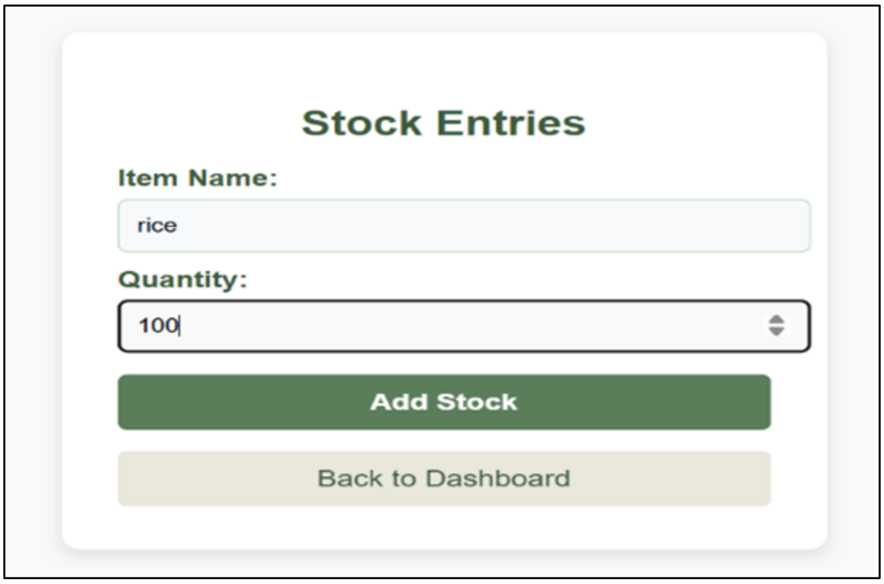



**Figure 8.** Stock Entry Page

After stock is ready for dispatch to PDS shops, the Godown Manager records it through the Dispatch Stock Page. The system captures details such as the items dispatched, quantity, and receiving PDS shop. This updates the Godown Database and the PDS Shop Database, making stock movement transparent as shown in Fig.9.

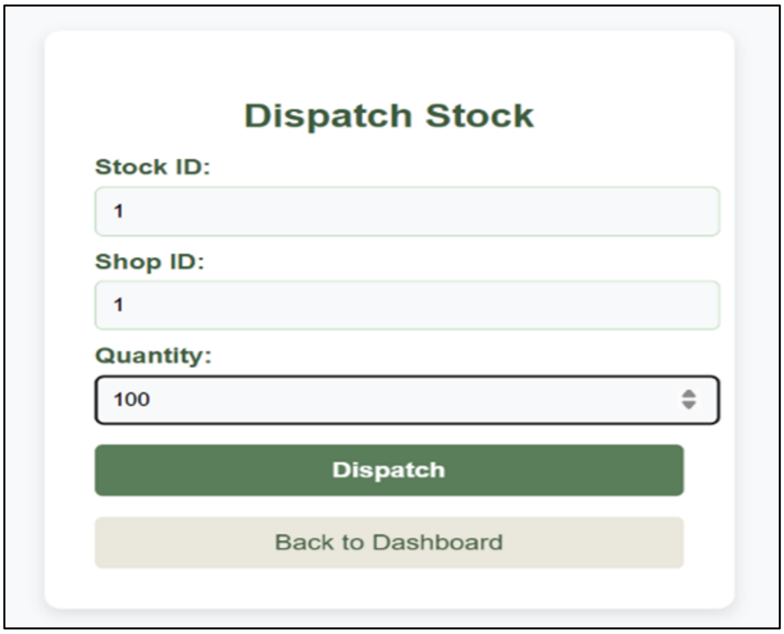



**Figure 9.** Dispatch Stock Page

The Shop Owner Login Page enables PDS Shop Owners to log in securely and view their dashboard. Like the admin login, it verifies the username and password before allowing access, so only authorized shop owners can handle stock records, as shown in Fig.10.


**Figure 10.** Shop Owner Login Page

The Shop Dashboard provides a clear and categorized view of all activities related to stock for the PDS Shop Owner. From here, they can manage stock received from the godown, record customer purchases, and view availability of stock. It enables shop owners to maintain their ration distribution records accurately, as shown in Fig.11.

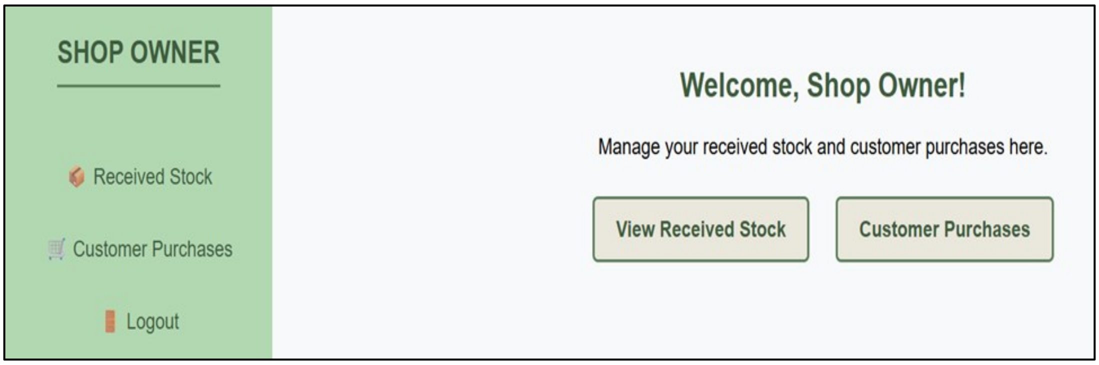



**Figure 11.** Shop Dashboard

Whenever a PDS shop owner receives a stock delivery from the godown, they utilize the Received Stock Page to check and authenticate the delivery. The system captures information such as item name, quantity, and date received, ensuring that the received stock matches what was sent out. This assists in the detection of any shortages or discrepancies, as shown in Fig.12.

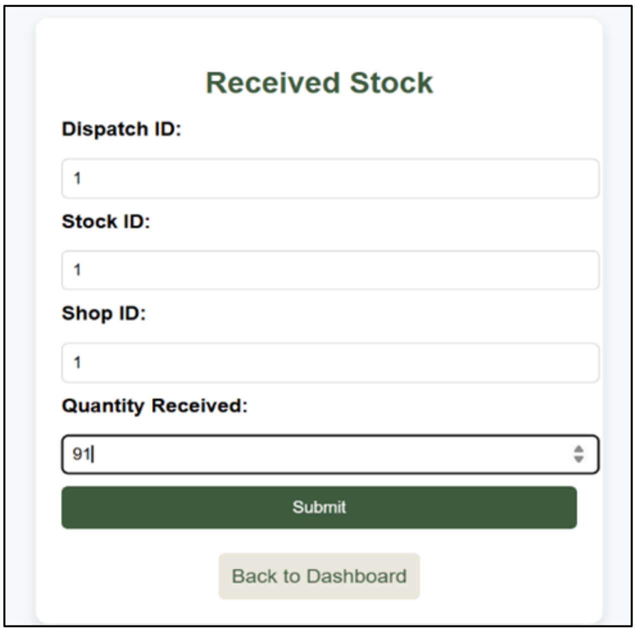



**Figure 12.** Received Stock Page

This page enables PDS Shop Owners to mark down rations dispensed to customers. Every transaction is documented with information such as the customer's name, products bought, quantity, and purchase date. It not only enables the tracking of stock usage but also helps ensure that distribution is done justly and transparently, as shown in Fig.13.

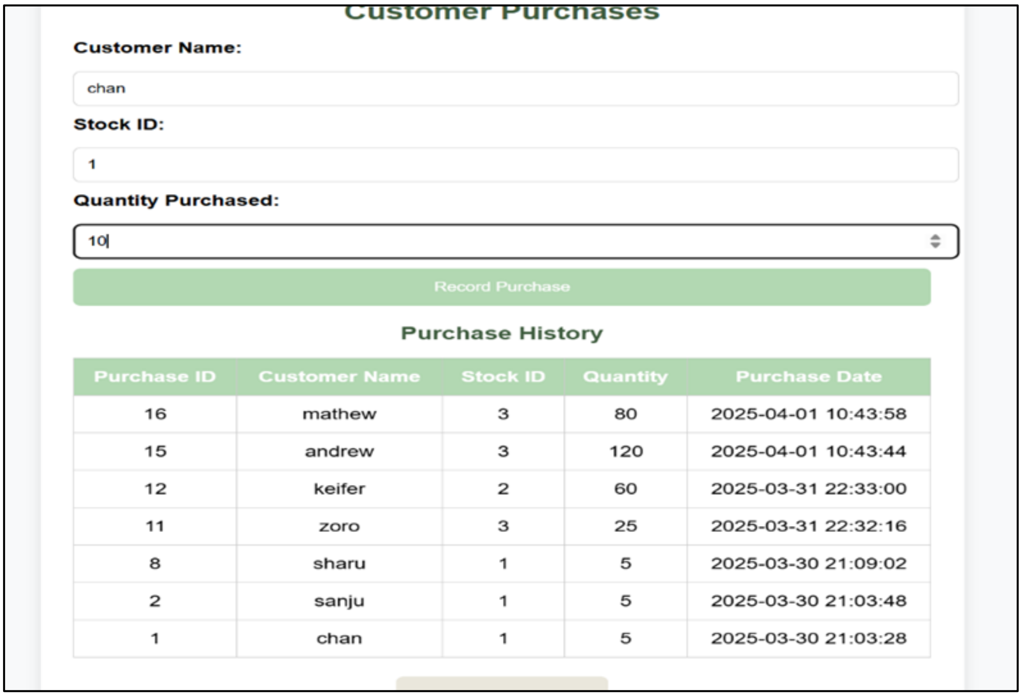



**Figure 13.** Customer Purchases Page

One of the key aspects of the system is the AI Theft Detection, which assists in detecting any missing or unaccounted stock. It will cross-check the dispatched stock records from the godown with the received stock records at the shop. Any discrepancy could mean potential theft or mismanagement, and it is also recorded in the blockchain ledger for effective action, as shown in Fig.14.

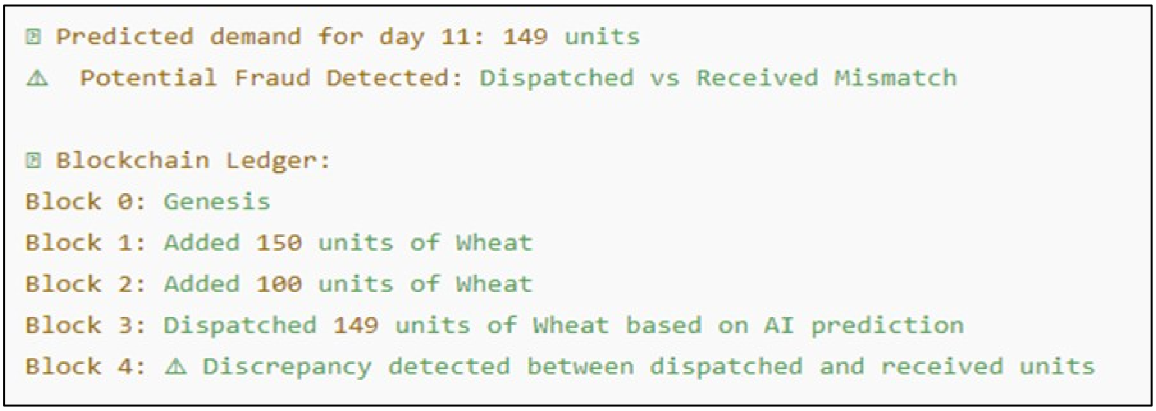
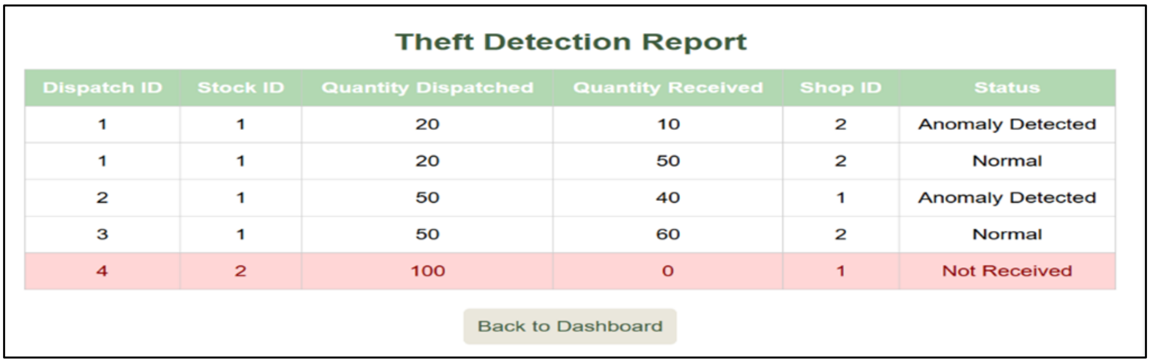



**Figure 14.** AI Theft Detection and Blockchain Storage

Ration stock-based smart contracts are deployed to record every stock arrival and dispatch with a unique ID and timestamp, ensuring transparency and traceability. Only the main ration admin has the right to maintain stock details on each transaction, which is stored immutably on the blockchain, as shown in Figure 15. Stock fraudulent transactions are also addressed in our smart contract, it works together with an AI tracking system that runs off-chain and provides real-time inputs to identify problems such as theft, discrepancies, or stock outages during dispatch in the form of theft reports [18-20]. These warnings are recorded through dedicated flags to notify higher-level ration stakeholders (admin) to take further action without delay.



Theft Detection Report

| Dispatch ID | Stock ID | Quantity Dispatched | Quantity Received | Shop ID | Status |
|---|---|---|---|---|---|
| 1 | 1 | 20 | 10 | 2 | Anomaly Detected |
| 1 | 1 | 20 | 50 | 2 | Normal |
| 2 | 1 | 50 | 40 | 1 | Anomaly Detected |
| 3 | 1 | 50 | 60 | 2 | Normal |
| 4 | 2 | 100 | 0 | 1 | Not Received |

Back to Dashboard

**Figure 15.** Theft Detection Page

In addition, smart contracts automate the release and delivery of supplies, minimizing manual errors and delays. The AI and blockchain combined tracking system integrated into warehouse surveillance enhances security by detecting unauthorized access and unusual activities in real-time. AI-powered demand forecasting further supports efficient planning by predicting stock requirements at each distribution center, enabling fair and timely supply to beneficiaries [22-25]. AI tracking with blockchain technology ensures that ration distribution is tamper-proof, timely, and accountable, as shown in Figure 16.


**Figure 16.** Rationstock Smart Contract Deployment

This GPS Theft Detection System tracks ration stock transportation using OpenStreetMap with Leaflet.js. A red marker indicates the starting point, while the blue path represents the travel route. The system continuously monitors for deviations from the predefined route. If an anomaly is detected, it triggers an alert to prevent theft. The Theft Detection Report is shown in Fig.17.

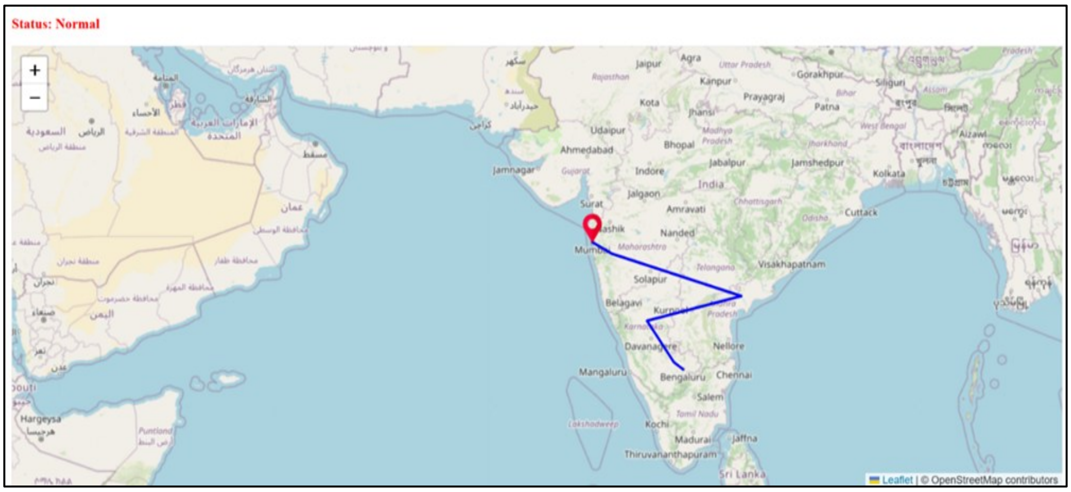



**Figure 17.** GPS Tracking Prototype

### 4.4 Comparative Analysis

The comparative analysis compares the efficiency of various algorithms in References [1], [2], and [3] with the Ration Stock Tracking System, depicting its better efficiency. References [1] and [2] have lower accuracy, reflecting deficiencies in their stock tracking and anomaly detection methods, while Reference [3] indicates improvement but lower efficiency. Conversely, the Ration Stock Tracking System is the most accurate, with credit going to its use of AI-based theft detection, FIFO stock management, and blockchain for secure tracing, providing maximum reliability, transparency, and minimized losses through theft or mismanagement, as shown in Fig.18.

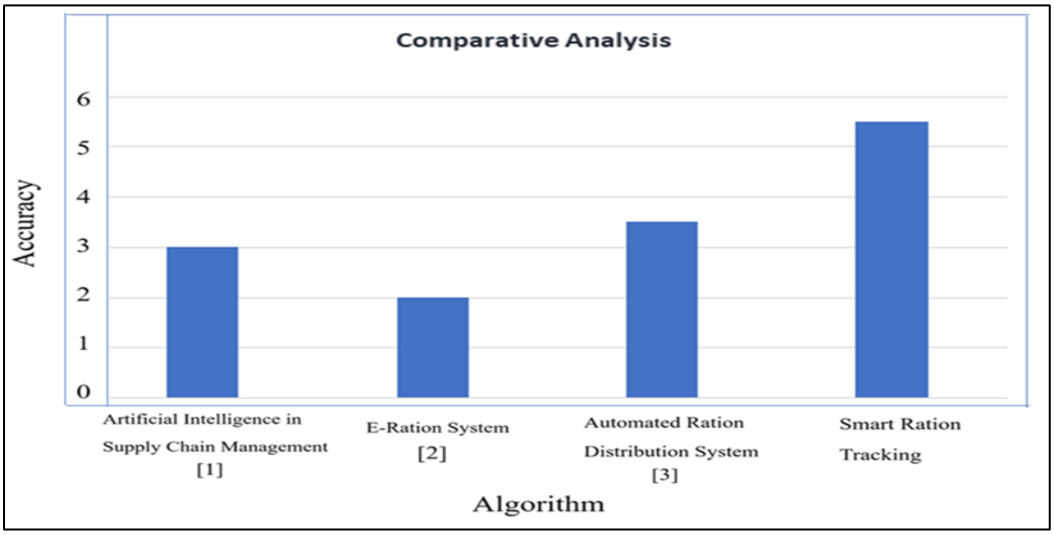



**Figure 18.** Comparative Analysis

## 5. Conclusion and Future Works

The Ration Stock Tracking and FIFO Management System is a cutting-edge intelligent solution that aims to improve transparency, security, and efficiency in the Public Distribution System (PDS) through the use of frontier technologies. The system utilizes AI-driven theft detection, blockchain for secure stock tracking, and GPS route tracking. AI algorithms scan patterns of stock movements, identify anomalies, and mark suspected theft or discrepancies in stock records. Blockchain technology guarantees secure, immutable, and transparent records of transactions, making tampering and unauthorized alterations impossible. GPS tracking mimics the movement of ration commodities and identifies route straying, with administrators alerted immediately to suspected attempts at diversion. The FIFO (First-In-First-Out) inventory management system ensures the use of older stock first, avoiding wastage and spoilage.

In the future, the system could be enhanced with RFID-based tracking to monitor inventory movements in real-time with precision. IoT sensors could be incorporated to monitor environmental factors like temperature and humidity and maintain optimal conditions for storage of ration goods. Predictive analytics using AI may be employed for demand forecasting as well as ensuring stock allocation optimized across regions so that shortages may be minimized while excess inventory is avoided. Smart contracts on blockchain technology can be used to automate stock allocation and ensure policy adherence without human intervention, building greater confidence. A mobile application can be created that offers real-time stock information, notifications, and tracking for administrators, PDS shop owners, and even customers. Biometric identification can be incorporated for safe and open beneficiary authentication, avoiding false claims. Shifting to a cloud infrastructure will enhance scalability, enabling the system to be rolled out nationwide with fewer infrastructure constraints. These upgrades will transform the ration distribution system into an AI-powered, blockchain-protected, and fully automated system, making it a fair, transparent, and corruption-free public distribution system while significantly cutting losses and inefficiencies.

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