Suresh G. A/P, 2026, 14:2
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology
An Open Access Journal

AI-Powered Trusted Community Delivery Model for Strengthening the Public Distribution System (PDS)

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Abstract- The Public Distribution System (PDS) plays a vital role in ensuring food security by distributing subsidized food commodities to economically weaker sections of society. However, the traditional distribution model faces several operational challenges including long queues at ration shops, lack of transparency, manual record keeping, and leakage of commodities during distribution. These limitations reduce the efficiency and reliability of the system. This paper proposes an AI-Powered Trusted Community Delivery Model designed to modernize the Public Distribution System using intelligent monitoring and digital verification mechanisms. The proposed system integrates artificial intelligence techniques such as route optimization algorithms, GPS-based tracking, OTP-based delivery authentication, and centralized administrative dashboards. The model introduces verified community delivery personnel who distribute ration commodities directly to beneficiaries at their homes. The system ensures transparency and accountability through real-time monitoring and automated delivery confirmation. The proposed framework has been validated through a prototype implementation and simulation-based analysis to demonstrate its feasibility and effectiveness. The results indicate that the model can serve as a practical and scalable solution for enhancing public welfare distribution systems.

Keywords—Artificial Intelligence, Public Distribution System, Route Optimization, Fraud Detection, OTP Verification, GPS Tracking, Smart Distribution System.

I. INTRODUCTION

The Public Distribution System (PDS) is a government initiative aimed at providing essential food commodities at subsidized rates to economically weaker sections of society. Despite its importance, the traditional system suffers from inefficiencies such as long queues, lack of transparency, and distribution leakage.

To overcome these issues, digital transformation combined with artificial intelligence can be used to enhance efficiency and reliability. This paper proposes a smart and secure delivery framework using AI-based techniques.

This study focuses on the design and validation of a prototype framework rather than large-scale deployment, ensuring feasibility analysis before real-world adoption.

II. LITERATURE REVIEW

Researchers and government agencies have explored several technological approaches to improve the efficiency and transparency of the Public Distribution System.

A. Aadhaar Linked Public Distribution System

The Aadhaar-based authentication system has been implemented in many states to eliminate duplicate ration cards and ensure accurate beneficiary identification. Beneficiaries authenticate their identity using biometric verification before receiving ration commodities.

B. Electronic Point of Sale (ePOS) Systems

Electronic Point of Sale devices are installed in ration shops to record transactions digitally. These systems store beneficiary authentication details, commodity distribution records, and transaction timestamps.

ePOS systems improve transparency by maintaining digital records.

C. Digital Ration Card Systems

Digital ration card initiatives allow beneficiaries to manage their ration card information through online portals. These systems simplify beneficiary registration, verification, and record management.

D. Limitations of Existing Systems

Although these digital initiatives improve transparency, several limitations remain. Beneficiaries must still travel to ration shops to collect their commodities. Elderly individuals, disabled persons, and people living in remote areas face accessibility challenges.

Additionally, existing systems lack real-time monitoring of distribution operations, making it difficult to detect fraud or delays.

Therefore, a system that integrates doorstep delivery with intelligent monitoring technologies is required.

III. PROPOSED SYSTEM ARCHITECTURE

The proposed AI-powered PDS system introduces a digital distribution framework integrating beneficiaries, delivery personnel, and administrative authorities.

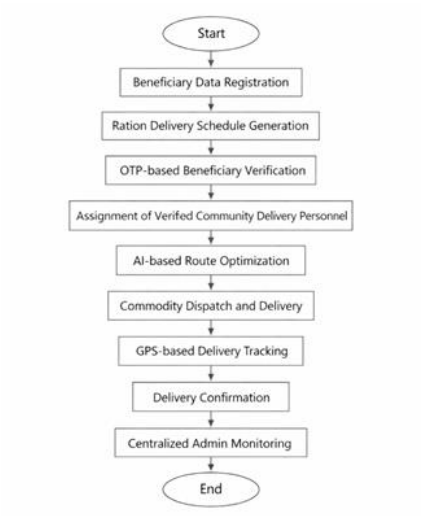


Figure 1. Workflow of the proposed AI-powered trusted community delivery system.

A. orkflow Explanation

The workflow of the proposed AI-powered trusted community delivery system begins with beneficiary data registration, where eligible beneficiaries are recorded in the system database. Based on the registered data, the system generates a delivery schedule for ration distribution.

The beneficiary verification process is carried out using OTP-based authentication to ensure that only authorized individuals receive the ration commodities. After successful verification, verified community delivery personnel are assigned to deliver the commodities.

The system then applies AI-based route optimization to determine the most efficient delivery path based on beneficiary locations. Once the route is finalized, the commodities are dispatched and delivered to beneficiaries.

During delivery, GPS-based tracking is used to monitor the movement of delivery personnel and ensure that deliveries are carried out at the correct locations. After successful delivery, a confirmation is recorded in the system.

Finally, all delivery activities are monitored through a centralized administrative dashboard, which provides real-time visibility and ensures transparency in the distribution process.

B. Verified Community Delivery Personnel

Trusted local individuals such as self-help group members and delivery agents are considered as community delivery personnel responsible for ration distribution.

C. AI Route Optimization

- AI algorithms are designed to determine efficient delivery routes
- Beneficiary location data is analyzed
- Optimal paths are generated to reduce time and cost

D. OTP Delivery Verification

- OTP is generated during delivery
- Sent to beneficiary mobile number
- Delivery is confirmed through OTP entry
- Ensures secure and correct delivery

E. GPS Geo-Tagged Delivery Confirmation

- GPS coordinates are recorded during delivery
- Ensures delivery location accuracy
- Prevents false delivery reporting

Table I. System Modules Description

Module	Description
Beneficiary Module	Stores beneficiary data
Delivery Module	Manages delivery agents
OTP Module	Authentication
AI Module	Route optimization
GPS Module	Tracking
Admin Dashboard	Monitoring

IV. RESEARCH METHODOLOGY

The methodology focuses on designing and evaluating the proposed system using simulation-based validation.

A. System Design

The proposed system consists of three main modules:

1. Mobile Application for delivery personnel
2. Administrative monitoring dashboard
3. AI monitoring and route optimization engine

B. Data Sources

- Beneficiary dataset
- Delivery personnel dataset
- Transaction dataset
- GPS tracking dataset

The system is evaluated using synthetically generated datasets to simulate real-world Public Distribution System scenarios without accessing sensitive government data.

C. Technology Stack

- Android Mobile Application for Delivery Personnel
- Web Dashboard for Administrators
- GPS Tracking Integration
- AI Route Optimization Algorithm

Table II. Technologies Used

Component	Technology
Frontend	Mobile/Web
Backend	Server
Database	SQL
AI	Optimization Algorithms
Tracking	GPS
Authentication	OTP

D. Operational Workflow

1. Beneficiary registration
2. Administrative approval
3. Delivery personnel assignment
4. Route optimization
5. Delivery execution
6. OTP verification
7. GPS confirmation
8. Dashboard update

V. DATA COLLECTION

Data collection is performed in a simulated environment.

- Beneficiary details dataset
- Delivery personnel dataset
- GPS tracking dataset
- Transaction logs

All datasets used are synthetic representations designed to emulate real-world distribution conditions.

VI. ANALYSIS APPROACH

The effectiveness of the proposed system is evaluated using multiple performance indicators. The analysis presented is based on simulation results obtained from the prototype implementation of the proposed system.

A. Delivery Efficiency

- Delivery efficiency is evaluated by comparing the time required to distribute ration commodities using the traditional ration shop model and the proposed AI-based delivery model.
- In the traditional system, beneficiaries must travel to ration shops and wait in queues.
- In the proposed system, delivery personnel distribute commodities directly to beneficiaries at their homes.
- The reduction in delivery time and waiting time indicates improved system efficiency.

B. Fraud Detection Capability

- The system includes monitoring mechanisms to detect fraudulent activities during distribution.
- AI-based monitoring can identify abnormal distribution patterns such as repeated failed deliveries or irregular route deviations.
- GPS tracking allows authorities to verify whether delivery agents visited the beneficiary's location.
- These monitoring features help prevent corruption and unauthorized distribution.

C. Monitoring Transparency

- Transparency is improved through real-time monitoring of delivery operations.
- GPS tracking provides accurate location information for each delivery event.
- The administrative dashboard displays delivery status, route information, and transaction records.
- This allows government authorities to monitor the system continuously and ensure accountability.

D. Beneficiary Satisfaction

- Beneficiary satisfaction is evaluated based on convenience and accessibility.
- Doorstep delivery reduces the need for beneficiaries to travel to ration shops.
- Elderly individuals and disabled persons benefit significantly from home delivery services.
- Reduced waiting times and reliable delivery services improve overall satisfaction.

Table III. Performance Parameters

Parameter	Description
Delivery Time	Time reduction
Efficiency	Route optimization
Accuracy	OTP success
Transparency	Monitoring
Scalability	Expansion capability

VII. RESULTS AND DISCUSSION

Simulation-based evaluation of the proposed system indicates improvements in distribution efficiency and transparency.

A. Leakage Reduction

- One of the major improvements observed in the proposed system is the reduction of ration commodity leakage during distribution.
- In traditional Public Distribution Systems, manual record keeping and lack of monitoring often lead to diversion of food commodities to unauthorized individuals or black markets.
- The proposed AI-powered system introduces OTP authentication and GPS-based delivery verification, which ensures that ration commodities are delivered only to the intended beneficiaries.
- When the delivery agent reaches the beneficiary's house, the system sends a One-Time Password to the beneficiary's registered mobile number.
- The delivery is confirmed only after the OTP is entered into the mobile application.
- Additionally, the mobile application records the GPS location of the delivery to ensure that the delivery occurs at the correct address.
- These mechanisms significantly reduce the possibility of fraud and ensure proper distribution of government resources.

B. Delivery Efficiency

- The AI-based route optimization algorithm improves the efficiency of ration distribution.
- The system analyzes beneficiary location data and calculates the most efficient delivery routes for delivery personnel.
- This reduces travel distance and delivery time for each delivery agent.
- By optimizing routes, delivery agents can deliver ration commodities to a larger number of households within a shorter period.
- Reduced travel distance also lowers fuel consumption and operational costs.
- As a result, the overall efficiency of the Public Distribution System improves significantly.

C. Faster Distribution

- The proposed system automates several processes involved in ration distribution.
- Delivery assignments are generated automatically through the system.
- Delivery agents receive delivery schedules and route information directly through the mobile application.
- This reduces manual administrative work and speeds up the distribution process.
- Digital transaction records eliminate the need for paper-based documentation.
- Faster processing and automated monitoring help ensure timely distribution of ration commodities.

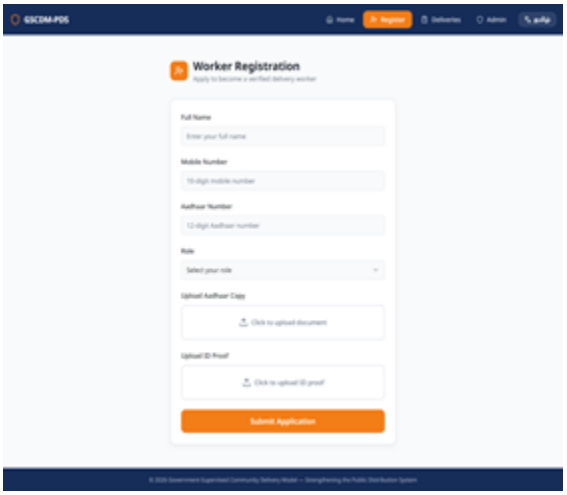
D. Beneficiary Satisfaction

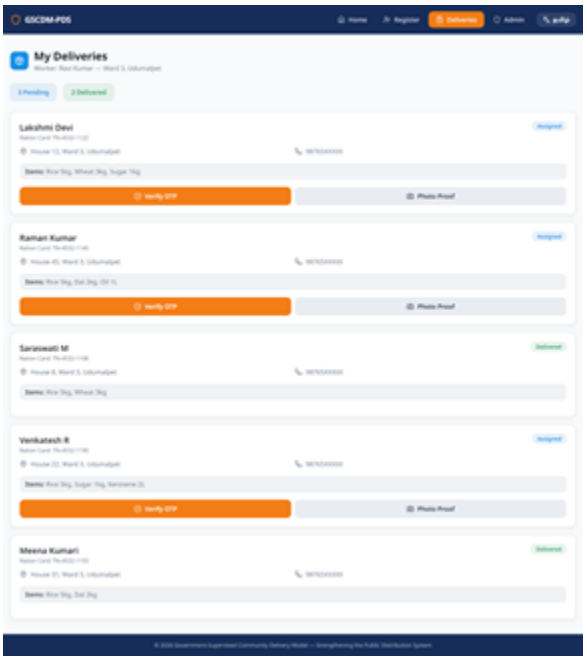
- The proposed system improves beneficiary satisfaction by introducing doorstep delivery of ration commodities.
- Beneficiaries no longer need to travel to ration shops or wait in long queues to receive their supplies.
- This is particularly beneficial for elderly individuals, disabled persons, and people living in remote areas.
- Doorstep delivery also helps working individuals who cannot visit ration shops during working hours.

- The transparent delivery process increases public trust in the Public Distribution System.
- Overall, the system enhances convenience and accessibility for beneficiaries.

E. Workflow of the Proposed System :

Figure 2 presents the prototype-based workflow developed for simulation and demonstration of the proposed system.





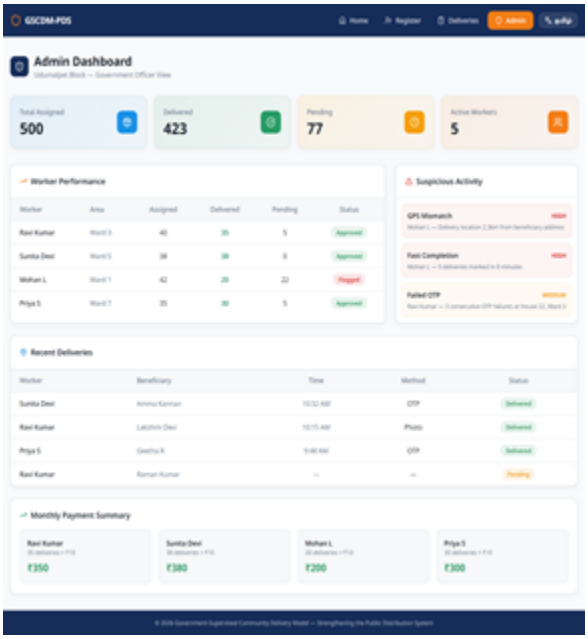


Figure 2. Prototype workflow of the proposed system.

The screenshot represents the functional flow of the proposed system, including beneficiary registration, delivery assignment, OTP verification, and monitoring. The prototype demonstrates the feasibility of integrating AI-based optimization and tracking mechanisms in the distribution process.

VIII. CONCLUSION

This paper presents a proposed AI-powered trusted community delivery model aimed at modernizing the Public Distribution System. The proposed framework integrates artificial intelligence, GPS tracking, OTP-based verification, and centralized monitoring mechanisms to enhance distribution efficiency and transparency.

The system is designed to reduce manual intervention, minimize distribution leakage, and improve beneficiary convenience through doorstep delivery services. The feasibility of the proposed model has been evaluated using simulation-based analysis, demonstrating its potential effectiveness under controlled conditions.

Future enhancements may include the integration of blockchain-based inventory tracking, advanced biometric authentication systems, and emerging technologies such as drone-based delivery for remote and inaccessible regions.

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