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RationSetu: A Unified Intelligent Ration Distribution Platform with Real-Time Stock Availability and Transparent Public Allocation, A Literature Review

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Abstract - The Public Distribution System (PDS) supplies subsidised grain to a few hundred million households across India. But it remains troubled by diverted stock, genuine families being left out, overcrowded fair price shops and grievances that go unanswered. This paper reviews seventeen scholarly and institutional sources that tackle those obstacles and the technologies put forward to ease them: Aadhaar-linked authentication, RFID and embedded devices, blockchain ledgers, ration portability, token and slot-booking methods, and AI-supported complaint handling. Each source was rated on a five-point evidence scale (E1 to E5) and then compared within its theme. Three conclusions stand out. Firm field evidence exists mainly for identity and payment reforms, while most student and prototype work has never been tried in a functioning shop. Tighter authentication cuts leakage but also shuts out some rightful beneficiaries, so a fallback route is fundamental. Stock visibility, queue management and complaint handling are almost always formulated as separate tools. The paper closes with seven research gaps, the shortcomings of current work, directions for further study, and a description of how RationSetu, a web platform that links consumers, distributors and administrators through shared live stock data, responds to these gaps.

Key Words**:** *Public Distribution System, Fair Price Shop, Real-Time Stock, Aadhaar Authentication, Slot Booking, Grievance Redressal, E-Governance, MERN Stack.*

1. INTRODUCTION

The Public Distribution System (PDS) is India's principal channel for delivering subsidised food. Every household holding a ration card is given a fixed monthly grain entitlement under the National Food Security Act of 2013, which the family collects from a nearby fair price shop (FPS). The arrangement looks uncomplicated on paper, and yet outcomes differ broadly from one state to another. A few states have rebuilt their frameworks and now serve most cardholders dependably [1]. But national approximations still show that a troubling portion of the grain never reaches the households it was intended for [2, 3].

Technology has, after all, long been seen as the cure. Across roughly fifteen years, entries were digitised and biometric verification was introduced at the point of sale. What is more, the One Nation One Ration Card scheme permitted migrant workers to draw their grain away from home. In parallel, engineering students and applied researchers have put forward smart cards, blockchain ledgers, token systems and chatbots. The two bodies of work seldom meet: economists ask whether a reform changed leakage, engineers show that a device functions on a test bench, and neither describes what the beneficiary actually experiences at the shop counter.

The project, RationSetu, takes the shop counter as its starting point. It is a web platform with three portals, one each for government administrators, distributors and consumers. Consumers can open a digital ration book, reserve a collection slot for a chosen date, and lodge a complaint supported by text, photographs or video. Distributors work through a prototype electronic point-of-sale (e-POS) workflow, while administrators monitor allocation and stock. The common thread is that all three groups work from the same live stock and allocation figures.

Objectives: This paper aims to (1) summarise what earlier research reports on each element of that idea, (2) assess how far the evidence can be relied upon, (3) compare current methods, technologies and their shortcomings, and (4) pinpoint the research gaps that remain open. The remainder is arranged as follows: Sec. 2 reviews the literature theme by theme; Sec. 3 sets out the research gaps and positions RationSetu against them; Sec. 4 explains the review method; Sec. 5 presents the comparative analysis; Secs. 6 and 7 cover challenges and future scope; and Sec. 8 concludes.

2. LITERATURE REVIEW

2.1 Leakage, Reform and the Difficulty of Measuring It

Early commentators credited the PDS's patchy record to weak governance rather than to a shortage of technology. Drèze and Khera argued that leakage declined in states that broadened coverage, lowered prices and tightened control over grain as it moved down the supply chain [2]. A study of Chhattisgarh by the United States Department of Agriculture (USDA) reaches a similar view: calories received from PDS rice grew nearly tenfold over ten years, but the rise had already begun before the widely cited post-2004 changes, so the authors declined to promise that other states copying those reforms would see the same outcome [1].

More recent figures show how unstable measurement can be. A re-assessment of household consumption surveys places leakage at roughly 42% in 2011–12, 24% in 2022–23 and under 9% in 2023–24 [3]. Its authors are careful about celebrating. Part of the latest drop reflects the end of free pandemic-era grain, and five states record negative leakage, which is possible

only if the survey overstates consumption. Figure 1 sets the competing estimates side by side.

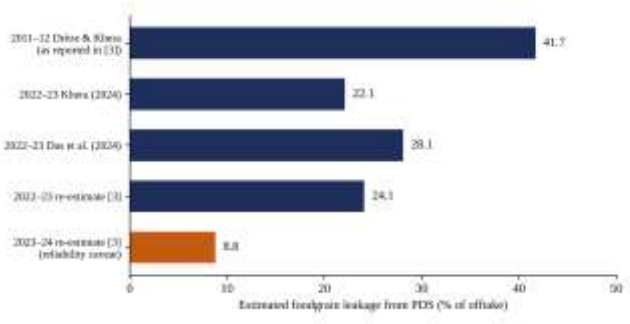


Fig -1: PDS Leakage Estimates as Reported in the Cited Sources (the Orange Bar Carries the Reliability Caveat Discussed Above)

The lesson for a platform such as this one is a modest one: national statistics cannot establish what any single system achieved. The most trustworthy proof will be the platform's own data on grain issued, grain collected and stock held at each shop.

2.2 Identity Checks and the Risk of Exclusion

Biometric identity attracts the most attention in this literature. In Andhra Pradesh, smartcard payments made welfare disbursements faster and more predictable and curbed diversion, at no cost to recipients [4]. A randomised evaluation of a financial-management reform in Bihar found that tighter and more transparent fund flows sharply lowered reported spending, whereas what beneficiaries received showed no measurable change; the saving therefore had to come from leakage [5]. Neither study concerns ration shops, but both suggest that better records can limit theft without harming the people being served.

For the PDS itself, a large experiment on Aadhaar-based biometric authentication frames the central design problem as a trade-off between two errors: admitting the ineligible and turning away the eligible [6]. The authors argue that checking each transaction against confirmed records can remove ghost beneficiaries. They also caution that dealers who lose income may pass that loss on to genuine households, and that strict authentication without a manual override invites exclusion.

Qualitative work shows what exclusion looks like on the ground. In a Rajasthan village, fingerprints worn smooth by farm labour failed repeatedly at the point of sale, and some families could not collect their grain [7]. Allu et al. classify the alternatives by mode (biometric or not), by data source (central or local) and by how often a person is confirmed. They observe that a smart card with a personal identification number (PIN), together with a short message service (SMS) one-time password (OTP), suits elderly people whose fingerprints read poorly. But central verification depends on a consistent network [8].

2.3 RFID and Embedded Smart Ration Shops

A sizeable cluster of engineering papers replaces the paper ration card with a radio-frequency identification (RFID) card, sometimes adding a fingerprint reader. One prototype couples the RFID or fingerprint check with a load cell and sends an SMS to the head of the household once the grain has been weighed out [9]. The attraction is often evident, since it targets leakage at the very last step, where weighing and handover take place. The weakness lies in the evidence; these papers describe circuits and workflows but uncommonly report a trial with real shopkeepers and beneficiaries, so they are graded E4 or E5. Special hardware is also needed in every shop. What is more, the expense of buying and preserving it is seldom tackled.

2.4 Blockchain and Public Allocation Records

Blockchain proposals promise a record that nobody can quietly change and that every party can inspect. Ahanger et al. outline a smart-contract framework in which each stage of grain movement, from the distribution centre to the shop, is written to a ledger and followed with Internet of Things (IoT) devices, so that transactions stay open to scrutiny and room for black-market activity narrows [10]. This speaks directly to transparent public allocation, yet it remains a design framework. Who would operate the nodes, how shopkeepers would be trained, and how the ledger would link with existing state systems are all left unanswered.

2.5 Portability and Migrant Access

Portability allows a cardholder to collect grain at any shop, including one in another state. Jha reports that interstate use under One Nation One Ration Card is still very small, below half a million transactions a month, compared with over twenty million a month for portability within the states [11]. Demand-side factors such as awareness and supply-side factors such as what a shop actually has in stock both appear to matter. The paper recommends stock planning that follows migration seasons, and publicity aimed at particular migrant routes. An Asian Development Bank study examines the same scheme from the user's viewpoint, including how much migrants really know about it [12]. The implication for a platform is that people must be able to see what a shop holds before they travel to it.

2.6 Slot Booking, Queues and Stock Visibility

Overcrowding and long waits have led many groups to propose web-based remedies. Sathya et al. describe a slot-based system in which people pick a time and pay online before visiting, to shorten the queue [13]. Reddy et al. build a token system: beneficiaries register online or at a kiosk, receive an estimated collection time and follow their place in the queue by SMS or app, while shopkeepers view appointments and manage inventory [14]. Rajeswaran et al. present a booking website where the cardholder logs in, selects a day, chooses items within the permitted limit, pays, and collects against an e-receipt; the site also displays shop timings and available stock [15].

These papers share the same basic idea, and all remain prototype descriptions. In the portions that could be read, none reports a controlled measurement of waiting time at a working shop, and none explains a firm cap on the number of households booked into one slot or what happens once a slot is full. One paper shows stock to users and another has the shopkeeper track it, but no paper stores stock, entitlement and booking in a single live record that all three roles can see.

2.7 AI-Assisted Grievance Redressal

A systematic review of thirteen studies on mobile artificial intelligence (AI) chatbots in public services concludes that such tools add value only when a conversation ends in something usable, that inclusion rests on flexibility and trust, and that responsible automation needs a clear path to a human officer [16]. The authors propose judging chatbots by how often they route a case correctly and how well they escalate, rather than by how quickly they reply. Applied work points the same way: one system lets citizens complain by typing, speaking or chatting, and then classifies each complaint using natural language processing (NLP) and sentiment analysis [17]. What is missing is a design built for the PDS. Typical ration complaints, such as short weight, a shop closed during the working hours, a refused entitlement or a failed fingerprint, benefit from photo or video

proof and from routing to the correct level of the supply hierarchy. General grievance systems do not model any of this.

3. RESEARCH GAP

On reading the sources together, seven gaps are spotted that earlier researchers have not closed. Table 1 pairs each gap with the response built into RationSetu and with the evidence that still has to be gathered.

Table -1: Research Gaps, Project Response and Evidence Needed

Gap	Observation in the Literature	RationSetu Response	Evidence to Collect
G1	Stock, queues and complaints are built as separate systems	One platform with admin, distributor and consumer portals on one database	Task tests across all three roles
G2	Consumers rarely see their own entitlement and history	Digital ration book with family details and monthly quota	Usability test with ration holders
G3	Shop stock is rarely visible to consumers and administrators in real time	Live stock figures updated at each distribution and shown on every portal	Accuracy of stock against physical count
G4	Slot systems lack documented capacity control	Date-wise slots with a configurable cap that closes when full	Slot-fill logs from simulation and pilot
G5	General chatbots do not fit PDS complaints	Complaint box with suggestions, photo and video proof, and a helpline	Complaint categories and resolution times
G6	Strict authentication risks exclusion; fallbacks are advised but seldom built	Card ID check now, with OTP and manual override planned beside any biometric step	Walkthroughs of failure cases with distributors
G7	Prototype papers uncommonly test with users or log metrics	Built-in logging of waiting, slot-fill and complaint data	Pilot protocol with preset metrics

4. METHOD

4.1 Search and Selection

The open web and academic indexes were searched with combinations of the terms “public distribution system”, “ration”, “fair price shop”, “Aadhaar”, “blockchain”, “RFID”, “queue”, “slot booking”, “stock” and “complaint”. A larger pool of titles and abstracts was screened, and only those sources that could be opened, read and checked were kept. Seventeen remained. Table 2 lists the inclusion rules and Fig. 2 shows the review workflow.

Table -2: Inclusion Criteria

Criterion	Rule Applied
Topic	PDS delivery, identity checks, portability, queues, stock handling or grievances
Source type	Journal article, conference paper, working paper or institutional report
Period	Foundational work from 2011 onward; most technology papers 2019 to 2026
Language	English
Access	Full text or full abstract available for inspecting

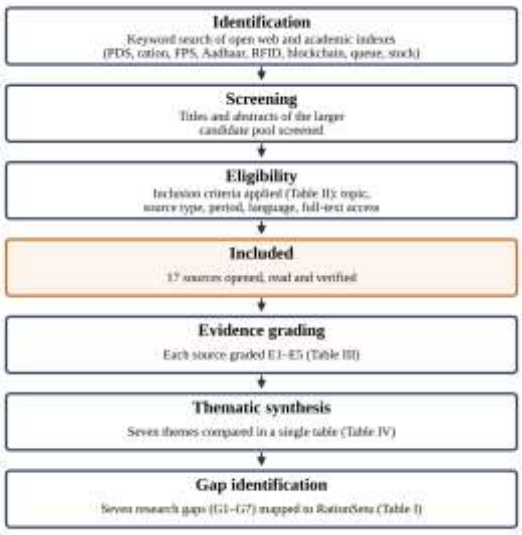


Fig -2: Flowchart of the Literature Search, Selection, Grading and Synthesis Process

4.2 Grading the Evidence

A randomised field study and a three-page prototype description should not carry the same weight, so every source was rated on the five-level scale in Table 3. The same grades are reused in the comparison in Sec. 5.

Table -3: Evidence Grades

Grade	Type of Source	How It Is Used
E1	Randomised or quasi-experimental field study	Basis for claims about impact
E2	Survey, case study or administrative data analysis	Patterns and lived experience; causes stated cautiously
E3	Systematic review or policy study	Synthesis and direction
E4	Prototype with a functional test	Shows it can be built, not that it works at scale
E5	Design or concept proposal	Shows intent only

4.3 Analysis

Each selected source was read in full, placed under one of the seven themes (Sec. 2), rated E1 to E5, and compared on its focus, approach, evidence grade and what it leaves unfinished. The gaps were then derived by looking across the themes for needs that no source tackled.

5. COMPARATIVE ANALYSIS

Table 4 places the technology-oriented sources side by side, giving the evidence grade from Sec. 4.2 and the item each one leaves unfinished.

Table -4: Comparison of Selected Studies

Ref.	Focus	Approach	Grade	What Remains Open
[6]	Biometric authentication in PDS	Randomised experiment with theory	E1	Fallback for failed authentication is advised, not built
[7]	Fingerprint failure in a village	Qualitative case study	E2	One site, no technical remedy tested
[8]	Non-biometric alternatives	Classification of options	E3	No implementation or field test
[11]	Interstate portability	Transaction-data analysis	E2	Tools that show consumers shop stock not examined
[10]	Blockchain ration shop	Design framework	E5	No rollout or cost evidence
[9]	RFID or fingerprint with load cell	Hardware prototype	E4	Hardware at every shop, no field trial
[13]	Slot-based online provisioning	Web prototype	E4	No per-slot capacity logic
[14]	Token queue management	Web prototype	E4	Not tied to household entitlements
[15]	Smart ration booking	Web prototype	E4	Booking, stock and complaints kept apart
[16]	AI grievance chatbots	Systematic review	E3	Not specific to PDS
[17]	AI grievance system	NLP prototype	E4	No PDS complaint types or evidence upload

A clear pattern emerges. The rigorous evidence (E1 and E2) concerns identity, payments and portability, whereas the technologies closest to the shop counter (RFID, blockchain, slot booking and chatbots) sit at E3 to E5. The present RationSetu prototype checks the ration card ID at the e-POS and does not yet match fingerprints; this is regarded as a sensible starting point in light of the exclusion evidence in Sec. 2.2. In addition, any later biometric step is planned only alongside an OTP route and a recorded manual override [6, 8]. The platform is built on the MongoDB, Express, React and Node.js (MERN) stack with token-based sign-in and separate permissions for each user group, a layered pattern also seen in comparable web systems [14].

6. HURDLES AND SHORTCOMINGS

The following problems were spotted in the existing research:

- **Thin field evidence.** Most technology papers are E4 or E5 prototypes or concept designs, and few report trials with real shopkeepers and beneficiaries [9, 10, 13, 14, 15].
- **Unreliable measurement.** Leakage estimates differ widely between studies and years. Also, the most recent figures carry reliability caveats [3].
- **Exclusion risk.** Strict biometric authentication can turn away genuine households, for example when worn fingerprints fail. Also, fallbacks are recommended more often than they are built [6, 7, 8].
- **Hardware and cost.** Devices are needed in every shop by RFID and load-cell solutions, and the cost of procurement and upkeep is rarely examined [9].
- **Rollout unknowns.** Blockchain frameworks leave open how nodes would be run and how shopkeepers would be trained. Also, how the ledger would integrate with existing state systems [10].
- **Fragmented frameworks.** Stock, booking and complaints are formulated separately, with no shared live record [13, 14, 15].
- **Curbed portability use.** Interstate portability remains small, partly because of low awareness and shop-level stock obstacles [11, 12].
- **Generic grievance tools.** AI chatbot work is not tailored to PDS complaint types or to evidence upload [16, 17].
- **Limits of this review.** It rests on seventeen sources that could be opened and verified, uses a simple five-level grading scale, and may miss relevant work that is not indexed or not in English.

7. FUTURE SCOPE

- Pilot RationSetu with ration holders and distributors, fixing the metrics in advance (waiting time, slot-fill, complaint resolution time, and stock accuracy against a physical count).
- Explore tamper-evident allocation records, including ledger-based designs, once the cost and integration questions are settled [10].
- Use shop-level stock data for seasonal stock planning that supports migrant portability [11].
- Extend complaint handling with PDS-specific categories, evidence upload and routing by level of the supply hierarchy, evaluated on routing precision and escalation quality [16].
- Test per-slot capacity logic in simulation and at a working fair price shop, and publish the resulting logs.
- Carry out comparative field studies of RFID, OTP and biometric options, looking at exclusion and cost.
- Build the OTP and recorded manual-override path before any biometric matching is introduced.

8. CONCLUSIONS

The literature indicates that technology can curb diversion when it improves records and accountability, but that identity rules can lock out the very people the system exists to serve. Most student and applied prototypes treat hardware, queues,

ledgers and complaints as separate roadblocks, and very few report measurements from a working shop. RationSetu is therefore best described as a joined-up platform that keeps live stock, entitlement, slot booking and complaints in one place visible to every user group, and that records enough data to be evaluated honestly. The immediate next phases are a pilot with ration holders and distributors employing metrics fixed beforehand, followed by the OTP and manual-override path ahead of any biometric matching.

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