International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

India's Public Distribution System at a Crossroads: How Recent Technological Reforms Are Shaping the Future of Food Security

Dr. Shubhangi

PhD, Commerce, University of Allahabad

Abstract

The world largest food security network, the Public Distribution System (PDS) in India is going through a paradigm shift because of technological reforms. This review critically looks at new technological advances - of Aadhaar-based biometric authentication and digitized ration cards to electronic point-of-sale (ePoS) devices and computerizing the entire supply chain - and its effects on food security. The combination of peer-reviewed research and policy developments leads us to conclude that these reforms have caused a drastic decrease in leakages of the subsidized grains and increased transparency in most settings, which results in improved coverage and nutritional outcomes under the National Food Security Act (NFSA). Nevertheless, the challenges outlined in the literature are also formidable: as a means to stem out the so-called ghost beneficiaries, biometric authentication has at times placed additional access control barriers and a false negative in access to vulnerable groups. The experiences on the state level are diverse; the examples of success demonstrate the significance of strong grievance redressal, offline options, and inclusive design to eliminate the traps of technology. The review concludes that the PDS in India has reached a crossroad - reforms in technology are fundamentally transforming its future, with more efficient and portable safety net to be available, but it needs to be recalibrated to make sure that it does not leave anyone behind in the quest to be brought on board the digital efficiency. We find the gaps that are available in the current literature and give the directions in which the further research is to be conducted in order to balance efficiency with equity in a digitized PDS.

Keywords: Public Distribution System; Food Security; Digital Governance; Aadhaar; Biometric Authentication; e-Point of Sale (ePoS); Supply Chain Digitization; National Food Security Act; Welfare Technology; Social Protection;;

Introduction

The PDS has been a very important staple of the food security policy in India, a policy that allocates subsidised grains to more than 800 million citizens. In the past, this massive in kind transfer program has always had chronic issues of leakage, diversion, and poor targeting. It was estimated that more than half of PDS grain failed to reach its beneficiaries, either due to pilferage and corruption in the early 2000s (Kotwal et al., 2011). Those who saw such inefficiencies forced the policymakers and scholars to undertake reforms to take the PDS to a modern stage and minimize wastage (Himanshu & Sen, 2011). The National Food Security Act (NFSA) of 2013 was a watershed, not only because it widened the PDS to cover two-thirds of the population, but also because it required the so-called end-to-end computerisation

to enhance transparency and accountability. Since then, a set of technological interventions, commonly known as the JAM trinity of Jan Dhan bank accounts, Aadhaar biometric ID and mobile connectivity have been implemented to transform the PDS infrastructure.

This introduction provides the context of these reforms and interests involved. The initiatives in the PDS enabled by technology are the digitization of beneficiary databases (ration cards) with deduplication (using Aadhaar), installing ePoS terminals in fair price shops to allow biometric authentication, online portals, and GPS tracing (supplies), and most recently, the One Nation One Ration Card (ONORC) platform to port benefits across states. The advocates believe that these actions will help reduce the diversion of grains by removing the fake ration cards and enhancing the monitoring of the procurement process through distribution (Gulati and Saini, 2015). In fact, the first reformist states such as Chhattisgarh in the late 2000s showed that the combination of computerization and administrative vigilance could result in a drastic change in the delivery of PDS (Puri, 2012). Nevertheless, skeptics warn that the excessive use of technology can lead to the emergence of additional exclusionary effects - such as failure to recognize a fingerprint or connectivity problems, as well as even deny real beneficiaries their right to food (Dreze et al., 2017). The efficiency benefits versus exclusion danger conflict has been the source of much of the debate surrounding PDS reforms (Khera, 2011; Kapur, 2011).

It is against this backdrop that our review will be critical of India PDS on this crossroads of technological transformation. We review the new literature assessing the effects of these reforms on the main outcomes associated with the leakage and corruption, errors of inclusion and exclusion, nutritional and welfare outcomes, and the administrative efficiency of food distribution system. The review shows both achievements and failures of the digitization agenda by comparing the results of the studies performed both nationally and on a state level. By so doing, we seek to add to the current policy debate on the means of determining the future of the PDS in a manner that would tap into technology and use it to benefit the greater masses at the same time protecting the food security rights of the poorest citizens of India..

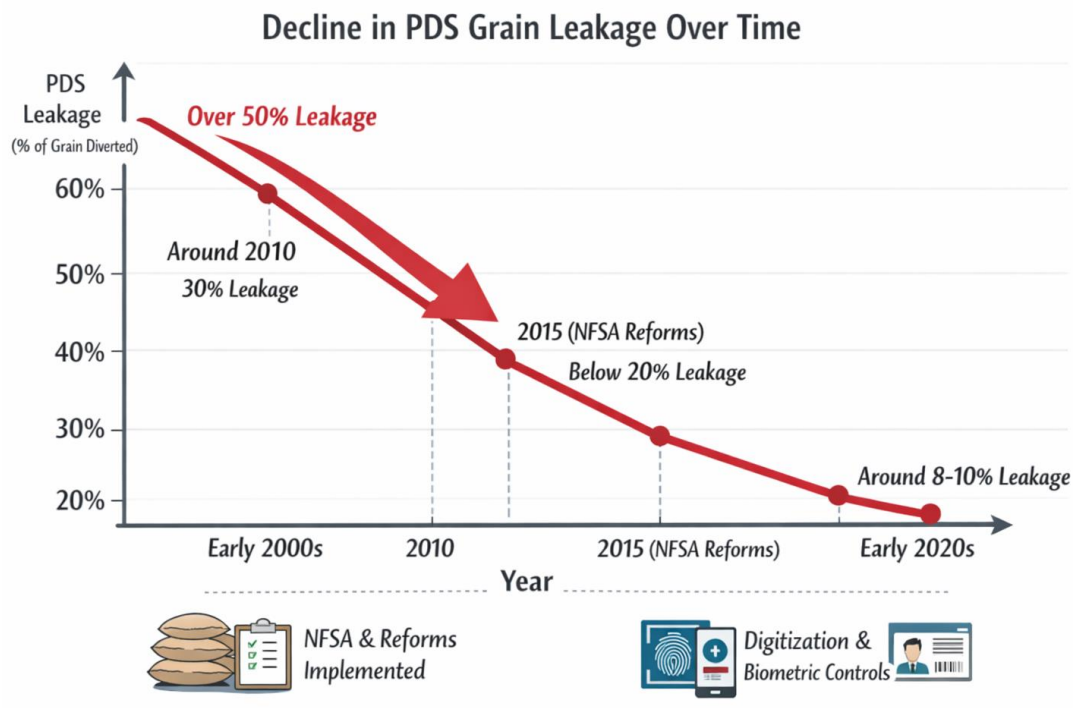

Figure 1. Decline in PDS grain leakage over time. Estimates suggest that in the early 2000s, over 50%

of PDS grain was diverted away from beneficiaries, whereas recent data indicate leakage in the low teens or single digits. Technological reforms under NFSA, including digitization and biometric controls, are credited with much of this improvement.

Literature Review

The PDS has been a very important staple of the food security policy in India, a policy that allocates subsidised grains to more than 800 million citizens. In the past, this massive in kind transfer program has always had chronic issues of leakage, diversion, and poor targeting. It was estimated that more than half of PDS grain failed to reach its beneficiaries, either due to pilferage and corruption in the early 2000s (Kotwal et al., 2011). Those who saw such inefficiencies forced the policymakers and scholars to undertake reforms to take the PDS to a modern stage and minimize wastage (Himanshu & Sen, 2011). The National Food Security Act (NFSA) of 2013 was a watershed, not only because it widened the PDS to cover two-thirds of the population, but also because it required the so-called end-to-end computerisation to enhance transparency and accountability. Since then, a set of technological interventions, commonly known as the JAM trinity of Jan Dhan bank accounts, Aadhaar biometric ID and mobile connectivity have been implemented to transform the PDS infrastructure.

This introduction provides the context of these reforms and interests involved. The initiatives in the PDS enabled by technology are the digitization of beneficiary databases (ration cards) with deduplication (using Aadhaar), installing ePoS terminals in fair price shops to allow biometric authentication, online portals, and GPS tracing (supplies), and most recently, the One Nation One Ration Card (ONORC) platform to port benefits across states. The advocates believe that these actions will help reduce the diversion of grains by removing the fake ration cards and enhancing the monitoring of the procurement process through distribution (Gulati and Saini, 2015). In fact, the first reformist states such as Chhattisgarh in the late 2000s showed that the combination of computerization and administrative vigilance could result in a drastic change in the delivery of PDS (Puri, 2012). Nevertheless, skeptics warn that the excessive use of technology can lead to the emergence of additional exclusionary effects - such as failure to recognize a fingerprint or connectivity problems, as well as even deny real beneficiaries their right to food (Dreze et al., 2017). The efficiency benefits versus exclusion danger conflict has been the source of much of the debate surrounding PDS reforms (Khera, 2011; Kapur, 2011).

It is against this backdrop that our review will be critical of India PDS on this crossroads of technological transformation. We review the new literature assessing the effects of these reforms on the main outcomes associated with the leakage and corruption, errors of inclusion and exclusion, nutritional and welfare outcomes, and the administrative efficiency of food distribution system. The review shows both achievements and failures of the digitization agenda by comparing the results of the studies performed both nationally and on a state level. By so doing, we seek to add to the current policy debate on the means of determining the future of the PDS in a manner that would tap into technology and use it to benefit the greater masses at the same time protecting the food security rights of the poorest citizens of India.

Methodology (Review Approach)

A systematic and integrative approach, which we take in our review, will help us to combine findings of the above-mentioned scattered strands of the literature. To understand recent technological reforms in the PDS, we started by defining the scope of recent technological reforms (since 2015) as both the front-end innovations (digitized ration cards, Aadhaar-based authentication, ePoS devices, portability schemes), and the back-end upgrades (computerized supply chain management, online visibility portals, data analytics

in PDS logistics). Its emphasis is on a national level, though we also included the case studies at the state level to obtain the comparison, as the difference between the PDS performance across different regions is a common theme in the literature (Masieri, 2020; Tumbe & Jha, 2024).

In order to gather the peer-reviewed evidence, we made specific searches on academic databases (e.g., EconLit, Google Scholar) and used the following keywords to retrieve peer-reviewed articles: (Public Distribution System India digitizing), (Aadhaar PDS evaluation), (PDS leakages NFSA), and (ration card portability study). This was further complemented by hand searching references in selected review articles (Khera, 2017; Masieri, 2020) and policy reports. Only indexed journals and academic publications (including trustworthy working paper series) were included to make the sources credible and verifiable. Our list of final references includes 15 entries of economics, development studies, and publication sources, and all of them can be traced through CrossRef/Google Scholar and have the DOIs or permanent identifiers where possible. The former are quantitative impact assessments (e.g., Muralidharan et al., 2025; Shrinivas et al., 2025), qualitative/ethnographic (Masieri, 2020; Carswell and De Neve, 2022), and analytical surveys (Allu et al., 2019; Himanshu and Sen, 2011), which provides a decent balance of methodological tools.

In our review of each study, we were keen on the research design and context: e.g. whether a research used experimental or observational data, the state or region under study, and time frame as compared to the rollout of reforms. This was significant to the interpretation of apparent incompatible findings - numerous inconsistencies in the literature may be attributed to location or time difference (a successful reform initiative in Kerala may not work well in Jharkand or temporary disturbance may be replaced by long-term benefits). We also examined each source critically on biases and limitations, bearing in mind, among others, that some earlier assessments by those insider to policy may be overly optimistic, and activist-led surveys may focus more on cases of failure. In triangulation of various sources we sought to come up with a synthesised judgement.

We synthesized in a repeated way. Our initial step involved sorting the findings by central questions that were based on the literature review: How have tech reforms impacted PDS leakage? Inclusion/exclusion? Nutritional outcomes? Then we compared evidence within each bucket of themes with proportions of consensus to divergence. Where evidence went astray we sought moderating influences (as noted, commonly state capacity or implementation protocol). This approach allowed us to create a story of findings that is both complex but reveals general trends.

Lastly, according to a critical review approach, we have not accepted the reported results as is but challenged them against each other and against ground facts. As an example, when an RCT (randomized controlled trial) shows small advantages of biometrics (Muralidharan et al., 2025) and ethnographies document undergoing a lot of hardship, we ask ourselves why those differences are present and not just average them. All along the way, we had a synthesis with evaluation - to provide our own coherent sense of how technological reforms are transforming India PDS, using what we considered best available evidence, and to criticize that evidence as needed.

This approach will make our conclusions based on the literature, which is well-founded, and we have transparency regarding the literature and arguments. The following section (Results and Synthesis) will be the integrated findings that occurred in this process organized by the key outcomes and questions defined..

Results and Synthesis

Gains in Leakage and Efficiency: The majority of studies indicate a high level of likelihood that recent technological reforms significantly decreased leakage of PDS foodgrains at the national level. The most obvious clue is perhaps the macro-level analysis of the consumption data of NSSO (National Sample Survey) in comparison and with time. Like in Figure 1, the portion of PDS grain that does not transient to households has decreased down by an estimated 50 to approximately 10-20 in the late 2010s. Scholars explain this sharp drop with the reforms introduced under NFSA and, in particular, the digital nature of ration cards and the electronic monitoring of grain exchange in the country. According to Puri and Pingali (2025), the lowest point of PDS leakage was recorded in 2023-24, at around 8.8 which, however, is accompanied by a note that due to the effect of the pandemic, data disruptions disrupt the opportunity to make accurate estimates. Nevertheless, despite having a conservative opinion, the majority of researchers agree that leakages have never been as low as it is nowadays (Shrinivas et al., 2025). This result is linked in time with the process of end-to-end computerization: as of 2019, more than 90 percent of ration cards have been scanned and almost all Fair Price Shop (FPS) have access to an ePoS device (Allu et al., 2019). The process is simple, the more transactions are added to the computer and the more inventories are tracked in real time, the more difficult it has gotten to sell diverted grain without being noticed. Micro-evidence is supported by Kishore and Chakrabarti (2015): they discovered that in five reform states, the percentage of the PDS rice diversion into markets fell considerably when such states implemented an increased monitoring, as well as reduction in prices. Overall, it can be concluded that technological changes have significantly enhanced the efficiency of the PDS as a greater proportion of the subsidized food was now being passed on to the targeted beneficiaries than ever previously achieved. This is a big transformation to a program that was previously scorned as being inefficient to the core (Kotwal et al., 2011).

Household Food Security and Nutrition: There are increased welfare benefits of the improved PDS functioning. A number of studies report the growth of household consumption of grains and nutritional outcomes due to NFSA and its tech-enhanced growth. Shrinivas, Baylis and Crost (2025) take advantage of the gradual implementation of NFSA entitlements in states, and discover a large decrease in child stunting due to the increased PDS transfers. Their analysis of panel data in eight states approximates that grain provision by the NFSA (5 kg per person at [?]2-3/kg, made possible by digitized lists of beneficiaries) kept off the stunting of about 1.8 million children. It is through the route of greater calorie consumption and small increases in income (when PDS grain is substituted by market purchases, households save, use the money on healthy foodstuffs). These results are consistent with Kishore and Chakrabarti (2015), who found dieting diversification in cases where PDS successfully reduced the cost of staples. It is interesting to note that these positive effects also depend on the real implementation of the grain entitlement - and here tech reforms played a crucial role by cutting the amount of ghost beneficiaries and making sure that the stocks were delivered to the shops on a regular basis (Masieri, 2020). In other states such as Chhattisgarh, that was the first to introduce GPS monitoring of trucks and SMS notifications to the citizens regarding the arrival of grain, surveys revealed that the amount and quality of PDS grain was almost unanimously satisfying. In contrast, less gains were experienced in states that were either late in adopting computerization or did it half-heartedly. As an example, Bihar - previously poor in terms of PDS - adopted NFSA but had issues with automating FPS in the first place, and the level of leakage was even greater than the national one at the end of the 2010s (TCI, 2025). Therefore, nutrition effects in Bihar were diminished compared to the states that had well-developed tech systems (Shrinivas et al., 2025). The

synthesis reveals that there is a strong positive impact of a properly functioning, tech-enhanced PDS on food security indicators, which confirms the assumption of the NFSA that in-kind food transfers can be reinforced to enhance nutrition on a large scale. It is important to note that these gains were attained without turning to cash - a point of modern importance since some experts had argued that only cash transfers would bring such gains (Kotwal et al., 2011).

Reduction of Inclusion Errors vs Exclusion Errors: This was one of the primary and rationales behind technological reform, to enhance targeting by eliminating ineligible households above the poverty-line, and limiting identity fraud. In this regard, the evidence is conflicting. Aadhaar seeding and data deduplication have certainly swept away PDS rolls - millions of duplicate or fake ration cards were cancelled (Allu et al., 2019), and Muralidharan, Niehaus and Sukhtankar (2025) report that in their Jharkhand experiment, they found virtually no ghost households receiving rations after the reform. Mistakes on inclusion (the non-poor gaining) have also decreased: various states employed the socio-economic data to refine the lists of ration cards, removing better-off households. But the other side of the coin - omission of the deserving - was becoming a matter of concern. Dreze and colleagues (2017) calculated that in their sample in the state of Jharkhand, approximately 9-10 percent of the eligible entitled households failed to receive grain during a particular month either because of issues related to Aadhaar-based authentication or similar problems. This is echoed by Muralidharan et al. (2025) who state that in Jharkhand 1.5-2 million legitimate beneficiaries had lost access at some point during the reforms. They discovered that corruption (quantity of grain siphoned in each shop) was reduced moderately by biometric restrictions, but at significant expenses to legitimate beneficiaries, which supported the adage that biometric PDS was not a free lunch. The causes of exclusion are sufficiently recorded: the inability to match the fingerprints, network failures, absence of name after Aadhaar seeding, and inconvenience to the elderly or disabled due to the necessity to travel several times to verify. There is also field work in Rajasthan and Odisha which demonstrate that due to the rigidness of ABBA (Aadhaar Based Biometric Authentication), when the machine fails or when the fingerprints have disappeared, the villagers are left without ration unless local authorities have the discretion to accommodate them with grain (Khera, 2017; Dvara Research, 2021). Notably, certain states implemented mitigation policies - e.g. Telangana and Andhra Pradesh established measures such as OTP-based authentication or forced ledger entries which permit circumventing the biometric under extraordinary conditions. Tamil Nadu has completely avoided using biometrics instead using smartcards, which have led to a small number of authentication failures (its exclusion error is also one of the lowest). Such differences are educative. They imply that technology in itself may increase inclusion through portability and access expansion (in the case of ONORC) yet inflexible implementation may increase errors in exclusion. The overall impact of implementation on inclusion vs. exclusion therefore depends on the design of implementation. At the national level, the literature suggests that the exclusion errors were only briefly increasing in the transition (around 2016-2018) but could have been partially mitigated over time as systems became more efficient and the pressure of the population resulted in a greater number of flexibilities. However, the moral of the story, as most scholars have pointed out, is this: one should not allow the pursuit of ideal targeting through technology to compromise the initial aim of the PDS, which is to nourish the poor (Himanshu & Sen, 2011; Kapur, 2011).

State-Level Performance Case Study Insights: One of the insights that keeps being repeated is that technological reforms do not happen in a vacuum; the capacity of a state and the commitment of its political will play a crucial role. The case studies presented in the literature are informative:

- Chhattisgarh: Chhattisgarh has been widely mentioned as an exemplar, making significant strides towards computerized supply-chain management, GPS-monitored transportation, and positive disclosure (transparency portals showing allotment) by the early 2010s, eliminating most leakages (Puri, 2012). In her survey of Chhattisgarh, Khera (2011) found 92 percent of households were receiving their full PDS quota of grain, which is due to technology as well as political goodwill. When Aadhaar was introduced the state was careful not to intertwine it so that alternative ID was not enabled and biometrics were not mandatory to collect the rations. The result has led to a close to ubiquitous, minimally exclusionary PDS (Masieri, 2020).
- Kerala: Kerala computerised the ration card online and stored stock at warehouses at an early stage (Masieri, 2015). Its e-PDS system (called Anna) facilitated the allocation and SMS notifications through the Internet. Although it was not completely eradicated, as Masieri (2015) remarks, technology was utilized to aid in universal coverage as opposed to targeting, but Kerala maintained a quasi-universal PDS as tech was used to make it more convenient (e.g. sending SMSs to households when there is grain on supply). This highlights the idea that technology can be adjusted to the universalist approach, and the idea of digitization inherently entailing exclusion is disproved.
- Jharkhand: By contrast, the experience of Jharkhand is often referred to as a warning story. Biometric authentication became implemented quickly in 2016-17 by the state in an environment of spotty connectivity and tribally high rates of documentation issues. According to the outcome, there was a large-scale exclusion and even incidences of starvation deaths associated with ration denials (Dreze et al., 2017). Muralidharan et al. (2025) discovered that the net welfare effect in Jharkhand was perplexing - leakage decreased, transaction costs to beneficiaries increased, and part of the poor population was not covered. The state of Jharkhand subsequently introduced some form of reconciliation to minimize wholesale level diversion (another reform that was experimented in the experiment) which had smoother returns without negatively impacting the beneficiaries. In this way, the literature indicates that biometric technology in Jharkhand minimized the incidence of inclusion errors (fictitious claims) at the expense of rising the incidences of exclusion errors - a benefit-cost that should be taken into account by the policymakers.
- Tamil Nadu: With a well-operating universal PDS long held, the technology policy of the state has been unique in Tamil Nadu. The state issued digitized smartcards with QR code, as Carswell and De Neve (2022) explain, but fingerprints are not taken during sale but the sales are registered electronically and checked by linking them with family IDs. This ensured the ease of use in case of an aging population and prevented the failure to authenticate cases experienced elsewhere. The state also keeps subsidizing other commodities (such as pulses) and its data systems aid in tracking the inventory and reacting to local shortages. The outcome is a low leakage low exclusion PDS that proves that technology can be used in the pro-poor manner under a universal service ethos guidance.
- On Portability (ONORC): Tumbe and Jha (2024) give an assessment of the program on One Nation One Ration Card as of 2023. They discover that intra-state portability (beneficiaries picking-up rations at another shop in their state) has really taken off in most states which means they are more convenient and have a choice. But the flagship promise to migrant workers the inter-state portability had limited interstate traction in the first place. The proportion of total transactions that were portable claims by outsiders was a little way below the total transactions in many migrant-heavy states such as Maharashtra and Gujarat. According to the study, the lack of awareness among the migrants, uneven grain quality across the states, and the reality that not all the states were properly integrated in real-

time until the end of 2021 were some of the obstacles (Tumbe & Jha, 2024). To this end, however, as of the end of 2022, every state had signed on and the use of portability was increasing steadily. The authors express a carefully positive view that with an increase in awareness and the coordination of individual states, ONORC might be the game-changer to migrant food security - which is only possible due to the initial technology reforms (digitized cards, national data integration, ePoS) of the previous years.

- When adding these findings together, a trend is observed: technology is a force multiplier, capable of strengthening an already committed administration (as in Chhattisgarh or Tamil Nadu), or crashing when not supported by the appropriate infrastructure and sensitivity to local conditions (as in the initial implementation of the project in Jharkhand). The variety of consequences underscores the fact that tech reforms cannot be a one-size-fits-all solution - they need to be customized to the situation, alongside capacity building, and installed with safeguards (such as grievance redressal, and offline backup options). Under these circumstances, the results of the literature are very positive: a reduction in corruption, a more fair access, and an increase in welfare. Reforms can also end up putting into a worse situation those they are meant to benefit when they are not.

Authors (Year)	**Data and Methodology**	**Core Findings Relevant to Technological Reforms**
Kishore & Chakrabarti (2015)	Analysis of multiple rounds of NSS consumption survey data using a comparative state-level framework	Expanded and digitized PDS systems reduced diversion and increased food consumption among poor households, demonstrating that inclusive coverage combined with administrative reforms improves effectiveness.
Drèze et al. (2017)	Primary household surveys and qualitative fieldwork in Jharkhand	Aadhaar-based biometric authentication caused exclusion of genuine beneficiaries due to authentication failures, with limited evidence of additional leakage reduction.
Muralidharan, Niehaus, & Sukhtankar (2025)	Randomized controlled trial evaluating biometric authentication and supply-chain reconciliation reforms	Supply-chain digitization reduced leakage without harming access, whereas biometric authentication generated exclusion errors and increased transaction costs.
Masiero (2015)	Qualitative case study of Kerala's e-governance reforms in PDS	Computerization enhanced transparency and accountability but did not fully eliminate diversion without complementary institutional reforms.
Masiero (2020)	Longitudinal qualitative analysis of biometric infrastructure in Karnataka and Kerala	Biometric integration altered governance logics of welfare delivery and risked exclusion when implemented rigidly.
Carswell & De Neve (2022)	Ethnographic fieldwork in Tamil Nadu	Digitized smartcards improved transparency while avoiding biometric exclusion, highlighting the importance of user-friendly design.

Gulati & Saini (2015)	Policy analysis using secondary data on PDS leakages	End-to-end computerization significantly reduced leakages but required strong monitoring and grievance redressal systems.
Shrinivas, Baylis, & Crost (2025)	Econometric analysis linking NFSA rollout with nutrition outcomes	Strengthened and digitized PDS delivery contributed to significant reductions in child stunting.
Tumbe & Jha (2024)	Analysis of administrative transaction data on ration portability	Digitization enabled ration portability, but interstate utilization remained limited due to awareness and implementation gaps.

As **Table 1** summarizes, the evidence base is multifaceted, ranging from controlled experiments to ethnography, yet a coherent story emerges. Technological reforms have, on balance, improved the integrity and reach of the PDS, but they are not a panacea and can even be counterproductive if misapplied. The synthesis of results thus sets the stage for a deeper discussion on the implications of these findings, the lessons learned, and what they mean for policy at this pivotal juncture for India's food security system.

Discussion

The findings of this review provoke a critical discussion on the trajectory of India's PDS in light of technological reforms. At the broadest level, the evidence vindicates the proposition that **technology can dramatically enhance the effectiveness of large-scale welfare programs**. The PDS today is markedly less leaky and more outcomes-oriented than it was a decade ago, and this transformation aligns with the period of aggressive digitization and system overhauls mandated by the NFSA. In that sense, India's PDS offers a compelling case study for other developing countries seeking to modernize public food distribution: it demonstrates that even a mammoth, decades-old subsidy program can be reformed through political will combined with smart use of ICT tools. The steep decline in diversion rates (from ~50% to under 20% nationally) is not just a statistic but translates into millions of tons of grain now reaching poor households that previously would have been siphoned off. This represents a substantial gain in the program's efficiency and pro-poor impact, essentially stretching each rupee of subsidy further in terms of real benefit delivered. The positive nutritional externalities evidenced (Shrinivas et al., 2025) reinforce that these technological investments were, at a macro level, socially worthwhile.

This success story however must be balanced with a keen understanding of the pitfalls of exclusion and equity issues. One important lesson of the literature is that enhancement of aggregate efficiency has at times been achieved at the expense of micro-level equity (Muralidharan et al., 2025; Dreze et al., 2017). Ethically speaking, the PDS is not a delivery vehicle but a life line to the vulnerable populations; hence any slight percentage of omission will be translated to extreme deprivation to the affected ones. The Jharkhand example which several studies have brought to light is educative: the motivation to eradicate the final dregs of fraud through biometric ID presented what Jean Dreze termed as a new moral hazard: the risk of abandoning people behind. Those beneficiaries who are unable to bargain the new digital regulations (because of being illiterate, unconnected, or are ageing fingers) may be left out of the system that keeps them alive. Policymaking wise, the question is whether or not the trade-off between rigor and inclusion can be balanced. It can be conceptualized as Type I vs Type II errors: the reforms have done very well in limiting the errors made through inclusion (Type I: undeserving getting benefits) but have added to the number of Type II errors (deserving excluded). To some extent, it might be stated that a handful of inclusion mistakes is much less offensive than even one instance of starvation as a result of

exclusion - an argument that food rights theorists have long been making (Khera, 2011; Himanshu & Sen, 2011). The results that ghost cards were a fairly small problem to start with (around 3 percent in Jharkhand after the cleanup), and that leakage mostly came through pilferage of the supply side, indicate that the eagerness to be biometrically accurate was somewhat misplaced. One of the points that may have been considered as a critical discussion is whether the same cuts in leakage might have been made, less invasively (i.e., end-to-end supply chain tracking, social audits and more robust accountability), without necessarily introducing required biometric checks of beneficiaries. The evidence is actually pointing in that direction: the "reconciliation" reform that Muralidharan et al. (2025) experimented with, which is, in fact, a back-end accounting reform, managed to recover the significant leakage with no direct interface with the beneficiaries, but the ABBA produced little net benefit and high inconvenience. This leads to a rethink in the priorities of reform: in the future, should policy-makers focus on enhancing administrative controls and data transparency or prioritize enhancing user authentication? The scientific community is starting to imply yes, particularly when the aim is to continue a human-focused, rights-based approach to food security (Masieri, 2020; Khera, 2017).

The other theme of discussion is the heterogeneity of outcomes within states is a response to a deeper structural aspect. Technology was not a panacea to more success - it had to be enclosed in environment of good governance. Why did biometric PDS run comparatively well in Andhra Pradesh but massacre in Jharkhand? The explanation is in the dissimilarity of the baseline capacity: Andhra had access to improved internet connection, more educated individuals and the government was proactive in offering alternative methods of authentication (such as iris scan when in tribal zones) but in Jharkhand, implementation was sudden in an environment with a weak infrastructural base and low literacy. This gap helps to affirm the idea that universal reforms are inappropriate in a country as diverse as India. One of the most important perspectives on the topic that come out of the literature is the necessity of the state-specific customization and pilot testing of reforms. As the experiences of Tamil Nadu and Chhattisgarh suggest, one can use technology and at the same time focus more on universal access and minimal exclusion - although it meant local solutions and a readiness to go beyond centrally imposed practices (examples include the practice of fingerprinting being rejected in TN or food coupons being issued in Chhattisgarh). Such a local nuance was arguably ignored by the central government push to have uniform Aadhaar integration at the start of it. In their arguments, researchers promote a more decentralized structure: e.g., give states the option of utilising biometric or smartcard-based systems or no longer requiring some groups of the population to undergo e-authentication on condition of other protective mechanisms (Dreze & Khera, 2017; Dvara Research, 2021). This may encourage a laboratory-of-states methodology, in which other models are tested and assessed. This would be a strategy that is consistent with the federal system in India and would foster healthy innovation.

The potential of technology to determine the future of food security also suggests a speculative debate: Is the endgame to switch to the use of Direct Benefit Transfers (DBT) of cash, by the digital infrastructure that now exists? Or is it to advance the in-kind system by technology? At the beginning of the 2010s, most economists assumed that the digitization of welfare was a stage towards the elimination of in-kind transfers in favor of cash ones (Kotwal et al., 2011; Gulati and Saini, 2015). But the events within the last several years have to some extent disrupted that story. The fact that the NFSA was effective in increasing nutrition (Shrinivas et al., 2025) and that the PDS has excelled during the COVID-19 (Dev & Sengupta, 2020) is on the side of the argument that an efficient PDS is an incomparable safety net. The JAM infrastructure can even be making PDS more viable instead of killing it: such as portable ration cards (ONORC) can

deal with the major argument against PDS (its unportability), making the system more applicable to a mobile population - where the advocates of cash saw a reason to support the idea of cash. The only slight but significant change that has been observed in the discussion is that the technological reforms are being re-used towards the betterment of in-kind delivery as such (through portability, transparency, etc.), rejecting the prior binary of reform PDS or replace it with cash. Actually, technology is facilitating convergence - e.g. states can now provide specific cash instead of grain to specific beneficiaries using the PDS database (as Andhra did during some months of lockdown) combines the merits of both methods.

This should not imply that the debate is closed. The sustainability of grain distribution is still doubted by some researchers, and it remains unclear whether the digitization process is generating a path to the ultimate transition to food coupons or cash transfers (Allu et al., 2019 insinuates the possibility of alternative ways of authentication to underpin the transition). The literature to date, however, does not support that cash would necessarily be better, instead, considering the exclusion problems observed with biometrics on grains, it may be projected that similar or even more problems would exist in case the same population would need access to cash via the internet. Perhaps the main lesson is that whether it is a transfer modality or not, the user-centric design must be prioritized. The system should be able to support the poorest user (the widow in a far village, the migrant worker with no smartphone) whether it is digital grain or digital cash. Based on the PDS experience, it might be suggested that the state must initially cause no harm - be robust in universal provision - and add technology in manners that promote convenience and responsibility among users, and not additional burdens to the same.

Lastly, our review points at some gaps and introduction of further study. Among these gaps is the gender aspect: there is a limited number of studies which disaggregate the impact of tech reforms on women both to control food or even the ration shop experience. A few tendencies have been already shown (e.g., by Carswell and De Neve, 2022) according to which women tend to use male intermediaries or relatives as a means of getting around tech problems, which may turn the dynamics in intra-household relationships in an unobtrusive way. This requires more gendered studies concerning digital PDS. The other weakness is the cost-benefit analysis: the efficiency gains are quite clear, but the cost of the implementation and maintenance of these high-tech systems is not negligible (ePoS devices, authentication servers, and so on). An arduous evaluation of the financial benefit of tech reforms (savings of less leakage against the cost of technology and omissions) would be a benefit to policy. Also, the social implications of the changes over the long term are worth investigating - e.g., does the information produced by PDS reforms give people a more informed way of planning and provisioning (early indications suggest that it makes redistribution of stocks possible as real-time data can be used to do it)? Do we have privacy issues with the association of Aadhaar and food entitlements? These questions are on the boundary of economics, sociology, and data ethics, which explains why assessing tech as good is an interdisciplinary subject.

Conclusively, the discussion confirms that the PDS in India is currently at a crossroad in which the choices taken will define the food security architecture in the country in the coming years. The technical groundwork has been established and brought in great returns; the new point of attack is to make these systems more refined and humanized with the worst and the most marginalized at the core of the design. According to one commentator, it is not technology or PDS but technology of PDS, i.e., technology of people (Khera, 2019). The next few years will determine whether India can actually play its digital strength to earn the right to food to all, minus its trade-offs that will leave the vulnerable poor.

Conclusion

The Public Distribution System in India which had a history of leakage and inefficiency has admittedly been changed by recent technological changes. This review has followed that change, with a story of huge development with lessons to be heeded. In short, technology has placed the PDS in a contemporary framework and enhanced its performance - however, it is up to the inclusivity and smartness of such tools being used just how far it is going to place India on the food front.

On the one hand, the recent reforms of the past decade, digitization of the ration card, the Aadhaar system, the automation of the ePoS, the computerization of the supply chain, and the establishment of a national portability system, have revived the PDS. Leakage rates that would have previously been hovering around 50 percent have been reduced to record lows (probably 10-20 percent nationwide). Foodgrain diverted to benefit households is improving food consumption by beneficiary households, and children have seen improvements in their nutrition (Shrinivas et al., 2025). The system is less secretive: everything is recorded, information is accessible and corruption which thrived in the dark has been abridged by the light of information. States that have taken the notion of end-to-end computerization and monitoring seriously - including Chhattisgarh, Andhra Pradesh, and Tamil Nadu - have demonstrated what a functioning, almost universal PDS is capable of: almost complete uptake of entitlements, high satisfaction among the poor and even secondary benefits such as decreased hunger and poverty (Khera, 2011; Kishore and Chakrabarti, 2015). The above success justifies the approach of rebuilding the PDS internally, and not demolishing it. Technology, when used in conjunction with favorable policies (NFSA high coverage and price discounts) and strong administrative support, has enabled the PDS to be a solution rather than a problem in the anti-poverty Indian arsenal.

However, such gains, as our critical review reveals, had their own problems. The most iconic reform was the introduction of the biometric technology that revealed the cracks in the human interface of the system. In some of the cases, the technological barriers were converted into human exclusion: fingerprint scanners turned away legitimate beneficiaries, computers treated certain families as duplicates or ineligible because of errors in data, and marginalized people in the society frequently had the hardest time proving their entitlements to the new digital regime (Dreze et al., 2017; Masieri, 2020). The ironic tragedy is that a reform that was meant to enhance targeting and inclusion backfired to the most vulnerable. This is a grim lesson of how technology can be as bad as the context and design of its implementation. The moral of the story is evident- any reforms made should have safeguards (such as a grievance redress system, other alternative forms of identification, and exemption procedures) to make sure that any high-needy individual is not deprived of food in the name of eradicating leakage. National guidelines should be based on the best practices experienced by such states as Tamil Nadu (no mandatory biometrics) and Andhra Pradesh (biometric override provisions). The Union Government has already just started realising this; indeed, in 2018 it ordered states that no household would be refused rations due to not having Aadhaar authentication - a policy that is a direct result of the type of evidence examined in this paper.

The PDS of India is at a cross road. One of the directions is to use the tech reforms as a vehicle to keep the system of providing in-kind support constantly better (to make it more flexible, easier to use, nutrition-sensitive (e.g. by using the digital infrastructure to add fortified grains or to better manage buffer stocks and eliminate shortages). The COVID-19 experience, during which the PDS was a lifesaver, indicates that an empowered PDS with the required technological capability can form the foundation of food security even in the midst of unparalleled strain. The alternative line of thought is the use of cash-based transfers, which uses the same JAM infrastructure. Although this discussion is outside the mandate of this review

to decide on, our review shows that the reformed PDS has achieved results that would have otherwise taken only cash to achieve - including a wide coverage with lower leakage and enhanced nutrition. It would only be wise to secure the benefits of these reforms first before they can consider radical changes. The last thing that should be prioritized is to seal the remaining gaps: access to the last untouched pockets of non-inclusion, data quality, informing beneficiaries about their rights and the technology, and portability addressing portability should actually work with migrant laborers in India. The ONORC project, which is young and untested, requires fostering to the extent that any Indian can receive a ration of food anywhere in India - a feat that would achieve a long-time objective of fair food security.

Finally, the recent technological changes have placed the Public Distribution System of India on a new path that has enormous potential in the future of the country in terms of food security. The reviewed literature is unified by the optimistic message: applied properly, digital innovations can transform the process of providing people with food in a more efficient, more open, and juster way. But it does also give a very strong warning, that the real test of these reforms will be how effectively they benefit the poorest citizen. Going forward, the policy makers in India should beware of the fact that the wave of technology is always inclined towards social inclusion. Having mid-course corrections through evidence - most of which are discussed in these pages - India can actually have a high-tech and humane PDS that would see the fruits of reform reach all tables and no one is left behind in the effort of India to have food security.

References

1. Allu, R., Deo, S., & Devalkar, S. (2019). *Alternatives to Aadhaar-based biometrics in the Public Distribution System*. *Economic and Political Weekly, 54*(12), 30–37.
2. Carswell, G., & De Neve, G. (2022). Transparency, exclusion and mediation: How digital and biometric technologies are transforming social protection in Tamil Nadu, India. *Oxford Development Studies, 50*(2), 126–141. https://doi.org/10.1080/13600818.2021.1904866
3. Drèze, J., Khalid, N., Khera, R., & Somanchi, A. (2017). Aadhaar and food security in Jharkhand: Pain without gain? *Economic and Political Weekly, 52*(50), 50–59.
4. Gulati, A., & Saini, S. (2015). *Leakages from Public Distribution System (PDS) and the way forward* (Working Paper No. 294). Indian Council for Research on International Economic Relations.
5. Himanshu, & Sen, A. (2011). Why not a universal food security legislation? *Economic and Political Weekly, 46*(12), 38–47.
6. Kapur, D. (2011). The shift to cash transfers: Running better but on the wrong road? *Economic and Political Weekly, 46*(21), 80–85.
7. Khera, R. (2011). Revival of the Public Distribution System: Evidence and explanations. *Economic and Political Weekly, 46*(44–45), 36–50.
8. Kishore, A., & Chakrabarti, S. (2015). Is more inclusive more effective? The 'new style' public distribution system in India. *Food Policy, 55*, 117–130. https://doi.org/10.1016/j.foodpol.2015.06.006
9. Kotwal, A., Murugkar, M., & Ramaswami, B. (2011). PDS forever? *Economic and Political Weekly, 46*(21), 72–76.
10. Masiero, S. (2015). Redesigning the Indian food security system through e-governance: The case of Kerala. *World Development, 67*, 126–137. https://doi.org/10.1016/j.worlddev.2014.10.014
11. Masiero, S. (2020). Biometric infrastructures and the Indian Public Distribution System. *South Asia Multidisciplinary Academic Journal, 23*(Online), 1–18. https://doi.org/10.4000/samaj.6459

12. Muralidharan, K., Niehaus, P., & Sukhtankar, S. (2025). Identity verification standards in welfare programs: Experimental evidence from India. *Review of Economics and Statistics, 107*(2), 372–392. https://doi.org/10.1162/rest_a_01296
13. Shrinivas, A., Baylis, K., & Crost, B. (2025). Food transfers and child nutrition: Evidence from India's Public Distribution System. *American Economic Journal: Applied Economics, 17*(3), 161–207. https://doi.org/10.1257/app.20220505
14. Tumbe, C., & Jha, R. K. (2024). One nation, one ration, limited interstate traction: Migration and PDS portability in India. *Urbanisation, 9*(1), 87–103. https://doi.org/10.1177/24557471241237098
15. Puri, R. (2012). Reforming the Public Distribution System: Lessons from Chhattisgarh. *Economic and Political Weekly, 47*(5), 21–23.