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**CHALLENGES OF DIGITAL TRANSFORMATION AND INDIAN PUBLIC
DISTRIBUTION SYSTEM: A SYSTEMATIC REVIEW**
Short-running title: Pitfalls of Digital Transformation in Indian Public Distribution System

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Abstract: The public distribution system of food in India targets vulnerable components of society. The system has been organized differently by the different states of India, with different variable results. Thus, the present study focuses on the ICT module advancement originated by GOI (Government of India) and highlights the impact of ICT on the PDS. A comprehensive review directed in December 2020 to recognize the articles that explored the literature on the digitalization of the PDS and various ICT reforms in India by browsing various databases. The study finds a prerequisite to organizing an awareness campaign for the beneficiaries regarding the benefits of an automated system. The study assessed that from the various initiative ICT modules, Aadhaar based biometric mode of authentication and allocation of FPSs through ICT seems to be more effective and find the difficulties in executing schemes. Thus, the administration's responsibilities are to address these uninvited difficulties and alter these schemes by developing operative networks with innumerable stakeholders. Therefore, central and state governments should make participative policy probable by involving the residents, civilian organizations, and programmer experts. Moreover, this paper will help the Government, academic literature, and policymakers build robust models using ICT interventions in food security programs.

Keywords: Public Distribution, Digitalized mechanism, India, Economic policy, Web portals, Integrated technology

摘要：印度食品的公共分配系统针对的是社会弱势群体。印度不同的州对系统进行了不同的组织，产生了不同的结果。因此，本研究侧重于由 GOI（印度政府）发起的 ICT 模块进步，并强调了 ICT 对 PDS 的影响。于 2020 年 12 月进行的全面审查旨在表彰通过浏览各种数据库探索有关印度 PDS 数字化和各

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种 ICT 改革的文献的文章。该研究发现了为受益人组织有关自动化系统好处的宣传活动的先决条件。该研究评估了从各种倡议 ICT 模块来看，基于 Aadhaar 的生物识别模式通过 ICT 进行身份验证和 FPS 分配似乎更有效，并发现了执行计划的困难。因此，行政部门的职责是通过与无数利益相关者建立有效的网络来解决这些不请自来的困难并改变这些计划。因此，中央和州政府应该通过让居民、民间组织和程序员专家参与进来，使参与性政策成为可能。此外，本文将帮助政府、学术文献和政策制定者在粮食安全计划中使用 ICT 干预措施建立健全的模型。

关键词：公共分发，数字化机制，印度，经济政策，门户网站，集成技术

1. Introduction

The utilization of ICTs is to provide upgraded facilities to the residents by intensifying the limpidity of an administrative organization (Puri, 2012). The practice of ICTs in governmental organizations fills the gap between the residents and government agents (Bhuniya, 2011; Chhabra et al., 2016; Grover and Chopra, 2017). Technology implementation is not the solitary aspect that influences the extensive alteration of community supervision in the state—technology adoption by operators mains to fulfill projected purposes (Weerakkody et al., 2013). Employing ICTs in the public sector cannot be esteemed without understanding the challenges faced by mediators in accepting advanced technology. According to UNESCO, "E-Governance is defined as the usage of technological intervention in Public sector with improved communication information networking, better service delivery, decentralized decision-making process, effective limpidity, and accountable governance as the aim of these ICT interventions." ICTs adoption in the Public section cannot be accepted because of the hurdles and obstacles confronted by mediators. Traditionally, ICTs adoption and citizen utilization were the emphases of maximum researchers. However, numerous studies have accentuated the importance of reviewing the role

of technology, technology adoption, and attitudes of mediators in e-governance (Chopra and Rajan, 2016; Weerakkody et al., 2013).

According to the Food and Agriculture Organization (FAO) of the United Nations, 2014, "India is still struggling with extensive poverty, malnutrition, and hunger which accounts for more than 24 percent of the world's food insecurity". The fact is that starvation disseminates the vicious circle of poverty is embedded in previous studies (Pathak & Singh, 2011), and the primary precedence of the Indian Government is to accessing the proper diet for the poor. The Indian Government has commenced with numerous e-governance and targeted distribution schemes to create more conscientiousness in food security programs. Black marketing ICT intervention is essential to make the PDS effective and overcome corruption (Chopra and Rajan, 2016). Digitalization in the FPSs reduces the diversion and leakages of food grains by increasing the limpidity (Bathla et al., 2015). More than 160 million households are served under PDS schemes, but India still accounts for 195 million are undernourished (Chhabra et al., 2018; Grover and Chopra, 2017; Chopra et al., 2017; FAO, 2019). Economic and physical accessibility of food commodities is provided to the BPL households amid the world's chief circulation network with more than

535,000 FPSs (Chhabra et al., 2016). Still, many inefficiencies are found in the food supply system, like leakage and diversions, counterfeit cards, and black marketing (Rajan et al., 2016). Certain states' preemptive use of E-PDS has led to substantial enhancements in intensifying transparency, empowering beneficiaries, and diminishing fraud from the system. Other advantages of digitalized PDS include slashed transaction time, easier recipient verification, investigation of transaction data, and user-friendly progressions (Chopra and Rajan, 2016). Ejiaku (2014) revealed that prevailing studies did not unambiguously apprehend the complications faced by the stakeholders, beneficiaries when exposed to new technology. Hence, there is an intense prerequisite to study the challenges while experiencing wit new technology adoption. Thus, the present objective of the study to highlight the digitalized modules initiated by GOI progress and their impact on PDS, reviewing the materials and methods behaved to finds the issues and benefits, and, lastly, exploring the future scope. For the accomplishment of the purpose, the present study has been divided into four sections. The primary segment highlights the role of ICT on Indian PDS and its effectiveness. The secondary section talks about materials and methods, section deals with data extraction. The following section examines the theocratical background, which reports the explanation of the planning module, benefits to be, and prior issues in the system. Lastly, the

discussion section concludes the discussion as well as the findings of the study.

2. Material and Methods

To identify the barriers, challenges, benefits, and implemented ICT reforms on the PDS, the author supported the systematic review by subsequent the "Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines" (Oberoi & Kansra, 2019). The article follows guidelines as well as procedures of writing to improve the eminence of the systematic review.

2.1 Searching and Screening

An encompassing desk search was conducted for all articles, thesis, and reference papers in available databases using prearranged keywords. The investigation was born in the following databases: MEDLINE, Scopus, Web of Science, ProQuest, EBSCO, Grey literature (FAO, World Bank, IFPRI, and UNSDG), and peer-reviewed journals. Comprehensive literature is addressing digital technology, PDS, food schemes, cultural and economic aspects. Additional studies were explored by scrutinizing the references of including articles or backward referencing, which lead to the expansion of the search articles list. The search terms were adjusted by the various databases to intensification the possibility of retrieving material. Table1 represents keywords and search terms used in the scoping review.

Table 1: Keywords Searching Criteria

Keywords Search Criteria	
Digital Technology	Internet, Web-based, online, Data Visualization, Mobile application, ICT, Digital Governance or E-Governance, Biometric Infrastructure, Smart Phone,

	Webcast, Web browser, Smart Phone, Digitalization, Technology, Use of GPS technology, Smart card, SMS based monitoring
PDS	Public distribution System, TPDS, Indian PDS, Revamped PDS CORE-PDS, Reconstruction of PDS, Storage and Distribution, Fair Price shops
Food Security	Food accessibility, Food availability, Food utilization, Procurement, Distribution, Nutritional Security, Sustainability

2.2 Search Criteria

The inclusion criterion for scrutinizing articles as follows: a) including all the publications, which have been conducted on enhancing the Public Distribution System through digital technology; b) covering Indian nation and its states; c) were of research under the journals that are to be peer-refereed articles in English language only from 2009-2020, including quantitative, qualitative and mixed search empirical search; d) Indexed in Scopus, web of science, Google scholar,

Emerald, and Medline. The exclusion criteria for systematic review as follows: a) publication in which original papers have not been published in the English languages; b) Book and book Chapters; c) publications not available in the full text; c) Website and newspaper articles; d) Social Media content; e) Studies on digital public health, including interventions but not associated to the dimensions of food security; f) Published in non-peer reviewed journals (Oberoi & Kansra, 2020).

Table 2: Description of Search Criteria for Scoping Review

Description	Inclusion Measures	Exclusion Measures
Language	English	Published in Language other than English
Time Frame	2009-2020	Pre2009
Publication	Peer- reviewed Literature	Website, Newspaper articles, and social media content, posters, editorials, and opinion pieces
Study Topic	Studies refer to e-governance, digitalization, food security, distribution system, and government policies related to the public distribution system.	Involve public health, climatic change, and water management aspects.
Population	Indian Indigenous population	Relates to the non-indigenous population

2.3 Identification of Relevant Papers

The process of identification of relevant papers can be witnessed in Figure 1. At the first stage, they primarily screened the titles and abstracts to identify potentially relevant articles. At the 2nd stage, screening of full text. Once all the records are filtered by the eligibility criteria for inclusion and exclusion criteria. Data were extracted, and only 27 papers met the eligibility criteria for this study. A brief account of work reported by past researchers has been discussed according to constructs wise in the following heads:

Table 3: Summary of Digital Technology Influencing PDS Profile of Review Studies

Sr. No.	Author	Year	Study Area	Major Findings	Issues	Solutions
1.	Aher et al.,	2017	India	The study's main aim is to overcome corruption and malpractices by using 'Automatic Ration Card Using RFID and GSM'. The study found that this system will help in maintaining transparency in PDS and the database can be kept effectively.	<ul style="list-style-type: none"> • Bribery • Uneven distribution • Ration forgery 	<ul style="list-style-type: none"> • Purchase Module • Alert Module • Stock Module • Biometric Verification Module • RFID Card Verification Module • Login Module
2.	Bhattacharya et al.,	2017	India	The targeted public distribution system plays a vigorous role in the social protection of the Indian economy by providing subsidized food. The Government of India diversified the various programs but continuously emphasized the targeted distribution system by implementing	<ul style="list-style-type: none"> • Identified Beneficiaries • Urban bias • Extensive leakages 	<ul style="list-style-type: none"> • Doorstep Delivery of food commodities. • Usage of GPS technology. • Digitalized Ration Cards • Grievance Redressal Mechanism (GRM)

				reforms in the policy through ICT.		
3.	Biswal and Jenamani.,	2018	India	The study investigated the impact of RFID adoption in non-profit supply chain organizations. It revealed that incentives to deploy RFID hinge on the denial cost, the brutality error, and contraction in retrieval.	<ul style="list-style-type: none"> • Inclusion and exclusion error • Storage • Transportation • Distribution • Bogus ration card 	<ul style="list-style-type: none"> • Digitalized database • Computerized Supply Chain • Transparency portal
4.	Chatterjee, R	2020	India	The study suggested that India's technological upgradation and innovative strategies bridge the gap between the various shocks like socio-economic and health.	<ul style="list-style-type: none"> • Transportation • Hampering agricultural logistic and supply chain 	<ul style="list-style-type: none"> • Mechanized machinery for farmers
5.	Chhabra and Chopra	2016	India	The studies identified the various hurdles that affected the implementation of point-of-sale devices by using Six Sigma methodology and revealed that smooth adoption of point-of-sale devices helps to the which will translate in the smooth supply chain of the	<ul style="list-style-type: none"> • Grain leakage • Distribution error 	<ul style="list-style-type: none"> • Less pilferage • Smooth commodity distribution • Automated machinery facilitates the FPSs dealers

				commodity at various levels.		
6.	Chhabra et al.,	2020	India	The study indicated that technology anxiety, Internet trust, and resistant change in technology impacted user adaption behavior.	<ul style="list-style-type: none"> • Grain leakages • Diversions • Black marketing • Corruption 	<ul style="list-style-type: none"> • Enhanced ICT users' skills
7.	George and McKay	2019	India	The study emphasized the influential role of the distribution system in tackling poverty, hunger, and malnutrition and highlighted the role of food security and child mortality due to operational inefficiencies.	<ul style="list-style-type: none"> • Leakage • Corruption • Diversion of grains 	<ul style="list-style-type: none"> • Tracking and electronic Governance • Enhancement in the Govt. programs
8.	Gowd KK	2020	Chhattisgarh, India	The present study CORE distribution system in Chhattisgarh state and access the main determinants by evaluating the role of government and NGO performers in the implementation of the distribution system.	<ul style="list-style-type: none"> • Exclusion and inclusion errors • Issues in the Biometric Authentication System • Food grain diversion • Bogus and Ghost cards 	<ul style="list-style-type: none"> • Electronic PDS system • CORE-PDS
9.	Granheim et al.,	2020	India	The study aimed to support digitalized systems in the food supply chain, and the thematic	<ul style="list-style-type: none"> • Food leakage • Operational efficiency 	<ul style="list-style-type: none"> • Computerized procurement and distribution • Transparency

				research showed the trends and potential significances on nutritional status.		
10.	Jharkhand et al.,	2016	India	The study used a novel approach to PDS using smart cards based on RFID. The study found that this approach can break barriers like duplication, security and is the efficient way of PDS. It also helped in deduction manual work and malpractices in the system.		<ul style="list-style-type: none"> • Invalid and dummy card escaped • The quantity acquired by the beneficiaries. • Usage of Ration Card
11.	Kaur	2019	India	The study addressed the framework of the Indian food security system and ensured safety through PDS and NFSA	<ul style="list-style-type: none"> • Procurement • Warehousing • Wastage • Frauds • Food Adulteration • Inferior food quality • Corruption 	<ul style="list-style-type: none"> • Transparency • Traceability • Accountability • Blockchain • Artificial Intelligence • Robotics • RFID • Food Security • Crop diversification and food price stabilization • Effective water management
12.	Kumar and Mohanty	2012	India	The study investigated the implication of HFS and consumer protection in India.	<ul style="list-style-type: none"> • Fraud • Corruption • Black Marketing 	

				The study revealed a lot of inefficiency in the system due to fraud and corruption in PDS. The study also suggested some measures to overcome this problem at a micro-level.	<ul style="list-style-type: none"> • Inefficiency in the operational management 	
13.	Kumar and Pal	2013	India	The empirical study tried to develop a framework for Integrated ICT and PDS in developing economies to improve the system. The study found that ICT framework effectiveness needs good internet connectivity, seeding of Aadhaar, bank details of the beneficiaries, efficient human resources, and proper upgrades of hard wares and soft wares at each level.	<ul style="list-style-type: none"> • Diversion and leakage of food grains • Bogus Cards • Lack of transparency • Mismanagement and ineffectiveness in supply chain 	<ul style="list-style-type: none"> • Digitalized tracking movement • Use of GPS technology • Aadhaar Card Seeding • Technology Advancement
14.	Menon	2018	Jharkhand	The study explored Aadhaar based biometric authentication in Ranchi. The study found that beneficiaries could not get the full benefit of the system due to	<ul style="list-style-type: none"> • No UID member has been registered • UID has been registered but with mistakes • UID has been 	

				incomplete information.	registered and confirmed, but biometric authentication was unsuccessful	
15.	Masiero	2015	Kerala	The study revealed the role of e-governance in designing policies. The study showed that digitalized programs had been persistently formulated to combat rice mafia diversion and mistargeting of beneficiaries.	<ul style="list-style-type: none"> • No mobile number has been registered • The mobile number has been registered, but OTP does not reach the beneficiary 	<ul style="list-style-type: none"> • E-governance adoption
16.	Masiero and Prakash	2019	Karnataka	The study investigated the role of ICT in anti-poverty schemes like PDS. The data was collected from the survey which was conducted in Karnataka.	<ul style="list-style-type: none"> • Leakages • Illegal diversions of goods • Rice mafia • Market Diversion • Ghost cards 	<ul style="list-style-type: none"> • Institutionalization of ICT innovation

17.	Pathak et al.,	2020	India and its Various states	The study analyzed the challenges and issues regarding food security faced by an old citizen and a vulnerable society based on a systematic review. Also, analyzed the macro-level aspects to strengthen the Public distribution system and various programs allied with migrant workers, laborers, and farmers.	<ul style="list-style-type: none"> • Exclusion errors • Leakages in PDS • Black marketing of food grains • Disrupted supply chain 	
18.	Pathan et al.,	2018	India	The study studied the intelligent ration card system. The study found that this process or framework will help the administration efficiently provide ration with the beneficiaries.		
19.	Reardon	2020	India	The study revealed the relationship between the transaction cost and uncertainty in the economy due to some external shocks that transformed the supply chain, which ultimately affected the food security of the economy at the		

				national and household levels.		
20.	Satyanarayana and Rajasekhara	2019	Andhra Pradesh	The study investigated the impact of ICT in PDS in Andhra Pradesh. The study found that Aadhaar seeding was the process that was added to the system. This process will help in rooting out the duplication. The study found that AEPDS and ICT was the best practice done.	<ul style="list-style-type: none"> • Transparency Issue • Poor Governance and operational services • Delivery mechanisms • Exclusion errors • Inclusion errors • Diversion of grains • Duplicate cards 	<ul style="list-style-type: none"> • Aadhaar seeding • ICT reforms in PDS
21.	Shukla et al.,	2015	India	The study identified that agricultural practices and distribution systems where the technology can have a high impact acknowledged the need for advanced schemes and improvement in operational management to avoid duplication and discrepancies in the system.	<ul style="list-style-type: none"> • Procurement • Transportation • Storage • leakage and spoilage 	<ul style="list-style-type: none"> • Follow the biodegradable ways • Opt Environment-Friendly methods • Proper warehousing and distribution channel • Sustainable aquaculture and livestock farming
22.	Singh et al.,	2020	India	The study proposed the conceptual model for the blockchain by using		

				the Hyperledger fabric and big data analytics and supporting the various stakeholders' decisions.	
23.	Singh S. et al.	2020	Tamil Nadu, India	The study adopted the simulation model for PDS smooth networking and help in developing a robust supply chain to fulfill the demand of beneficiaries. Also, assist in providing decision-making provision for redirecting the vehicles.	<ul style="list-style-type: none"> • Lack of authentic identification of beneficiaries • Issues of ghost ration cards • Leakage of food grains during the process • Lack of real-time monitoring system • Lack of decentralized database to store data, but more importantly • Issue of trust and a single source of truth
24.	Upendra et al.,	2020	India	The study focused on strengthening the economy in food security because a continued increase in the population	<ul style="list-style-type: none"> • Digital agriculture • Smart farming • Supply chain strategies

				increases the demand for food, but on the other side, Climatic condition is highly variable, which become the major obstacles in the agriculture practices to achieve improved crop yield.		<ul style="list-style-type: none"> • Weather forecasting techniques
25.	Valarmathy et al.	2013	India	The study introduced substituting ration cards with the computerized commodity dispensing machine that operates on the technology of RFIDs and GSMs which will help in check on wastage and misconduct or malpractices		<ul style="list-style-type: none"> •Automated Ration Cards •Use of GSM and RFID technology •Digitalized supply chain system
26.	Wani et al.,	2019	India	For achieving the targets set by the Government of India major obstacles are a low investment in agricultural technologies, Lack of technical knowledge and awareness about the technological update, poor infrastructure, and complex and	<ul style="list-style-type: none"> •Availability •Affordability •Quality •Safety 	

				lengthy value chain by involving a large no. of intermediaries. The major factor of stagnant productivity levels in the economy is a lack of awareness among the farmers.		
27.	Masiero	2020	Kerala and Karnataka	Computerization of social protection schemes and effects of digital transformation on electronic APDS	<ul style="list-style-type: none"> • Food Diversion • Exclusion Error • Uncertain transition of cash transfer System • Technological Malfunctioning 	<ul style="list-style-type: none"> • Datafication of population

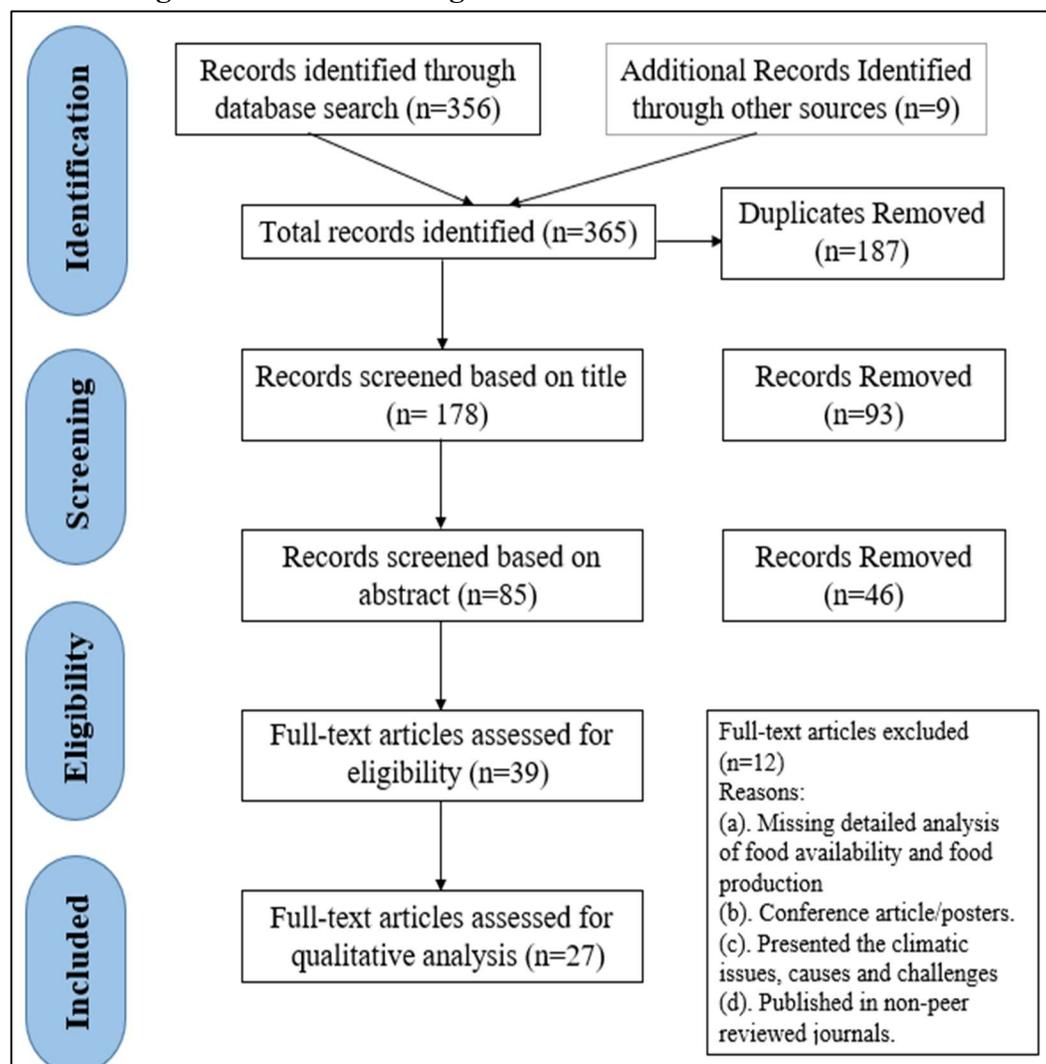
3. Theoretical Background

ICT adoption in PDS contributes to eradicating poverty and hunger. Even the Government of India introduced RPDS, TPDS, E-Pos Machines, AAY, Seedling of Aadhaar card, DBT, food coupons, etc. The noticeable characteristics are universal coverage, high physical access, prioritize the beneficiaries, providing subsidized food. But the main drawback of this distribution system is low quality and quantity of food grains, diversion of foodstuffs, disrupted supply chain and black marketing, etc. (Gowd KK. et al., 2020; Granheim et al., 2020; Jha et al., 2013; Ghumaan and Dhiman, 2014). To make the PDS effective and overcome the numerous prior drawback's ICT adoption and E-governance are

crucial. Some initiatives are taken for E2EC (End to End Computerization), using biometrics (Balani, 2013; Chopra and Rajan, 2016). The digitalization of the distribution system helps to resolve the problems and challenges to a great extent. Enhanced transparency is attained by making information generally accessible to all stakeholders involved in the supply chains. It is mandatory to analyze the effectiveness of digitalized PDS. So, other benefits and challenges of implementing ICTs are showed in Fig.2. This conceptual framework also comprises various technologies viz; Microsoft office, web servers, JSP, HTML as the front-end client. This section builds the basis of the proposed framework by inspecting the current status of

current ICT intervention and reforms adopted by PDS to determine the issues and challenges in the system.

Figure 1: PRISMA Diagram for Detailed Inclusion Criteria



Source: Based on Oberoi and Kansra (2019), as suggested by Moher et al. (The PRISMA Group, 2009).

3.1 Process and Role of Stakeholders in Indian PDS

In the world, PDS is having the largest distribution network which serving approximately 231 million households (Balani, 2013). The GOI has introduced numerous schemes to improve the concentration of subsidy assistances through NFSA, 2013. TPDS scheme covers the population belonging to BPL, APL,

and AAY. However, some negligence in the scheme is criticized due to poor beneficiary identification, operational inadequacies, diversion of food grains during transportation, and bogus cards (Jha et al., 2013). The Food Cooperation of India (FCI) is the primary nodal assistance that conducts all procurement, storage, Transportation, Bulk allocation, and distribution on behalf of the régime. FCI acquires the food

grains from the state government agencies or directly from the farmers. To meet the demand of the deficit area, Food Cooperation resettles the grains centered on the order and off-take in the previous period to the warehouses of that region. Then, the state government allocates the received food items to each district and further to individual FPSs to serve the beneficiaries based on the schemes. Then beneficiaries purchase food grains from the nearby FPS at the subsidized price, as shown in Figure 2:

3.1.2. Prior Issues in PDS and Impact of ICT Modules

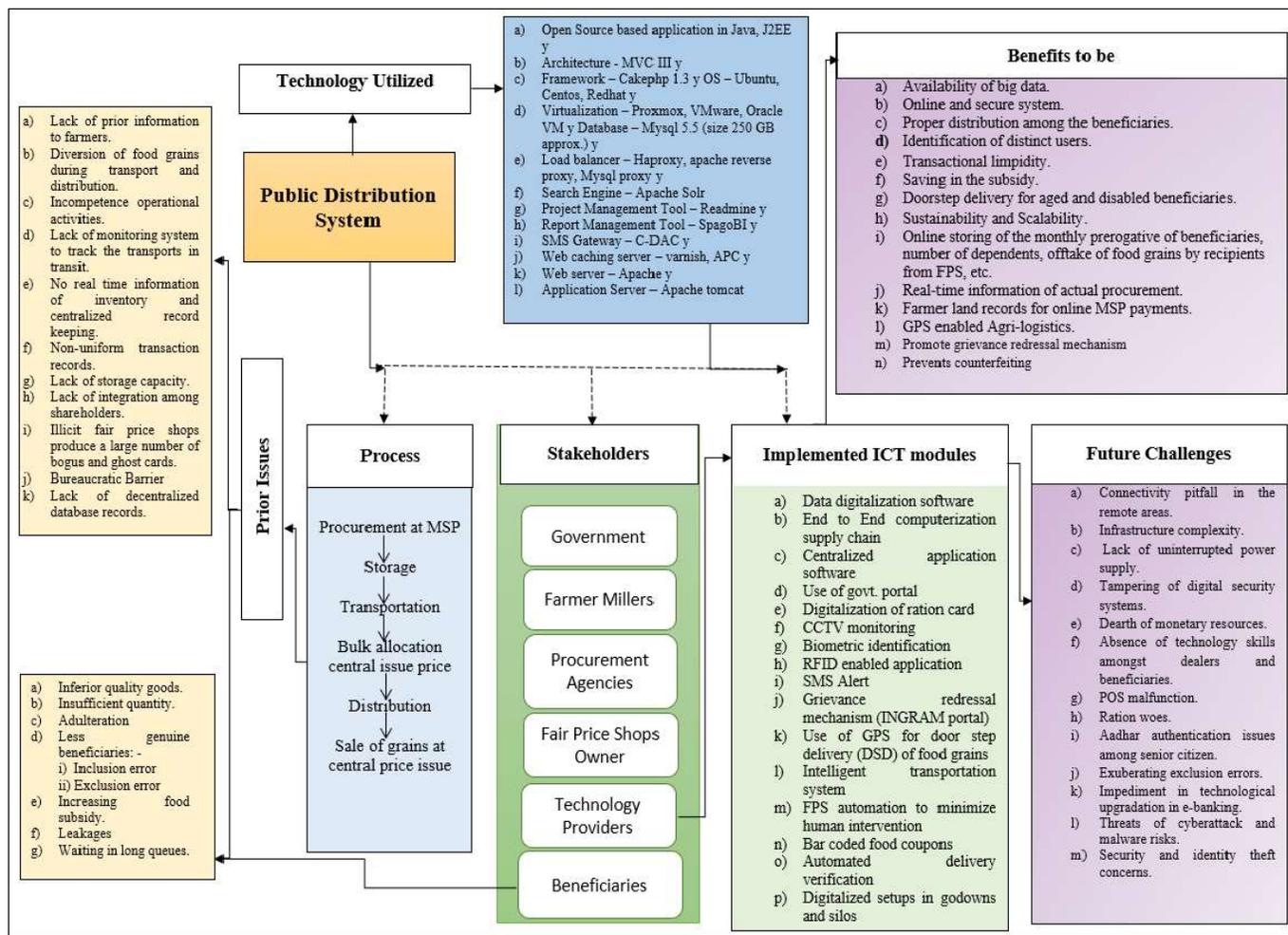
Numerous barriers and enablers are persuading the effectiveness of PDS, which were explored across the studies encompassed in the review process. Although the GOI procures the various steps in identifying ultra-poor families, there are still error-prone activities involved to identify the beneficiaries due to the unethical protocols (Khera, 2011; Mahamallik and Sahu, 2011; Svedberg, 2011 and Ghumaan and Dhiman, 2014).

In India, the public distribution system of food addresses vulnerable groups, including the poor, by making food available to those who cannot afford to pay for it. The different states of India have implemented varying systems that have yielded uneven results. (Verma, 2018;

Satyanarayana and Rajasekhara, 2019; Masiero, 2020; Bohtan and Mathiyazhagan, 2020).

Further, as per the survey of the Food and Civil supplies in several states revealed that approx. Sixty-four lakh families are BPL, and about sixteen lakh bogus cards are in circulation. The flow of these ghost cards directs that grains are deflected from worthy families into the open markets. FPSs dealer rustles up these bogus ration cards and sells the commodities at high prices which leads the shortage of food grains to the deprived vulnerable people (Gayatri, 2015; Singh et al., 2013; Hitaswi et al., 2017; Allu et al., 2018 and Bohtan, and Mathiyazhagan, 2020). The nonexistence of Aadhaar number unavoidably excludes entitled entities from being enumerated as recipients in the ration card. Since there is also a risk of elimination fault associated with either the recording of ration card details to Aadhaar details incorrectly or the inactivation of Aadhaar numbers for a horde of more information, for instance, document authentication collapse or indefinite apprehension of biometric data, there is a risk of elimination fault from the inappropriate recording of ration card details to Aadhaar details or inactivation of Aadhaar numbers. (Ghabru and Rathore, 2017; Balani., 2013; Satyanarayana and Rajasekhara, 2019; Masiero, 2015).

Figure 2: A Conceptual Model Regarding the Prior Issues and ICT Reforms to PDS Process



Lack of storage and scrutinizing system to trace the transports in pass way issues continue to limit the effectiveness of PDS (Shukla, 2015; Kumar and Pal, 2013, Staynarayana and Rajasekhra, 2019). Diversion and leakage of food grains during the process are significant glitches faced in the system. The Majority FPSs dealers don't dispense the food grains as a prescribed amount. According to NSSO (2011-2012), leakage in PDS is about 46.7 percent due to the destruction of food grains during the transportation diversion of food grains to the non-beneficiaries (Khera, 2011; Dreze and Khera, 2011) and exclusion of people entitled to the food grains (Kotwal et al., 2011; Kasim and Kumar; 2018; Gulati and Saini, 2015; Jha and Ramaswami, 2010, Himanshu and

Sen, 2011 and Khera, 2011b). In most places, the transactional data record was done manually, which is inclined to tampering and human errors (PIB,2015; Kumar and Pal, 2013; Pathak et al., 2020). Apart from FPSs and transportation, some FPSs dealers exchanged high-quality goods with lesser quality goods from the open markets (Gupta and Singh, 2016; Wani et al., 2019).

3.1.3. Implemented ICT Modules and Its Benefits

To resolve the inconsistency in the distribution system viz; Ghost cards, Lack of authentic users, record keeping and Lack of an operating system of inventory and trace the trucks pass through, etc. to make system transparent, ICT can play a vital role in detecting multiple or ghost cards,

inclusion and exclusion errors, maintaining the database of entitlement of food grain and takeoffs and providing it to beneficiaries with the help of biometric identification. The amount of diversion of food grains can be detected easily. A secured monitoring system of transport and transactions up to providing it to beneficiaries is needed. Identification of BPL families is the most perplexing task and the origin for the successful accomplishment of the PDS system to reach the maximum extent. Allowing Aadhaar linked and digitized ration cards feature to the PDS is very helpful in online entries and authentication of beneficiaries' information. It also helps in trailing the privileges and takeoffs by the recipients (Gowd, 2020; Parikh, 2013b; GOI, 2012 and 2013; Svedberg, 2011 and Khera 2011b; Verma et al., 2018).

Alteration of subsidized grains to non-existent receivers and private markets can be contended by linking Aadhaar cards with PDS (GOI, 2012). Linking Aadhaar plays an important role in facing many challenges like identifying beneficiaries, an entitlement of food grain, diversion of food grains, and detecting duplicate/ghost cards. Through digitalized Aadhaar, each beneficiary would be a hundred percent secured of an assigned quota of a commodity (Krishnan et al., 2011). However, some studies are done in contradiction to this alternative. The Supreme Court has not entirely permitted the Aadhaar card due to various political interventions and communal issues (Tanksale and Jha, 2015). An additional drawback of linking entitlements to the Aadhaar card is unruly not matching senior citizens' fingerprints. Although the Aadhaar Act, 2016 stated that Aadhaar Biometric Authentication (ABBA) in the PDS had already evidenced devastating in Jharkhand and

Rajasthan states. Hence, ABBA should not practice in other states (Bharadwaj et al., 2016). FPSs are facilitated by using a PoS (Personal Object Switching) unit to swap out the FPS. The shipment confirms the customers, keeps the number of subsidized ounces they are allotted, and encourages recipients to participate in the Supplemental Nutrition Assistance Program (Verma et al., 2018; Nair, 2019). In the DBT system, cash is given to the recipients rather than being given out in the form of a subsidized quota. The NFSA recommends this alternative technique as a means of support for the existing PDS. Food commodities will be available to anyone in the open market. To expedite the adoption of DBT in the States and UTs, we will provide seed Aadhaar and bank account information to the adoption units and grant recipients from the States and UTs. Cash transactions could save the country around 30,000 crore rupees annually (Verma et al., 2018; Kumar, 2015; GOI, 2013). This software has many benefits that will help reduce the operational costs of the business, encourage receivers to favor extended preferences, and assist groceries with cheap pricing (Balani, 2013).

To fight the diversion of food grains, GPS technology uses GPS technology to follow the passage of trucks hauling foodstuffs from depots to FPS (Balani, 2013; Verma et al., 2018; Sahoo et al., 2019). Whereas SMS-based services will help citizens arrive and dispatch goods on the FPSs by getting the SMS alerts on their registered mobile numbers (Nagavarapu and Sekhri, 2014; Gupta and Saxena, 2015; Perampalli and Dube, 2016; Verma et al., 2018). Public Grievance Redressal Machinery will be used to register grievances and suggestions

(Parkash and Manyam, 2018; Singh and Maurya, 2017; Verma et al., 2018).

Table 4.: ICT Reforms to PDS: An Overview

ICT Reforms	Advantages	Implementing States
Digitalized ration cards	Online access permits authentication of beneficiary data, saves monthly privilege of recipients, total no. of dependents, and off-take of food commodities by the recipients from FPSs, etc.	Andhra Pradesh, Chhattisgarh, Chandigarh, Delhi, Daman and Diu, Gujarat, Karnataka, Kerala, Lakshadweep, Punjab, Puducherry, Uttar Pradesh, Telangana, Madhya Pradesh, Tamil Nadu, Andaman and Nicobar Islands, etc.
Automation of FPSs through ICT	Allocation of Fair Price Shops, web-based challans, and declaration of stock balance through a computer, efficiently track all the transactions.	Andhra Pradesh, Chhattisgarh, Chandigarh, Gujarat, Karnataka, Haryana, Odisha, Puducherry, and Telangana
Usage of the smart cards	The computerized system is used to store the data of beneficiaries and their details, including BPL/APL category, no. of family members, which prevent counterfeiting.	Haryana, Andhra Pradesh, Orissa, etc.
Usage of GPS technology and Automation of supply Chain	Track the movement of trucks that carry food grains from states to fair price shops through GPS.	Completed: - In Delhi, Chhattisgarh, Gujarat, and Puducherry In progress: - Chandigarh, Andhra Pradesh, Daman and Diu, Haryana, Jammu and Kashmir, Lakshadweep, Jharkhand, Karnataka, Odisha, Punjab, Rajasthan, Tamil Nadu, and Uttar Pradesh
Monitoring by the usage of SMS	Allow all the citizens to Register all the mobile no. So, they can quickly receive the SMS alerts regarding the food grains arrival and dispatch	Chhattisgarh, Uttar Pradesh, and Tamil Nadu
Web Portal Usage and GRM	Endorses the usage of GRM as a toll-free number for addressing grievances as well as suggestions.	Chhattisgarh, Chandigarh, Delhi, Gujarat, Haryana, Himachal Pradesh, Maharashtra, Mizoram, Odisha, Puducherry, Rajasthan, Tamil Nadu, and Uttar Pradesh

Source: Press release by "Ministry of Consumer Affairs, Food and Public Distribution and Justice

Wadhwa committee Report on Computerization of PDS operations in (2013)."

Though the impact of ICT in the PDS increases transparency and positively impacts identifying the actual beneficiaries, many people still have no knowledge of information technology like illiterate and old age people, which creates the fear of insecurity among them. An increase in the biometric authentication process's efficiency can help people overcome their fear (Gowd, 2020; Parikh, 2013b; GOI, 2012; GOI, 2013; Svedberg, 2011, and Khera 2011b; Verma et al., 2018). Digitalization has been magnificently escalating the PDS services (Tanksale and Jha, 2015). The beneficiary details, including biometrics, are constantly updated and changed from time to time as required for output accuracy. Hence the database is always complete with up-to-date information. Consequently, the precision of the yielding is comprehensive to percent. Primarily disabled beneficiaries' rations are delivered at their doorstep by a Fair Price shop dealer with full biometrics authentication. The APDS is widely ecological and economically feasible (Satyanarayana and Rajasekhara, 2019 and Gowd, K.K, 2020). According to Satyanarayana and Rajasekhara (2019), the study showed that the Krishna district in Andhra Pradesh saved approx. Rs. 88.9 crores worth of subsidy only in fifteen months during 2015 and under the ICDS, Krishna was operating 3812 Anganwadi, 113 hostels, and 3157 primary and upper schools by availing AePDS scheme. While comparing these savings, all other costs like installation cost of no. of computers installation, set -up of proper infrastructure, E-Pos devices, and iris scanners are insignificant. The PDS also provides amenities to the MDM program, Anganwadi centers, and ICDS (Satyanarayana and Rajasekhra, 2019). This ultimately means that there are no pilferages in the distribution of food commodities in these programs. This

digitalization in the system has overawed the complications of the feedback mechanism. The integration of computerized centers at each level of Governance has improved the process. The beneficiary can directly share his feedback about their problems and suggestions regarding the quantity distributed and quality of grains and the issue regarding the distribution time and many more things directly to the higher authority without tempering of information through middle and lower executive members. These reforms can provide valuable insights for program implementers, practitioners, and formulators to project explicit areas.

3.1.4. Future Challenges of ICT Adoption

Fig. 1 represented a prioritized list of challenges. The biggest challenge that the digitalized technology faces are a lack of infrastructure. A significant roadblock to the use of ICT modules is the Lack of infrastructures such as a telecommunication system, IT personnel, and a reliable source of electricity (Ejiaku, 2013). Also, the FPS lacks the money needed to make e-PoS purchases, the installation, and the training of personnel necessary to work on it. This occurs when the state has to maintain machines even though the appliances are worn out and thus unable to be replaced. Older people often face this problem because their fingerprints aren't distinctive. A failure for more senior citizens who do not have digital signatures is rare, but the solution is still being worked on (Satyanarayana and Rajasekhara, 2019). An essential part of the Aadhaar-based biometric authentication is the internet (ABBA).

Beneficiaries can lose their entitlements bad identification failures because of either poor quality of fingerprints or poor internet connectivity. Beneficiaries are as frustrated with

the Lack of Internet access as dealers are (Satyanarayana and. Rajasekhara, 2019). Real-time verification is disrupted, leaving the possibility of grain diversion. Several people were still using their ration cards even though the cards had expired. While they had completed the application procedure and had official confirmation that their application had been approved via a paper slip or via a short message service (SMS), they had not yet received their new ration card. The rations were not getting to them (Satyanarayana and. Rajasekhara, 2019).

4. Discussion and Conclusion:

The study presented a systematic approach to finding the main ICT reforms and their impacts and challenges on the PDS. Thus, the study highlighted the main issues faced by the E-PDS viz; identification of the beneficiaries under the scheme, adulteration in the quality, and malpractices during the procurement and distribution of commodities. These issues are the major hindrance to the successful implementation of the PDS. But the use of technology and the internet in the delivery mechanism can reduce leakage and tampering when used tactically. ICT system confirms the credentials of beneficiaries with the help of biometric and touch screen facility access, an online payment system, e-challans, an automatic vending machine for the clearance of commodities to overcome the many obstacles and hindrances in the present scenario. Automated PDS can indeed reduce the corruption level in the economy, but the automation in the supply system cannot procure corruption and black marketing. The GRM should generate limpidity combined with an accessible approach for a beneficiary to lodge grievances with confidence that the objection

will be handled. But still, there is a severe prerequisite to reconnoiter the disparities in the networking of the Indian distribution system. The study identifies, classifies, and evaluates the various methods to provide digital identifies. But most of the studies assessed that despite additional substitutes being accessible, the Aadhaar based biometric approach of verification appears to be more operative for the registration. Subsequently, the enduring exercise of linking the ration card with the Aadhaar card is a promising step towards strengthening the PDS. But on the other hand, various parameters such as internet connectivity, financial budget, proper infrastructure, availability of trained staff, and e-governance centers are significant constraints. Therefore, the central and state governments could critically evaluate their regional contexts before choosing the methods and performing numerous assessments before selecting the method.

5. Future Research and Limitations of the Study

Future research should examine and validate the medicating effects of Digitalized Public distribution system antecedents with their main components. Quantitative methods could be used in this study to analyze stakeholders' responses and gain a proper understanding of relationships, and examine significant challenges in adopting the new technologies. Besides, quantify the problems and performance efficiency of present PDS, mapping and scientifically measure the PDS supply chain. The systematic review has also held few limitations. Firstly, the exclusion of those studies published under the non-peer-reviewed journals and some relevant articles presented as conference papers. The omission of these articles and relevant articles may have been

introduced some biases into the PRISMA framework and systematic review. There is wide heterogeneity in the culture, beliefs that make the generalization difficult. Lastly, the conceptual model in this study is elementary and will prerequisite empirical validation.

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