DIGITAL PUBLIC DISTRIBUTION SYSTEM (DPDS): A CASE STUDY IN WARANGAL DISTRICT

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By

S. SRINIVAS
(Roll. No. 700809)

Department of Mechanical Engineering
National Institute of Technology, Warangal
TELANGANA – 506 004
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Abstract

One of the most popular scheme which is being jointly implemented by both the Central and State Government in India is Public Distribution System (PDS). Under PDS Government supplies food grains to poor, through network of PDS supply chain comprising Food Corporation of India (FCI) established by Government of India to ensure the security and supply of Food and other essential items to the citizens of India. PDS Supply chain mainly consists of three main parties (i) Food Corporation of India which supplies to some distribution centres referred to as Mandal Level Stock Points's (MLSP).(ii) Each MLSP, in turn supplies materials to some associated fair price shops(FPS).(iii) From FPS finally to the customer. The PDS, despite its many successes, has over the years manifested a broad array of problems. The PDS suffers from chronic management shortcomings concerning: the extent and timing of procurement, poor forecasting capacity, antiquated logistical systems to support storage and delivery functions, huge inventory and transport costs, poor quality food grain, harassment of consumers at the point of client interface, and exclusion of large numbers of the poor from the system entirely, either through incapacity to process their claims or outright disqualification despite clear evidence of need. The focus is on the above challenges which have plagued the PDS system by under taking case study of Warangal district in Telangana State.

To combat such issues, the case study work of Warangal district studies a multi echelon public distribution system consisting of Warehouses like FCI Godowns, some distribution centres like MLSP's, a large number of retail servicing centres like FPS's. It is suggested a model with aim of minimizing the total expenditure including ordering and reordering costs and inventory holding costs for smooth distribution of product(say rice) from Warehouses to MLSP's and MLSP's to retailers (FPS's). The mathematical model proposed is solved by using a Binary Particle Swarm Optimisation Technique. The technique is employed for a realistic data collected by using a code written in C++. It is found that for the realistic data the model could yield a 31.82% reduction in expenditure compared to existing procedure employed under PDS.

The other objective of this work is to develop a transportation model for movement of commodity from FCI godowns to MLSP and from MLSP to FPS by considering multi-depots, dispatching quantity, routes arrangement and time-window constraints in order to reduce the

delivering cost for Warangal district. The work proposed a hybrid heuristic approach to solve this type of multi depot vehicle routing problem with time window. This heuristic method first employs the nearest-neighbour searching algorithm, starting from the initial DC, and then assigns the nearest depots to the DC. The initial solution plan is then generated using this algorithm. Later this initial solution plan provided as input to best case selection algorithm to optimize the results. The transportation starts from the delivering rice from FCI owned godowns to MLSP and again from MLSP to FPS. It is found that for the realistic data the model resulted observations as A) The number of vehicles used in daily delivery tasks can be effectively estimated and optimally arranged, as a result the overall cost is reduced. B) It is observed that 78% of earlier expenditure can be reduced under Stage I transportation and 28% can be reduced at each MLSP when compared to what is being spent now as per the model developed. Thus huge amounts spent on transportation of PDS can be minimized and significant savings can be achieved by adoption of these supply chain techniques in real life.

Further to address other problems and to ensure transparency in PDS for successful implementation of the programme developed a Cloud based approach that streamline the beneficiary database and track the inventory throughout the supply chain of the system. Different stages of supply chain are modelled. Cloud computing is a term used to refer to a model of network computing where a program or application runs on a connected server or servers rather than on a local computing device. This is done by using smart card and smart card reader which runs on Radio Frequency Identification (RFID) technology which will act as Point of sale device (POS). POS are the devices which are used to make transactions on the retail shop. The integration of the information that get from software is done with public district portal (web portal) which will have all the details regarding public distribution system. The integration and designing of WebPages is done with languages like PHP (Pre hypertext processor), MySQL, CSS (cascading style sheets). Smartcards are used for beneficiary authentication. Java code is used for Smartcard programming.

The design of web portal also aims at the display of information related to Fair Price Shops (FPS) with respect to associated ration cards, entitlement of beneficiaries, stock positions at Mandal Level Stock points (godowns), movement of stocks, stock availability at each FPS etc. The portal is also designed to allow a card holder to login his/her complaints, and to get the contact details of Food & Civil Supplies officers in the vicinity. Under the portal some static information, which is permanent, can also be included for display.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATION

AAY	Antyodaya Anna Yojna
APL	Above Poverty Line
BPL	Below Poverty Line
BPSO	Binary Particle Swarm Optimization
CMfg	Cloud Manufacturing
CSC	Civil Supplies Corporation
CSD	Civil Supplies Department
CSV	Comma Separated Values Format
CVRP	Capacitated Vehicle-Routing Problem
EAS	Employment Assurance Scheme
EOQ	Economic Order Quantity
FCI	Food Corporation of India
FPS	Fair Price Shops
IOT	Internet of Things
JRY	Jawahar Rozgar Yojna
MIS	Management Information System
MLSP	Mandal Level Stock Points
MDVRPTW	Multi Depot Vehicle Routing Problem with Time Window
NFC	Near Field Communication
PDS	Public Distribution System

PHP	Hyper Text Pre Processor
POS	Point of Sale Device
PSO	Particle Swarm Optimization
RFID	Radio frequency identification
SQL	Structured Query Language
TPDS	Targeted Public Distribution System
VRP	Vehicle Routing Problem
VRPB	VRP with Backhauls
VRPPD	VRP with Pickup and Delivery
VRPTW	VRP with Time Window

Introduction

1. Introduction of Public Distribution System

Both State and Central Governments in India are implementing many welfare schemes for benefit of poor people. One among most the popular schemes is the 'Public Distribution System'(PDS), through which the Government distributes food grains like rice at subsidized prices through fair price shops to the public. This is one of the most popular schemes of Governments to improve the lives of its citizens. Essential Commodities like rice, wheat, sugar, oil etc will be supplied at the subsidized rates to its population through PDS[08]. Union as well as state governments spend thousands of Cores of rupees through different schemes to improve the lives of common man in the country. Even though there is an improvement in the lives of citizens after independence, the magnitude of improvement is not matching the funds spent, due to leakages in the funds which can be avoided or minimized in the delivery mechanism at several stages. It is needless to say that Public Distribution System (PDS) is a very important scheme for providing food security to the poor and needy.

The Public Distribution System (PDS) evolved as a system of management of scarcity and for distribution of food grains at affordable prices. PDS can be distinguished from private distribution in terms of control exercised by public authority and the motive predominantly being social welfare in contrast to private gain. Broadly the system includes all the agencies that are involved from procurement stage to the final delivery of goods to the consumer. The agency that is involved in the process of procurement, transportation, storage and distribution are Food Corporation of India (FCI). Civil Supplies Department (CSD) and Civil Supplies Corporation (CSC) and Fair Price Shops (FPS) which are the agencies, involved in provision of PDS. The FPS is the last link in this process, which is mostly owned by private individuals. Hence, the most important aspect that distinguishes PDS is the involvement of government agencies and government control over the entire distribution system. The procurement and movement of stocks starts from the delivering of rice from FCI owned godowns to Mandal

Level Stock Point (MLSP) in the first stage and again from MLSP to Fair Price Shop (FPS) in second stage.

The Government procures the rice stocks from millers and stores at their warehouses (FCI). The FCI supplies to some distribution centers referred to as MLSP's. Each MLSP, in turn supplies materials to some associated FPS's. Thus in a distribution system we have (i) FCI warehouses, (ii) a small number of Mandal Level Stock Points (MLSP's) (iii) a large number of Fair Price Shops (FPS) which are, in sets, associated with each Mandal Level Stock Point (MLSP). This is the structure of a multi echelon PDS. The procurement of rice by FCI, its storage, supply to MLSP's, ordering/reordering by MLSP's for their respective demands, their storage and supplies to FPS's, all these involve considerable expenditure. The procurement and inventory maintenance and transportation, under PDS in Warangal hitherto is attended to in a trial and error basis but not scientifically. Sometimes total cost involved may be on higher side also. In this thesis the author considered the planning of this distribution at FCI scientifically using techniques of inventory control and minimization of total cost and also considered the development of Vehicle Routing Problem (VRP) for Public Distribution System (PDS) including multi-depots, dispatching quantity, routes arrangement and time-window constraints in order to reduce the delivering cost. Apart from this the author also considered to develop a cloud based model by incorporating the application of smart card technology with smart ration card in distribution of food grains at fair price shops(retailers) and authentication of beneficiary to ensure transparency in the PDS.

1.1 Public Distribution System in India

The Public Distribution System (PDS) in India is more than half-a century old as rationing was first introduced in 1939 [08] in Bombay by the British Government as a measure to ensure equitable distribution of food grains to the urban consumers in the face of rising prices. Thus, rationing in times of crisis like famine was the historical precursor to the national policy of stabilization and management of food grains. Among the number of Price Control Conferences held during 1940-42, the sixth, held in September, 1942 laid down the basic principles of a Public Distribution System for India. The Food Department, set up in December, 1942, formulated an All India Basic Plan that dealt with issues such as procurement, contracts for purchasing agents, public distribution, inspection and storage. The basic objective of the then emerging policy was stabilization of food prices.

With inflation spiralling and the food situation deteriorating persistently in many parts of the country, the Food Grains Policy Committee (1943) recommended for the introduction of rationing in urban centres with a population of more than 100,000. The consequent food distribution was exclusively focused on the urban centres. That with partition, India bequeathed 82% of the population of the subcontinent, 75% of the cereal production and 69% of the irrigated area aggravated the food situation. However, under the influence of Mahatma Gandhi, a policy of decontrol was announced in December, 1947. Policies kept changing with the reintroduction of controls in September, 1948, shift to decontrol during 1952-54 and recourse to controls in 1957.

The Food Grains Enquiry Committee (Ashok Mehta Committee Report, 1957 [58]) argued for controls of a flexible indirect nature, opening of more Fair Price Shops (FPSs) and continuing the zonal policy of bringing together surplus and deficit areas within zones, controlling prices within each zone. The import of food grains during 1958-66, mostly under P.L. 480, induced the U.S. to take such measures as withholding grains in the last minute and imposing conditional ties on its policy on currency valuation, foreign trade and production, pricing and distribution of fertilizers. In 1966, imports had reached about 14% of the food grains availability in the country which, with consequent glut in the market, might partly have resulted in the crisis in domestic production during1964-66.

The Green Revolution and food self-sufficiency brought about a new dimension in the food grains management. The focus was on fair procurement price for farmers to insulate them from market anomalies, buffer stocking, and control of market prices and public distribution of essential commodities. Food Corporation of India was established in 1965, to function as an autonomous organization, working on commercial lines, to undertake purchase, storage, movement, transport, distribution and sale of food grains and other food stuff.

The Study Team on FPSs headed by Shri V.M. Dandekar (1966) [58] observed that the foreign supplies had proved inadequate in meeting the increasing demand for food grains through FPSs. The Team recommended that the pricing in FPSs should be market oriented and that they should maximize their share in the market. The Food Grains Policy Committee (1966) advocated formulation of a National Food Budget on the basis of zonal restrictions, introduction of statutory rationing in bigger urban areas, intensification of procurement, building up buffer stocks and a more important role for Food Corporation of India in inter-state trade.

The Sixth Five Year Plan (1980-85) had, inter alia, envisaged that the Public Distribution System would "have to be so developed that it remains hereafter a stable and permanent feature of our strategy to control prices, reduce fluctuations in them and achieve an equitable distribution of essential consumer goods". Essential Supplies Programme, introduced in 1982 as the 17th point of the New 20 Point Programme, intended to expand the PDS through more FPSs, including mobile FPSs, to make available text books and exercise books to students on a priority basis and to promote strong consumer protection movement.

The number of FPSs increased from 2.30 lakhs in January, 1980 to 3.02 lakhs in January, 1984 [56]. While the Government of India had itself shouldered the responsibility of supplying essential commodities, viz; wheat, rice, sugar, kerosene, edible oils and soft coke, the State Governments had the option to add other items considered essential by them. Effective working of the Programme was predicated on ensuring multi-faceted co-ordination, as the essential commodities were handled by different governmental agencies; food grains by the FCI, sugar by the FCI/State Civil Supplies Corporations/cooperatives, import and distribution of edible oils by the State Trading Corporation, soft coke by Department of Coal and Coal India Limited and kerosene by Indian Oil Corporation/Bharat Petroleum/Hindustan Petroleum.

The Evaluation study on Essential Supplies Programme (1985) [58] revealed that major weaknesses and deficiencies of PDS did not exist in either the lack of sufficient coverage or want of necessary administration machinery but in certain operational inadequacies such as irregular supply (to the FPSs and in turn to consumers) and poor quality leading to non-drawl, non lifting of sanctioned quotas by the FPSs in the rural areas, general pessimism by the FPS dealers about the profitability of running FPSs, underweighment, etc**.**

In 1984, Government of India created the Ministry of Food and Civil Supplies with two departments namely Department of Food and Department of Civil Supplies; the latter being in charge of PDS. During the Seventh Five Year Plan, an Advisory Committee on PDS headed by the Union Minister for Food & Civil Supplies was constituted by the Government of India to review its working from time to time. Consumer Advisory Committees were to be constituted at district, block/tehsil levels.

The Essential Supplies Programme gave way to Revamped PDS (RPDS) in 1992 with focus on disadvantageous areas. Under RPDS, 1752 blocks, falling under Desert Development Programme, Drought Prone Areas Programme, Integrated Tribal Development Projects and Designated Hill areas , were identified as economically and socially backward. Essential commodities- wheat, rice, levy sugar, imported edible oil, kerosene and soft coke were supplied in the RPDS blocks at subsidized prices. Food grains at the rate of 20 Kg per month per family (@5 Kg per capita) was envisaged to be distributed through FPSs.

The scheme also envisaged creation of PDS infrastructure, on 50% subsidy and 50% loan basis, in the form of godowns for storing food grains and Mobile Vans for door-step delivery of PDS items to the FPSs and for final distribution of these items in inaccessible areas. Vigilance Committees were to be formulated at different levels to ensure proper distribution. PEO Evaluation of the working of the RPDS (1995) indicated that though the scheme was generally beneficial to the vulnerable section of the population cutting across the regions and states, there were still gaps and constraints in the implementation, availability of very limited door delivery services to FPSs, inadequate facilities for storage at FCI telling upon the quality of grains, FPS level gaps in opening time, working hours, regularity of distribution and communication to consumers, Vigilance Committees not being able to serve their purpose meaningfully and non consideration of socio-economic and cultural situations regarding preferences of commodities.

1.2 Targeted Public Distribution System (TPDS)

The Targeted Public Distribution System (TPDS) [60] was launched in 1997 to benefit the poor and to keep the budgetary food subsidies under control to the desired extent following failure of the earlier PDS system. Conceptually, the transition from universal PDS to TPDS was a move in right direction, as it was designed to include all the poor households and raise the unit subsidy and ration quota considerably for them. The objective of keeping the budgetary consumer subsidy in check was proposed to be met through sale of food grains to Above Poverty Line (APL) households at Economic Cost and confining the budgetary food subsidy to about sixty five million identified Below Poverty Line (BPL) families. Though the supply of the requisite quantity of food grains for distribution at BPL prices was to come from the Central Pool, the success of TPDS in terms of meeting its stated objectives depended largely on the ability of State Governments in identifying the genuine poor families, restricting the number of poor families to the number estimated by Planning Commission and in putting in place an effective and efficient delivery system.

The salient features of TPDS as depicted in its Guidelines [58] are the following:

1) TPDS proposed to issue 10 Kg of food grains per BPL family (revised to 20 Kg w.e.f. April, 2000) at specially subsidized rates. The average lifting of food grains by the state in the last 10 years would be the allocation to the state in the first year. Out of this, the quantity in excess of BPL entitlement, known as transitory allocation, would benefit the APL population, but at a price that is not subsidized.

2) States should design credible financial and administrative arrangements to ensure the physical movement of food grains to the FPSs and subsequent issue to the poor. The provision of subsidy would be conditional on this.

3) TPDS proposed to extend the issue of specially subsidized food grains to the beneficiaries of EAS and JRY at the rate of 1 Kg per person per day. The proposal was to give food coupons to the EAS & JRY beneficiaries, which they can exchange for food grains at their FPSs. States should take proper care to see that these food grains are actually issued to them.

4) The BPL population in any State could be seen as the provisional estimates reached by the Planning Commission for the year 1993-94 by the Expert Group methodology. This should form the macro estimate of BPL population at the State level.

5) For the micro selection of BPL population, the quennial surveys made by the Ministry of Rural Areas & Employment could form the basis. Gram Panchayats and Gram Sabhas should be involved in the initial identification of beneficiaries. Doubtful cases should be verified. Urban slum dwellers would generally qualify for selection. Applications from non-slum urban areas should be verified. Thrust was to include landless agricultural labourers, marginal farmers, rural artisans and craftsmen, urban slum dwellers and daily wage earners in the informal sector. These criteria were only indicative. However, the aggregate number of BPL beneficiaries should be within the Expert Group estimate of BPL population.

6) The issue of ration card would give entitlement to its holder to obtain certain essential commodities, at a certain scale, at certain prices, at specified outlets and in as many instalments during the month.

7) It was commended to all States to adopt the Tamil Nadu proposition of pasting the photo of the head of the family on the card.

8) New cards could be issued to eliminate the bogus cards, which were in circulation. If the cards had been issued in the recent past, instead of fresh issue, the existing ones for the identified BPL families could be appropriately stamped and be affixed with the photographs of the heads of the families.

9) Government of India's commitment on subsidized food grains is limited to: a) the quantity necessary for 20 Kg per BPL family, b) the quantity required for EAS and JRY, and, c) the quantity required for transitory allocation. Requirement by states above these quantities would be subject to availability and at commercially viable prices. The states should therefore re-examine their scales of issue and modify them suitably. States offering greater quantity or lower price should bear the additional burden of food grains and fund.

10) States should keep the end retail price at the FPS level to their BPL population at not more than 50 paise per Kg. States were free to fix the margin on APL price within the limit of the actual expenses incurred.

11) While the Central Government was responsible for ensuring availability, acceptability and affordability, the states should ensure accessibility of food grains to the poor through a network of FPSs.

12) A proper system of monitoring the FPSs should be introduced and reports should be obtained every month, and if felt necessary, at shorter intervals. Too frequent inspections may harass the FPS dealers. Inspection schedules should be prepared for district and taluka level officers. A checklist may be used during inspections to make them pointed. Remedial actions should immediately be taken. Cardholders present at the shop during inspections should be consulted.

13) The collector should make weekly review of the bottlenecks faced and the actual off-take, especially the BPL off-take, from the shops. At the state level, the secretary-in-charge should make such a review once a month.

1.3 Distribution of Food Grains

The importance of the public distribution system lies in situation where there is a shortage of food grains in the market rather than a real shortage, for prices are not left to be determined by the market forces alone but are to an extent controlled by the government. The unrealistic approach of the government, while pursuing a policy of controls and regulations often results in hoarding by traders and speculators and consequently the prices are very high. Distribution through government agencies is precisely significant in the context of overcoming shortages in the market and ensuring an equitable distribution of food grains at reasonable price.

The national objective of growth with social justice and progressive improvements in the living standards of the population make it imperative to ensure that food grains are made available at reasonable prices. Public Distribution of food grains has always been an integral part of India’s overall food policy. It has been evolved to reach the urban as well as the rural population, in order to protect the consumers from the fluctuating and escalating price syndrome. Continuous availability of food grains is ensured through about 4.5 lakhs fair price shops spread throughout the country. A steady availability of food grains at fixed prices is assured, which is lower than actual costs due to Govt. policy of providing subsidy that absorbs a part of the economic cost (about 45%). Under the Targeted Public Distribution Scheme effective from June, 1997, stocks are issued in the following two categories:

1) Below Poverty Line: Determination of the families under this category in various states is based on the recommendation of the Planning Commission. A fixed quantity of 35 Kg. food grains per family per month is issued under this category. The stocks are issued at highly subsidized Price of Rs.4.15 per Kg. of wheat and Rs. 5.65 per Kg. of rice. During the year 2000-2001, Govt. of India decided to release food grains under Antyodaya Anna Yojana. Under this scheme, the poorest section of population, out of earlier identified BPL population, is covered. Food grains are being provided to 1.5 crores poorest of the poor families, out of the BPL families, at highly subsidized rates of Rs.2/- per kg of wheat and Rs.1/- per kg of rice by FCI. This is the biggest food security scheme in the world.

2) Above Poverty Line– Families, which are not covered under BPL, are placed under this category. The stocks are issued at Central Issue Price of Rs.6.10 per kg of wheat and Rs.8.30 per kg of rice.

1.4 Public Distribution System in Telangana State

Telangana State Civil Supplies Corporation Ltd. is a State Agency appointed by the State Government for lifting of Rice and Wheat from FCI and Levy Sugar from factories under PDS. It is the responsibility of the corporation to undertake transportation, storage and delivery of the stocks under PDS at the door steps of the FPS dealers. The transportation of stocks from FCI/factories to Mandal Level Stock Points is called Stage-I transportation, which is being undertaken through the district-wise transport contractors appointed separately for food-grains and Levy Sugar. The transportation from MLS Point to the door step of the F.P. Shop Dealer is called Stage-II transportation, which is being undertaken through Contractors and Stage-II contractors are appointed by the District Collectors on approval of the rates by Head Office. Figure 1.1 shows the stages of the supply chain in Telangana.

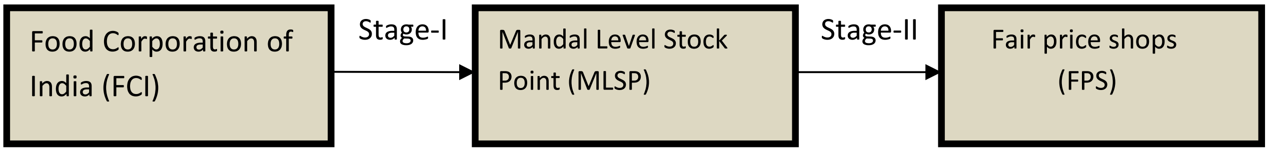


Figure 1.1: Supply Chain of PDS

1.5 Food Corporation of India (FCI):

The Food Corporation of India undertakes the procurement of food grains on behalf of the Government of India and State Governments in the States, where it has been entrusted with this responsibility either as a sole agency or jointly with other public procurement agencies. It also undertakes massive price support operations for food grains and cereals on behalf of the Central and State Governments to protect the interests of the growers. It prevents distress sales by ensuring to the farmers, predetermined procurement/support prices. It also handles huge stocks of food grains procured by other agencies for the central pool, and utilizes the services of co-operative societies to the maximum extent possible. Another major function of the Corporation is the distribution of procured/ imported food grains through nearly 5 lakh fair price shops all over India. Food grains are issued on the basis of the allocations made by the Central Government. The Food Corporation of India makes food grains available to the vast majority of population at reasonable prices. The quantity of food grains distributed through public distribution and open sales has varied in between 17.4 to 25.8 million tonnes during the last 5 years.

1.6 Mandal level Stock Points (MLSP)

These are the intermediate inventory storage points run by the T.S. Civil Supply Corporation. The grains are stored and according to the prescribed procedure sent to the different fair price shops under their jurisdiction.

The Corporation is having 18 Mandal Level Stock Points in the Warangal District for storage cum distribution of stocks. As and when the extra storage space is required, Corporation is hiring additional godowns of State Warehousing Corporation in district.

1.7 Fair Price Shop (FPS)

Essential commodities like Rice, Wheat, Sugar, Iodized Salt and Kerosene are being distributed to the targeted cardholders as per the eligibility and rates fixed by the Government through the Fair Price Shops.

- **Objectives of FPS**

  To ensure proper supply of essential commodities through the fair price shops to the targeted cardholders at the quantum and rates fixed by the Government. As a result, the consumers are relieved from the clutches of the traders' rampant exploitation.

- **Functions of FPS**

  The fair price shop dealers are required to lift the allotted essential commodities by paying the cost and make available adequate stocks at any given time. They shall distribute the essential commodities to the cardholders as per their eligibility and rates fixed.

1.8 Working of PDS System in Warangal District:

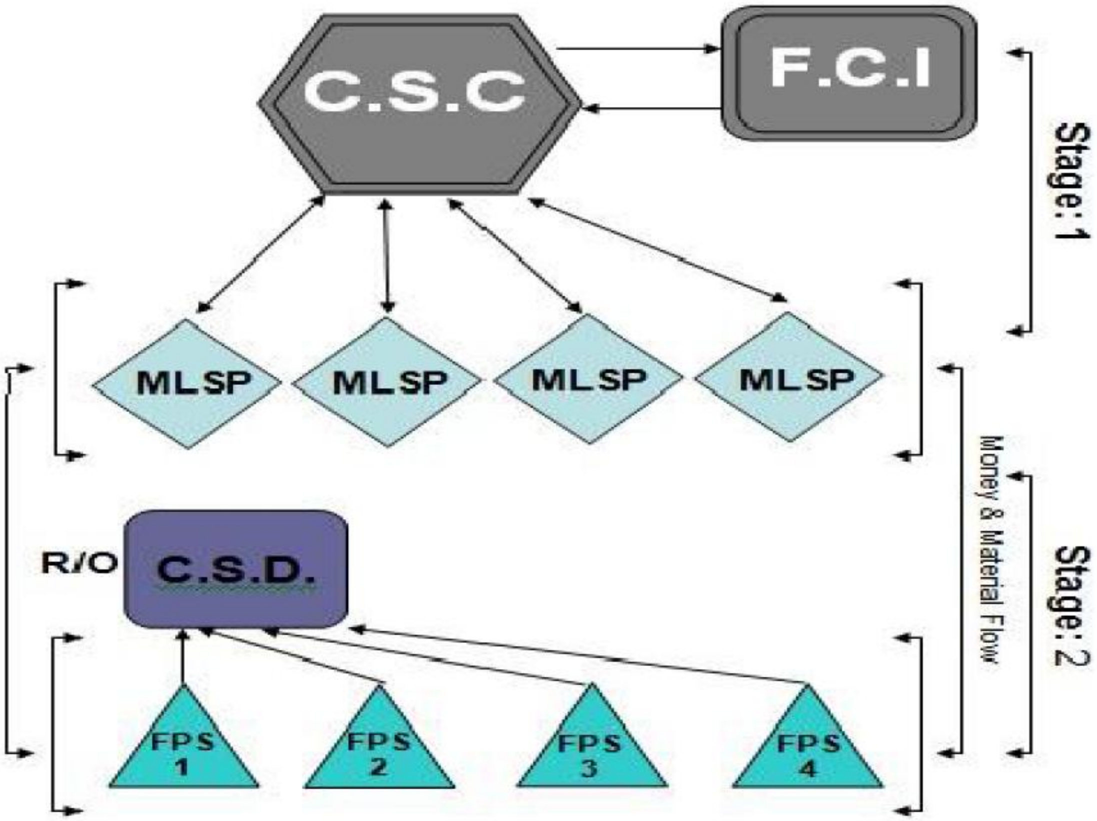


Figure 1.2: Working of System

The working of PDS system in Warangal district is shown in figure 1.2 as above. The Civil Supplies Department (CSD) of district allocates the Quantity of goods to Fair Price Shops (FPS) as per the no. of card holders and their eligibilities attached to FPS. The Civil Supplies Corporation (CSC) supplies the goods to FPS through Mandal Level Stock Points (MLSP) after receipt of Release order issued by CSD at respective MLSP'S and advance payment by way of DD from FPS. The FPS distributes the goods to cardholders and pays advance amounts to CSC by DD for release of stock for next month. There are 18 Mandal level stock points (MLSP) which serve the total of 51 mandals. In 51 mandals there are 2011 FPS. The monthly demand of the FPS is served between 20^{th}-1^{st} of every month. The rotation of material is cyclic, MLSP received material from FCI owned godowns. There are 7 FCI owned godowns, located at different locations. These FCI owned godowns have huge amount of buffer as procurement of the material (i.e. rice) from the millers is cyclic and is done throughout the year. In the 1^{st} Stage, materials move from FCI godowns to Mandal level stock points, in the 2^{nd} Stage materials move from Mandal level stock point to Fair Price

Shops(FPS).Thus the PDS is a structure of a multi echelon of Inventory and Distribution model. There are many systemic challenges that plague the PDS system today and the key ones are described below:

- **Inventory Cost –** The Government is maintaining large amount of stocks at various warehouses to meet the demands of food grains under PDS with non scientific approach, resulting the Crores of rupees of Government money is invested for unproductive work. There is a need to minimize the overall inventory carrying cost by estimating optimum quantity estimation and the reordering time period.
- **Transportation Cost –** The Government is spending Crores of rupees every year in transportation of food grains from FCI to fair price shops as the region is so widely spread that the delivering cost is almost always tremendously high if only a single Distribution Centre (DC) is in charge of all deliveries. Even though more delivery costs are incurred, the timely distribution of food grains to the public is not being ensured. It is necessary to enhance the efficiency in delivery of goods from FCI godowns to all depots (FPS).Naturally delivery cost is key factor in the pricing of delivery services. To reduce this cost research has tended to focus on the Vehicle Routing Problem (VRP) as a key factor in delivery efficiency.
- **PDS Ghost Card –**
  A number of bogus ration cards which do not correspond to real families, exist in the BPL and AAY (Anna Anthodia yojana) categories. The quantity of food grains drawn on the basis of these bogus cards is a significant leakage from the system, as it does not reach the intended beneficiaries and unauthorised users take advantage. To enable proper distribution of food grains in a channelized manner, the Government/ local distribution planners allot ration cards on one and only one authorized ration card for each family. Sometimes, some get ration cards on the name of nonexistent families and these are termed as bogus cards.
- **System Transparency and Accountability –**
  The most serious flaw plaguing the system at present is the lack of transparency and accountability in its functioning. At present there are no checks on PDS regarding the possible identification of leakages in the form of supply to bogus card holders / shadow card holders. The system lacks transparency and accountability at all levels making monitoring of the system extremely difficult.

- **Grievance Redressal Mechanisms –**
  There are numerous entities like Vigilance Committee, Anti-Hoarding Cells constituted to ensure smooth functioning of the PDS system. Their impact is virtually non-existent on the ground and as a result, malpractices abound to the great discomfiture of the common man. Apart from the challenges described, transportation of food grains and appointment of dealers of Fair Price Shops have also become difficult issues.

1.9 Motivation for Thesis work:

The existing working of public distribution system is not satisfactory due to non scientific approach .In view of this, the following problems are occurring:

- Non-availability of food grains in Public distribution fair price shops on time.
- Poor quality of the food grains.
- Inadequate supply of Commodities (Rice).
- Underweighing of Commodities (Rice).
- Loss of goods, commodities in transportation
- Bogus ration cards
- Improper timings of PDS shops
- Non-availability of information on arrivals of stocks at PDS shops to general public.

An imperative need to improve the present system is the motivating factor for taking up the present study.

1.10 Objectives of the Study:

In order to develop and evolve strategies for efficient management of public distribution system (as a network of supply chain) in Warangal district, the present study is undertaken with the following objectives.

1. To propose models for optimum quantity estimation of Rice at different levels of Supply Chain with the aim of reducing wastage and costs.

(a) Inventory model for minimization of warehouse expenditure by applying Binary Particle Swarm Optimization (BPSO) technique.

(b)Development and Analysis of Transportation model by Hybrid Heuristic Algorithms.

2. To develop a Web Based system for PDS for Warangal district and enable the users to know exact quantity of materials available and distribution of materials in FPS by using the technologies PHP, My SQL and thus achieve transparency in dissemination of information.
3. To suggest methodology for application of smart card technology for authentication of beneficiaries so as to eliminate the bogus ration cards at FPS level by using JAVA

1.11 Scope of the Study

Considering the working and structure of Public Distribution system in Warangal district, it is planned to study the existing working of PDS and development of suitable models for minimization of inventory and transportation expenditures in the supply chain of PDS. It is also planned to study and implement the technologies which ensures the transparency and accountability throughout the working of PDS system by Development of Web based portal and Authentication of beneficiaries to prevent the leakages at FPS's level and also monitor the allocation and movement of goods at different stages of supply chain. As a huge amount of budget is required for procurement, storage and distribution of rice from suppliers to consumers under PDS compared to other items. The study is restricted to only rice item distribution under PDS.

Hence it is important to build a system that can overcome the challenges faced by the PDS currently. This can be done by developing suitable models for inventory, transportation, cloud based supply chain with the help of Information Communication Technology to emulate the supply chain of PDS system at district level.

1.12 Overall Research Plan

The overall research plan for organization of thesis work involves the study of existing working of PDS, collection of data, analysis of data, development of models, followed by summary and conclusions is summarized as shown in Figure 1.3.

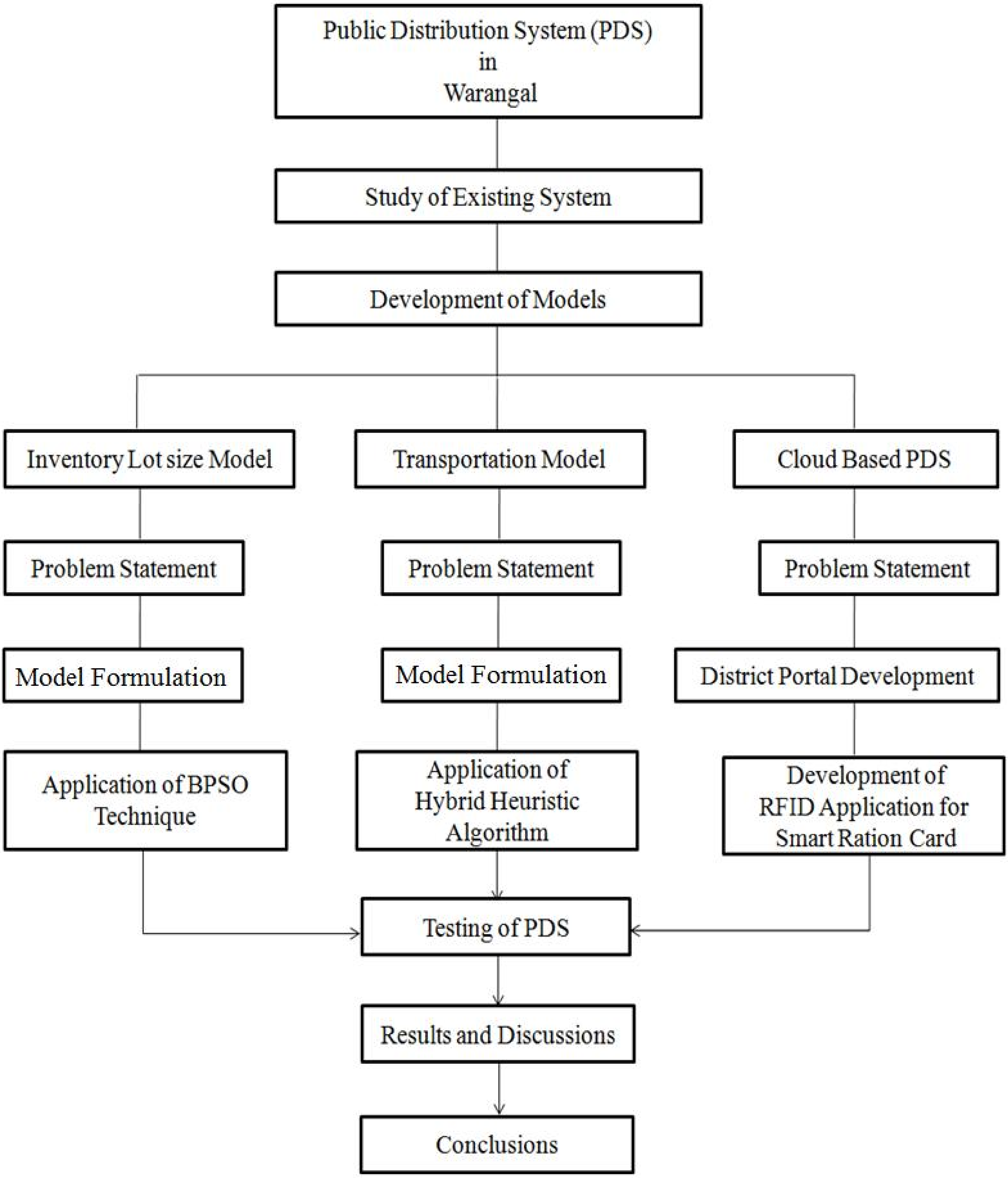


Figure 1.3: Over all Research Plan

The significant contributions made from the thesis work are;

Development of inventory Model for minimization of ware house expenditure for Warangal district The model describes a multi echelon public distribution system consisting of Warehouses like FCI Godowns, some distribution centers like MLSP's, a large number of retail servicing centers like FPS's. The mathematical model proposed is solved by using a Binary Particle Swarm Optimization Technique. The technique is employed for a realistic data collected by using a code written in C++. It is found that for the realistic data the model could yield a 31.82% reduction in expenditure compared to heuristic procedure employed earlier.

Development and Analysis of Transportation model in PDS for Warangal district The main objective of this model is to discuss Vehicle Routing Problem (VRP) for Public Distribution System (PDS) including multi-depots, dispatching quantity, routes arrangement and time-window constraints in order to reduce the delivering cost. The developed algorithm first employs the heuristic search for feasible solutions based on the constraints of both the time-window and loading capacity in the routing problem keeping the concept of nearest neighbor. Then the Best Case search algorithm is developed to select the best solutions simultaneously to gain an optimal solution in the problem domain. From the developed model it is observed that there will be significant savings if PDS adopts and implement this developed model in real life application.

The thesis work is further focused on development and implementation of Cloud based PDS supply chain with smart ration card application. In this model it is proposed to have web based design of 'public portal' to achieve transparency regarding PDS. The design aims at the display of information related to Fair Price Shops (FPS) with respect to associated ration cards, entitlement of beneficiaries, stock positions at Mandal Level Stock points (go downs), movement of stocks, PDS supply chain, stock availability at each FPS etc . The portal is also designed to allow a card holder to login his/her complaints, and to get the contact details of F&CS officers in the vicinity. Under the portal some static information, which is permanent, can also be included for display. Besides this introduction to smart ration card will eliminate any fictitious ration card present in the PDS and also contribute to the automation of distribution system at the fair price shop level.

1.13 Organization of the Thesis

The thesis consists of six chapters; the thesis work is organized as follows:

The Chapter 1 is introductory in nature, Structure of PDS in our country in general and Warangal district in particular is explained. Focus is primarily on explaining the problems faced by PDS.

Chapter 2 is devoted to present a brief review of the existing literature and present the gaps observed in solving the problems with respect to PDS of Warangal district. Towards end, a list of problems investigated in the thesis is presented.

Chapter 3 deals with a inventory Model for minimization of ware house expenditure for Warangal district The chapter describes a multi echelon public distribution system consisting of Warehouses like FCI Godowns, some distribution centers like MLSP's, a large number of retail servicing centers like FPS's. It is proposed to suggest a model with aim of minimizing the total expenditure including ordering and reordering costs and inventory holding costs for smooth distribution of rice from Warehouses to MLSP's and MLSP's to retailers (FPS's). The mathematical model proposed is solved by using a Binary Particle Swarm Optimization Technique. The technique is employed for a realistic data collected by using a code written in C++. It is found that for the realistic data the model could yield a 31.82% reduction in expenditure compared to heuristic procedure employed earlier.

Chapter 4 Presents a Development and Analysis of Transportation model in PDS for Warangal district The main objective of this chapter is to discuss Vehicle Routing Problem (VRP) for Public Distribution System (PDS) including multi-depots, dispatching quantity, routes arrangement and time-window constraints in order to reduce the delivering cost. The developed algorithm first employs the heuristic search for feasible solutions based on the constraints of both the time-window and loading capacity in the routing problem keeping the concept of nearest neighbor. Then the Best Case search algorithm is developed to select the best solutions simultaneously to gain an optimal solution in the problem domain.

Chapter 5 Presents development and implementation of Cloud based PDS supply chain with smart ration card application. In this chapter it is proposed to have web based design of 'public portal' to achieve transparency regarding PDS. The design aims at the display of information related to Fair Price Shops (FPS) with respect to associated ration cards, entitlement of beneficiaries, stock positions at Mandal Level Stock points (go downs), movement of stocks , PDS supply chain, stock availability at each FPS etc . The portal is also designed to allow a card holder to login his/her complaints, and to get the contact details of F&CS officers in the vicinity. Under the portal some static information, which is permanent, can also be included for display. Besides this introduction to smart ration card will eliminate any fictitious ration card present in the PDS and also contribute to the automation of distribution system at the fair price shop level.

Chapter 6 deals with valid conclusions drawn out of the thesis work and scope for future work. Conclusions for each of the models are detailed in the individual chapters. In this chapter a brief presentation of conclusions in nutshell are made.

While writing the thesis, for sake of easy readability, some of the terms are more than once elaborated. The references are presented towards the end in alphabetical order.

1.14 Summary

The evolution of Public Distribution System (PDS) is summarized. The scenario of PDS in India in general and in Warangal District of Telangana State in particular is discussed by depicting the introduction of Public Distribution System, Public Distribution System in India and Telangana State, distribution of food grains, the supply chain of PDS in various stages at district level, working of the PDS system etc., The systematic challenges that are to be addressed in distribution of commodity(Rice) under PDS for effective implementation of the system are described. Motivation for undertaking thesis work, Objectives of the Study, Scope of the Study, the overall research plan and the significant contributions made from the thesis work are also elaborated. The organization of thesis is described at the end.

Literature Review

In this chapter a review of existing literature related to the topic of study is presented. This chapter is divided into six parts- literature review of PDS, literature review of Inventory Control, literature review on BPSO in Inventory Control, literature review of Transportation, literature review of cloud computing and literature review of smart card authentication.

2.1. Literature Review on Public Distribution System

Gyan Prakash (2011) [29], gave an overview of the difficulties faced by Public Distribution System (PDS) in distribution of scheduled commodities to the targeted citizens through a network of institutions comprising Food Corporation of India (FCI) warehouses and fair price shops (FPS). This system is fraught with many difficulties such as inefficiency, deterioration of food grains, unsatisfactory quality of commodities, malpractices in weights and measures, mismatch of demand and supply, long waiting times, exorbitant corruption, rude behavior of shopkeepers and poor service delivery. The objectives of this study are to understand the design, implementation and monitoring of PDS supply chain activities. Understanding of which will be help in proposing redesigning of PDS processes, introducing IT based interventions, thereby, making flow of food items and other commodities visible and making some policy recommendation.

Brij Pal (2011) [09] He critically analyzed the organizational structure and their loopholes in the functioning of agencies like Food Corporation of India & Central Warehousing Corporation engaged in the procurement, transportation, storage and distribution. And suggests remedial measures to make the PDS transparent, efficient and effective without which the vision of food for all cannot be attained in India.

Vivek Kumar Dhand et al. (2010)[75] discuss strategy adapted in using ICT to control diversion and leakage in the delivery mechanism and its application in computerization of paddy procurement under public distribution system in Chhattisgarh State..

ReetikaKhera(2011)[59] estimates the proportion of grain "diverted" from the Public Distribution System (PDS) to the open market for several years in the past decade, by matching state off take figures published by the government, with household purchase reported by the National Sample Survey (NSS).

Shruth Cyriac et al. (2003)[68] studied the PDS system in Kerala-often referred to as the 'Kerala Model' of implementation of the food security programme which subsidizes consumers and procures grain from farmers at prices higher than market prices . After attaining self-sufficiency in food production, the main challenge of the PDS was translating this macro level food security to a micro level, so that households in states which couldn't produce enough food to feed its population and depended on imports could avail of the surplus in states which produced more than what was necessary to feed their population.

Dev (1996) **[18]** emphasized on proper targeting and improved delivery system in rural areas will make the PDS more efficient. Nevertheless, not PDS alone, but a mix of policies involving effective implementation of anti-poverty programmes, controlling inflation, improving health facilities, will be needed to solve the food security problem in India

Deaton (2008) [17] has studied the improvement in PDS operations is possible when all the activities of the system are analyzed in an integrated manner. Procurement of food grains, their storage, their inter-state movement, their allocation to various states and distribution by FPS are not isolated problems and therefore, must be tacked in a holistic perspective.

Thamarajakshi (1997) [73] mentioned about the operations of PDS supply chain is being performed by the public sectors. Involvement of private actors in the food grain market will provide the right cues to farmers in deciding their cropping patterns in line with the emerging demand for different agricultural commodities.

Indrakanth (1997) [33] has prounced the leakages in PDS operations take place at every stage of the supply chain and take place in various forms. The leakages may take place right at the warehouse level and food grain may not reach to the targeted FPS, or FPS dealer may divert a part of allotted quota to open market. FPS owner may collude with district supply authorities in this operation or the leakage may also take place at household level where beneficiary may purchase the ration but sell it in open market at higher prices.

Mooij (1994) [50] explained that **t**he public distribution system (PDS) in India represents a direct intervention by the government of food market. It involves subsidized distribution of limited quantities of essential food such as cereals, sugar, edible oil etc. Among them, distribution of cereals assumes crucial importance it is supposed to provide food security to the poor. Of late, however, PDS has come under severe criticism for its urban bias, its ineffectiveness in reaching the poor and its inefficiency with reference to cost of distribution in the food grain market.

Gaiha (2000) [28] has analyzed that Several empirical studies based on PDS purchases have shown that the poor were not benefiting much from the PDS .There is literally no public participation in the working of the public distribution system (PDS) network, even in an advisory capacity. The operational details of the PDS differ from state to state. Though the policy of setting up of FPSs owes its initiation to national food policy, its implementation remains the direct responsibility of the state governments.

Vijay (2005) **[76]** mentioned about the responsibility of the central government is to procure, store, and transport grains from purchase points to central warehouses, the responsibility of state governments and the union territory administrations is to transport these commodities from the central warehouses and distribute them to consumers through the network of FPS.

"For every Rs 4 spent on the PDS, only Rs 1 reaches the poor". In 2010 Honorable **Justice Wadhwa committee [38]** made an open statement. The committee gave some important recommendation of PDS System in Andhra Pradesh, few of which is given below:

- Ideally, there should be a system by which the grain allocated to the State can be equated with the grain distributed to the beneficiaries. Since the scale of distribution and the number of beneficiaries is very large this cannot be achieved manually. **Complete automation and computerisation is the need of hour.** The attempt at automation in the state by introducing Iris technology (Iris recognition is a method of identifying people based on unique patterns within the ring-shaped region surrounding the pupil of the eye) has not been a success owing to lack of an integrated approach to automation. There are doubts about the efficacy of the technology as well, which the committee has elaborated in its report. Be that as it may, the implementation of Iris in Andhra Pradesh has been faulty and half hearted, leading to counterproductive results in as much as it has resulted in increasing bogus cards rather than increasing transparency. The above recommendation, however, does not derogate from our consistent finding that carefully planned, implemented and monitored automation is imperative for the successful implementation of PDS.

After the recommendation of Honorable Justice Wadhwaa committee, every state started to computerize its PDS supply chain. After that researchers tried to build some computerized systems or models.

Amit Krishnan et al. (2011) [02] proposed a centralized model for the Indian Public Distribution System (PDS) and with intention that the least centralized data inventory also eliminates all possibilities of illegal siphoning of goods and thus ensuring that the government "spends less to supply more". For this purpose the system was proposed having its Point of Sale (POS) outlets centered around an ebox 3310 MSJK device which runs an OS customized in Windows CE.

Basanta Kumara Brajraj Mohanty (2012) [06] threw light on the magnitude of corruption at micro level, its implications which is governing our various government schemes. Such corruption level needs to be curbed in order to streamline the system. The micro level study finds that corruption in PDS in rural India is very high and the important reasons attributed to this are appointment of dealers on political lines, and no provision of margin to the dealers. Consumer clubs are found to suffer mainly from lack of financial support. These clubs can play a very important role in educating the rural consumers about the PDS and in ensuring their food security and welfare.

2.2. Literature Review on Inventory Control Problems

Schmidt and Nahmias (1985) [65], described a (S-1, S) continuous review model with Poisson demands, a fixed lifetime and a fixed lead time. Using the supplementary variable method, they obtained various system performance measures. They also conducted numerical optimization studies and observed some interesting properties.

H.Xu et al. (1991) [32], discussed a multi item, interrelated two-echelon distributed system and the perishability of the product. As introduced, FS (fair share) rationing aims at equalizing "end stock-points stock-out probability". Using FS and a discounted cost objective (with linear holding and backorders costs), they extended an optimal base stocks evaluation procedure from serial to chains with a divergent last echelon.

H. E Romeijn et al. (2007) [30], studied a two-echelon inventory policy situation and develop a generic modeling framework to solve its problems. The supply chain investigated takes into account location issues, inventory issues, and safety stock. The model is formulated as a set covering program and solved through column generation.

Axsater S (1993) [04], has addressed exact approaches to evaluate the system's cost for a two echelon supply chain (one-warehouse-multi-retailer-system), considering a periodic review and continuous review, respectively. These approaches consider the other quantities, the re-order-points, as fixed parameters.

S.K. Goyal et al. (1995) [62], proposed a production–inventory model is developed for a deteriorating item over a finite planning horizon with a linear time varying demand, finite production rate and shortages. The resulting nonlinear constrained minimization problem is numerically solved by using the box complex algorithm. The optimal number of production cycles that minimizes the average system cost is determined. Sensitivity analysis of the optimal solution is carried out.

Verrijdt et al. (1995) [74], proposed the integrated production, Inventory and Distribution routing problem is concerned with coordinating production, inventory and delivery operations to meet customer demand with the objective of minimizing the cost. Optimally solving such an integrated problem is in general difficult due to its combinatorial nature, especially when transporter routing is involved. The delivery consolidation problem is formulated as a capacitated transportation problem with additional constraints and is solved heuristically. They evaluate the performance of this proposed two-phase approach and report on its application to a real-life supply network.

Fijuwara Okitsugu et al. (1997) [27], described an ordering and issuing policies, arising in controlling finite life time fresh meat carcass inventories in supermarkets. A supermarket orders a product, which continues a set of sub products of fixed proportion, from a vendor at the beginning of each time cycle.

P.C. Yang et al. (2002) [53], proposed an integrated single-vendor multi buyers inventory system of a deteriorating item and they also consider a single producer, multi-distributors and multi-retailers inventory system develops the optimal and heuristic solutions using a significant cost reduction approach

M. S Daskin et al. (2002) [43], the model was formulated as a mixed-integer nonlinear program where all retailers had similar demand. The problem was solved using a Langrangian relaxation and heuristics in order to find feasible solutions.

F. You et al. (2010) [22], proposed a multi echelon location inventory model that considers network design and inventory management for one product at a time. Their model is leads to a mixed-integer non-linear program. It is solved in different ways, one of which is heuristic method which depends on initializations from convex relaxations and Lagrange relaxations. Hereby their formulations tackle both retailers and warehouse.

2.3 Literature Review of BPSO

Fatih Taşgetiren. M et al. (2003) [24], proposed a Binary Particle Swarm Optimization Algorithm for inventory lot sizing. The problem is to find order quantities which will minimize the total ordering and holding costs of ordering decisions. Test problems are constructed randomly, and solved optimally by Wagner and Whitin Algorithm. Then a binary particle swarm optimization algorithm and a traditional genetic algorithm are coded and used to solve the test problems in order to compare them with those of optimal solutions by the Wagner and Whitin algorithm. Experimental results show that the binary particle swarm optimization algorithm is capable of finding optimal results in almost all cases.

Yi Hana et al. (2009) [80], used a particle swarm optimization with flexible inertial weight for Solving capacitated multilevel lot-sizing problems. This paper proposed a particle swarm optimization (PSO) algorithm for solving the capacitated multi-level lot-sizing (MLLS) problem with assembly structure. All the mathematical operators in our algorithm are redefined and the inertial weight parameter can be either a negative real number or a positive one. The feasibility and effectiveness of our algorithm are investigated by comparing the experimental results with those of a genetic algorithm (GA).

Klorklear Wajanawichakon et al. (2011) [39], the authors presented a binary particle swarm optimization (PSO) algorithm for unconstrained multi-level lot-sizing (MLLS) problem, which is a production planning problem in materials requirements planning (MRP) system. The problem aims to find production planning which take the minimization of total setup costs and inventory holding costs. In algorithm they firstly randomly find a set of initial solution. Then, they use the particles to find solution according to standard mechanism of PSO. After that, authors apply hybrid selection mechanism to restart the algorithm. Hybrid selection is a kind of general restart mechanism in PSO but beside simply restart by randomly generate new solution, introduce good solutions which are generated from standard single level lot sizing problem such as Wagner and Whitin algorithm, Silver and Meal heuristic to combine with the current best solution and resulting of the hybrid selection, will get new population which will be used as in the standard binary PSO.

2.4 Literature Review on Vehicle Routing Problems

Jean-Franc et al. (1997) [36] proposed a tabu search heuristic capable of solving three well-known routing problems: the periodic vehicle routing problem, the periodic traveling salesman problem, and the multi-depot vehicle routing problem.

Bent et al. (2004) [07] suggested a two-stage hybrid algorithm for this transportation problem. The algorithm first minimizes the number of vehicles using simulated annealing. It then minimizes travel cost using a large neighborhood search which may relocate a large number of customers.

Mohamed Haouari et al. (2011) [49] described models and exact solutions approaches for an integrated aircraft fleeting and routing problem arising at TunisAir. Given a schedule of flights to be flown, the problem consists of determining a minimum cost route assignment for each aircraft so as to cover each flight by exactly one aircraft while satisfying maintenance activity constraints.

Feillet et al. (2004) [25] proposed an exact solution procedure for the Elementary Shortest Path Problem with Resource Constraints (ESPPRC) which extends the classical label correcting algorithm originally developed for the relaxed (non-elementary) path version of this problem.

P. Kilby et al. (2000) [54], studied the effect of different heuristic techniques. Then they investigated the performance of a number of construction and improvement techniques, and show that as the size of the solution space is decreased through addition of side constraints, certain conventional techniques fail while constraint directed techniques continue to perform acceptably.

BurcinBozkaya et al. (2010) [10] proposed a hybrid heuristic optimization methodology for solving this model. The optimal locations are searched for by a Genetic Algorithm while an integrated Tabu Search algorithm is employed for solving the underlying vehicle routing problem.

Ann Campbell et al. (1998) [03] studied vendor managed resupply as an emerging trend in logistics and refers to situations in which a supplier manages the inventory replenishment of its customers. Vendors save on distribution cost by being able to better coordinate deliveries to different customers and customers do not have to dedicate resources to inventory management.

Olli Braysy (2001) [51] developed genetic algorithm based approaches for solving the vehicle routing problem with time windows and compare their performance with the best recent meta-heuristic algorithms. The findings indicate that the results obtained with pure genetic algorithms are not competitive with the best published results, though the differences are not over whelming.

Aziz Ezzatneshan (2010) [05] proposed a hybrid ACO algorithm for solving vehicle routing problem (VRP) heuristically in combination with an exact. In the basic VRP, geographically scattered customers of known demand are supplied from a single depot by a fleet of identically capacitated vehicles.

Jonathan F et al. (2002) [37] discussed the problem of finding minimum number of vehicles required to visit a set of nodes subjected to a time window constraints. A secondary objective is to minimize the total distance travelled.

Jabal-Ameli et al. (2011) [35] discussed about Location Routing Problem which arises in many practical applications within logistics and supply chain management. The objective is to minimize the overall system costs which include the fixed costs of opening depots and using vehicles at each depot site, and the variable costs associated with delivery activities.

C. Duhamel et al. (2008) [15] addressed distribution network design problems that involves depot location, fleet assignment and routing decisions. The distribution networks are characterized by several depots, a capacitated homogeneous vehicle fleet and a set of customer nodes to be serviced with demands. The objective is to assign the serviced nodes to depots and to design the vehicle routes. The optimal solution minimizes both the depot cost and the total route distance in such a way that the total customer demand assigned to one depot is upper bounded by the depot capacity.

Shih. W et al. (2007) [67] proposed a hybrid algorithm for vehicle routing problems. The developed algorithm first employs the nearest-neighbor heuristic to search for feasible solutions based on the constraints of both the time-window and loading capacity in the routing problem. Because of its qualities the genetic algorithm improves the initial solution, avoids local optimization and gains a better solution in the problem domain.

Wang Jiang-qing et al. (2009) [77] developed a web-based system for dynamic vehicle routing problem. After proposing the architecture of the system, they developed a dynamic route evaluation model for modeling the responses of vehicles to real-time traffic information, and use a hybrid optimization algorithm to plan the routes of vehicles in dynamic network.

2.5 Literature Review on cloud computing

In October 2007, cloud computing was first introduced to the public through a cooperation between two computing companies, IBM and Google. Cloud computing as a model that allows the sharing of many computing resources as services to various clients. In this model, clients can easily change or adjust their service requirements at a very low cost. The Clouds in cloud computing includes both software and hardware in data center that are usable and accessible virtualized resources. The components of cloud computing include data, information, application semantics, metadata, schema, data dictionary, data catalog, and information model. Cloud manufacturing is one of the most important manufacturing mode in the future, in early 2010, academician **Li Bo hu (2010) [42]** systematically explained the cloud manufacturing in an article titled by cloud manufacturing--the newly service-oriented network-based manufacturing mode. Clouds manufacturing mixes network-based manufacturing and service technology with cloud computing, cloud security, high performance computing, IOT and other advanced technology to achieve all kinds of manufacturing resources (manufacturing hardware devices, computing systems, software, modes, data, knowledge, etc.) centralized management, intelligent business, provides readily available, demand-oriented, safe, reliable, high-quality, low-cost services to various manufacturing activities for manufacturing life cycle process.

Tao fei (2010) [72] designed the function structure of cloud manufacturing service management prototype system. Several key issues for cloud service composition, including modeling, description and consistency check, correlation relationship, composition flexibility, composition network as well as its dynamic characteristics, modeling & evaluation, and optimal selection were studied in particular.

Fan wen-hui [23] presented the integrated architecture of cloud manufacturing based on federation mode, which provided effective integration for various heterogeneous cloud manufacturing platform.

Y. Cheng et al. (2010) [78] studied a utility model and utility equilibrium of resource service transaction in Cloud Manufacturing. Decision-making methods have been developed to maximize the utility of a resource demander and resource provider. Yet it is difficult to represent the manufacturing resources without a standardized schema, not to mention that original user requests would be difficult to fulfill.

Parshant Sharma et al. (2014) [56] Cloud computing refers to the delivery of computing resources over the Internet. Instead of keeping data on your own hard drive or updating applications for your needs, you use a service over the Internet, at another location, to store your information or use its applications.

2.6 Literature Review on Smart Card Authentication

Ming-Huang Guo et al. (2010) [48] have proposed an idea of two factor WLAN security by using RFID technology. The conventional username and password login system is very much prone to be hacked by the hacker. Therefore this single factor authentication is not secure enough. In virtue of enhancing security, recent researches on authentication are built on Two-Factor Authentication schemes. Nevertheless, the expensive cost of building Two-Factor Authentication approach has affected the will of users. For the purpose of lifting the rate of usage, they have applied low-cost passive Radio Frequency Identification (RFID) tag along with the names and passwords of users as login authentication.

Marie-Pier Pelletier et al. (2010) [47] in their review paper have gone through the detailed application of smart card in public transportation system. Smart card automated fare collection systems are being used more and more by public transit agencies. While their main purpose is to collect revenue, they also produce large quantities of very detailed data on onboard transactions. These data can be very useful to transit planners, from the day-to-day operation of the transit system to the strategic long-term planning of the network. Their paper has covered several aspects of smart card data use in the public transit context. first, the technologies are presented: the hardware and information systems required to operate these tools; and privacy concerns and legal issues related to the dissemination of smart card data, data storage, and encryption are addressed.

S. H Choi et al. (2014) [61] have provided an idea about the application of RFID technology for the enhancement of customer shopping experience in the apparel retail. Traditional stores generally cannot fully satisfy customer needs because of difficulties in locating target products, out-of-stocks, a lack of professional assistance for product selection, and long waiting for payments. Therefore, they have proposed an item-level RFID enabled retail store management system for relatively high-end apparel products to provide customers with more leisure, interaction for product information, and automatic apparel collocation to promote sales during shopping. In that proposed system, RFID hardware devices are installed to capture customer shopping behavior and preferences, which would be especially useful for business decision-making and proactive individual marketing to enhance retail business.

Mandeep Kaur et al. (2011) [45] This paper gives an overview of the current state of radio frequency identification (RFID) technology. Aside from a brief introduction to the principles of the technology, major current and envisaged fields of application, as well as advantages, and limitations of use are discussed. Radio frequency identification (RFID) is a generic term that is used to describe a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves. It's grouped under the broad category of automatic identification technologies. In this paper Basic Principles of RFID technology along with its types are discussed.

Dino Zupanovic (2014) [20] has introduced framework for development of Near Field Communication based ferry ticketing system in Croatia. Croatian ferry operators' ticketing system represents classical over-the-counter ferry ticket system (OTCFTS) at ferry ports and characterized by almost absolute absence of any electronic payment options. Such system setup offers very limited set of options for end-users to decide when and where to purchase their ferry tickets. To overcome such issues he has proposed Near Field Communication (NFC) implementation as basis for defining a revised Croatian ferry ticketing system.

At present, the research on cloud computing and smart card application is still in the experimental stage at home and aboard, Cheng (2010) puts forward the basic functions and system designing of the cloud manufacturing services management and control platform, and gives the specific application, which has certain reference value. So taking the inspiration from literature the author tried to use cloud computing with smart card application in the supply chain of public distribution system.

2.7 Gap Analysis

From the literature survey it is found that, most of the researchers have suggested for improvement of PDS system but no concrete solutions for the real life existing problems are found. In most of the inventory and transportation models, authors have suggested solutions by taking into consideration many different cases which are not relevant to PDS network supply chain. Hence in this thesis an attempt is made to develop the models for real life working of PDS by collecting a large amount of data from the district administration and formulating the models for inventory, transportation, and web based system. This is done through analyzing the data and applying different techniques of Supply Chain Management (SCM) and Operation Research (OR) models including utilization of Smart card technology to address the existing problems.

2.8 Summary

The literatures in the fields of Public Distribution System, Inventory control problems, Binary Particle optimization Technique, Transportation and Vehicle Routing Problems, Cloud Manufacturing , Smart Card Authentication as mentioned in this Chapter provides an in-depth knowledge about the present condition as well the ongoing development in the concerned fields which is very much helpful for undertaking thesis work. Based on the literature , researcher has framed the idea for developing the solutions to the problems in public distribution sytem in the contex of inventory, transportaion and transperancy in the system.

Development of Inventory Model for PDS of Warangal District using BPSO

3.1 Introduction

In this chapter it is proposed to develop a mathematical model for the distribution of an essential commodity (Rice) in a multi echelon Public Distribution System and to solve the problem using techniques of inventory control and minimization of total cost. The recently developed BPSO technique is used to achieve the goal. Both State and Central Governments in India are implementing many welfare schemes for benefit of poor people. One among most the popular schemes is the 'Public Distribution System', through which the Government distributes food grains like rice at subsidized prices through fair price shops to the public. The Government procures the rice stocks from millers and stores at their warehouses (FCI). The FCI supplies to some distribution centers referred to as MLSP's. Each MLSP, in turn supplies materials to some associated FPS's. Thus in a distribution system we have (i) FCI warehouses, (ii) a small number of Mandal Level Stock Points (MLSP's) (iii) a large number of Fair Price Shops (FPS) which are, in sets, associated with each Mandal Level Stock Point (MLSP). This is the structure of a multi echelon PDS. The procurement of rice by FCI, its storage, supply to MLSP's, ordering/reordering by MLSP's for their respective demands, their storage and supplies to FPS's, all these involve considerable expenditure. The procurement and inventory maintenance, under PDS in Warangal is attended to a trial and error basis but not scientifically. Sometimes total cost involved may be on higher side also

3.2 Public Distribution System (PDS) of Warangal District

Public Distribution System includes the procurement (from the producer i.e. farmers) and distribution (to the customers i.e. common people) of essential commodities. As far as distribution is concerned, the whole model divided in two stages.

Stage 1: Ordering and Transportation of commodities from FCI owned godowns to intermediate ware houses, also known as Mandal Level Service Points (MLSP).

Stage 2: Transportation of material from MLSP to Fair Price Shops (FPS)

Material flow in various stages is as shown in the Figure 3.1.

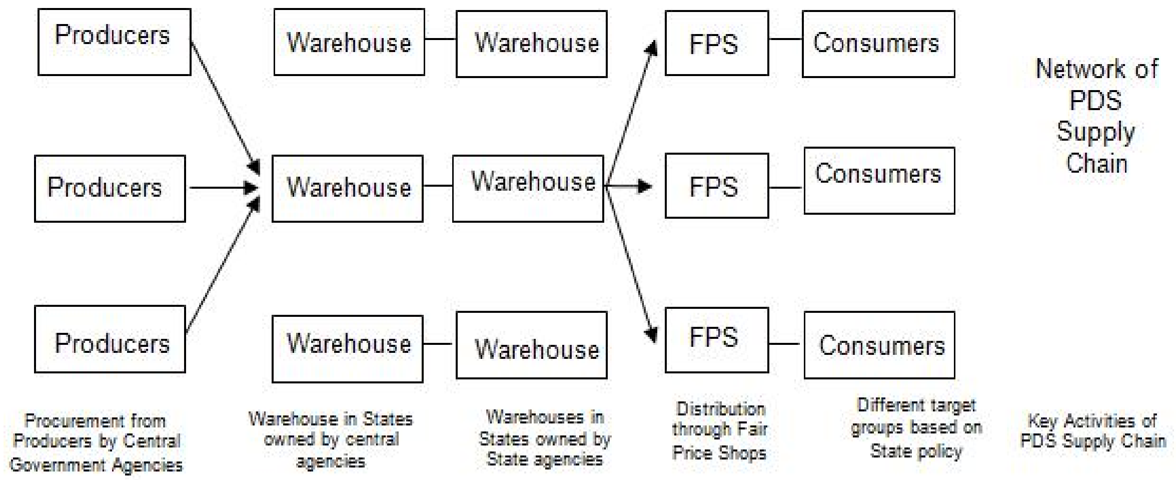


Figure 3.1 Flow of Material in various stages of PDS.

Warangal district is divided into various divisions and mandals from administrative point of view. There are 5 divisions, 51 mandals, 18 Mandal Level Stock Points and 2012 FPS in Warangal.

List of various Divisions in Warangal:

1. Warangal Division
2. Jangaon Division
3. Mahbubabad Division
4. Mulugu Division
5. Narsampet Division.

List of various Mandals in Warangal:

1.Atmakur	2. Dharmasagar
3.Geesugonda	4. Ghanpur(Stn)
5.Hanamkonda	6. Hasanparthy
7. Parvathagiri	8. Raiparthy

9. Sangem
10. Warangal
11. Wardhannapet
12. Zaffergadh
13. Bachannapeta
14. Cheriyal
15. Devaruppula
16. Jangaon
17. Kodakandla
18. LingalaGhanpur
19. Maddur
20. Narmetta
21. Palakurthi
22. RaghunathPalle
23. Dornakal
24. Kesamudram
25. Kuravi
26. Mahabubabad
27. Maripeda
28. Narsimhulapet
29. Nekkonda
30. Nellikudur
31. Thorrur
32. Bhupalpalle
33. Chityal
34. Eturnagaram
35. Ghanapur
36. Govindaraopet
37. Mangapet
38. Mogullapalle
39. Mulugu
40. Parkal
41. Regonda
42. Shayampet
43. Tadvai
44. Venkatapur
45. Chennaraopet
46. Duggondi
47. Gudur
48. Khanapur
49. Kothagudem
50. Nallabelly
51. Narsampet

List of various Mandal Level Service Points (MLSP):

1. CSC Hanamakonda
2. DCMS Warangal
3. Ghanpur Station
4. Wardhannapet
5. Jangaon
6. Kodakandla
7. Cherial
8. Mahabubabad
9. Thorrur
10. Maripeda
11. Kesamudram
12. Mulugu
13. Parkal
14. Chityal
15. Eturnagram
16.Motlapally
17. Narsampaet
18. Kothaguda

List of FCI owned godowns with their capacities in Tons and their distances in Kilometres from various MLSP's in Warangal district are furnished in Table 3.1

Table 3.1: List of FCI owned godowns and their distances(kms) from various MLSP's

S. No.	Name of MLS Point	FCI Kazipet	CWC Ennu-mamla	SWC Ennu-mamla	SWC Dharm-aram	SWC Jangaon	SWC Mah'bad	CWC Warangal
		88,340 (Tons)	8,500 (Tons)	10,000 (Tons)	20,000 (Tons)	30,000 (Tons)	10,000 (Tons)	2,500 (Tons)
1	Hanamkonda	6	14	14	18	51	94	5
2	Warangal	11	5	5	9	57	88	3
3	Ghanpurstation	22	37	37	41	22	121	30
4	Wardhannpet		29	29	33	46	93	27
5	Kodakanndla	74	76	76	80	55	94	76
6	Jangaon	52	67	67	71	8	141	60
7	Cherial	83	98	98	102	40	160	91
8	Mah'bad	95	86	86	76	138	5	87
9	Thorrur	58	53	53	57	72	47	51
10	Maripeda	93	88	88	92	107	35	85
11	Kothaguda	66	57	57	47	110	52	58
12	Narsmpet	45	36	36	26	89	53	37
13	Parkal	40	44	44	48	84	103	38
14	Chityal	65	59	59	63	109	128	63
15	Mulugu	58	53	53	57	102	90	59
16	Motlapally	53	60	60	64	87	116	58
17	Eturnagram	117	112	112	116	161	150	115
18	Kesamudram	74	68	68	72	107	24	66

List of mandals in Warangal division and their distances from MLSP's are shown in Table 3.2

Table 3.2: List of Mandals in Warangal Division and their distances(kms) from MLSP's

S.No	Mandal Name	Hanumakonda	Warngal	Ghanpur (Stn)	Wardannpet
1	Atmakur	24	21	50	47
2	Dharmasagar	16	20	29	21
3	Geesugonda	18	14	45	12
4	Ghanpur(Stn)	28	32	0	28
5	Hanamkonda	0	5	28	42
6	Hasanparthy	8	11	34	15
7	Parvathagiri	42	39	48	36
8	Raiparthy	40	36	46	33

9	Sangem	36	33	64	30
10	Warangal	5	0	32	47
11	Wardhannapet	31	27	28	0
12	Zaffergadh	42	47	15	38

Llist of mandals in Jangaon division and their distances from MLSP's are shown in Table 3.3

Table 3.3: List of Mandals in Jangaon Division and their distances(kms) from MLSP's

S.No	Mandal Name	Jangaon	Kodakandla	Cheryal
13	Bachannapeta	19	71	18
14	Cheriyal	37	89	0
15	Devaruppula	35	27	67
16	Jangaon	0	58	37
17	Kodakandla	58	0	89
18	LingalaGhanpur	12	49	43
19	Maddur	55	106	19
20	Narmetta	32	76	27
21	Palakurthi	36	20	68
22	RaghunathaPalle	12	67	45

List of mandals in Mahabubabad division and distances from MLSP's are shown in Table 3.4

Table 3.4: List of Mandals in Mahabubabad Division and distances (kms) from MLSP's

S.No	Mandal Name	Mah'bad	Thorrur	Maripeda	Kesamudram
23	Dornakal	30	73	61	58
24	Kesamudram	24.5	39	58	0
25	Kuravi	11.5	56	24	36
26	Mahabubabad	0	40	34	25
27	Maripeda	34	36	0	59
28	Narsimhulapet	51	25	21	49
29	Nekkonda	49	41	64	20
30	Nellikudur	22	32	51	8
31	Thorrur	44	0	35	40

List of mandals in Mulugu division and distances from MLSP's are shown in Table 3.5

Table 3.5: List of Mandals in Mulugu Division and distances(kms) from MLSP's

S.No	Mandal Name	Mulugu	Parkal	Chityal	Eturnagram	Motlapally
32	Bhupalpalle	42	35	31	92	53
33	Chityal	63	27	0	103	26
34	Eturnagaram	60	106	103	0	125
35	Ghanapur	78	62	86	137	82
36	Govindaraopet	21	68	65	39	86

37	Mangapet	72	118	116	18	137
38	Mogullapalle	48	33	58	107	60
39	Mulugu	0	46	63	60	107
40	Parkal	47	0	27	106	39
41	Regonda	23	11	18	82	42
42	Shayampet	33	12	36	92	50
43	Tadvai	43	89	87	18	108
44	Venkatapur	78	124	121	19	142

List of mandals in Narsampet division and distances from MLSP's are shown in Table 3.6

Table 3.6: List of Mandals in Narsampt Division and distances(kms) from MLSP's

S.No	Divison Name	Narsampet	Kothaguda
45	Chennaraopet	7	46
46	Duggondi	20	27
47	Gudur	21	46
48	Khanapur	24	23
49	Kothagudem	80	0
50	Nallabelly	44	63
51	Narsampet	0	45

The details of Mandal wise different type of ration cards and rice allotted for Warangal Division are furnished in Table 3.7

Table 3.7: Status of total BPL cards and rice allotment for Warangal Division

S.no.	Name of the Mandal	Total BPL Cards	Annapurna (AAP)		Anthyodaya (YAP)		White cards (WAP)							
			Cards	Rice Quota (in Qtls.)	Cards	Rice Quota (in Qtls)	1M	2M	3M	4M	5m and more	Total White cards	Rice Quota (in Qtls)	Total (In Qtls)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	Atmakur	17,295	54	5.40	1,361	476.35	1,180	2,859	3,276	5,262	3,303	15,880	2,170	2,651.31
2	Dharmasagar	19,579	66	6.60	1,677	586.95	1,340	3,358	3,493	5,562	4,083	17,836	2,446	3,039.47
3	Geesugonda	17,285	35	3.50	1,142	399.70	1,184	2,714	3,291	5,481	3,438	16,108	2,222	2,625.16
4	Ghanpur(Stn)	24,704	40	4.00	1,992	697.20	1,577	4,404	4,223	6,737	5,731	22,672	3,144	3,845.48
5	Hanamkonda	66,125	111	11.10	3,700	1,295.00	3,431	10,086	12,951	20,568	15,278	62,314	8,820	10,125.82
6	Hasanparthy	20,193	42	4.20	1,531	535.85	1,516	3,448	3,897	5,956	3,803	18,620	2,516	3,055.73
7	Parvathagiri	11,410	25	2.50	870	304.50	531	1,734	2,181	3,570	2,499	10,515	1,491	1,797.68
8	Raiparthy	14,307	42	4.20	1,048	366.80	783	2,661	2,775	3,988	3,010	13,217	1,815	2,186.28
9	Sangem	16,137	36	3.60	1,229	430.15	1,373	3,403	3,140	4,671	2,285	14,872	1,906	2,340.07
10	Warangal	73,466	159	15.90	5,240	1,834.00	3,906	9,912	13,168	22,208	18,873	68,067	9,832	11,682.14
11	Wardhannapet	18,592	77	7.70	1,570	549.50	990	2,573	3,174	5,217	4,991	16,945	2,457	3,014.44
12	Zaffergadh	12,875	23	2.30	973	340.55	869	2,299	2,475	3,576	2,660	11,879	1,618	1,960.69
	Total:	3,11,968	710	71.00	22,333	7,816.55	18,680	49,451	58,044	92,796	69,954	2,88,925	40,437	48,324.27

*M: Family Member

The details of Mandal wise different type of ration cards and rice allotted for Jangaon Division are furnished in Table 3.8

Table 3.8: Status of total BPL cards and rice allotment for Jangaon Division

S.No.	Name Of The Mandal	TOTAL BPL CARDS	Annapurna (AAP)		Anthyodaya (YAP)		White Cards (WAP)							
			Cards	Rice Quota (In Qtls.)	Cards	Rice Quota (In Qtls)	1M	2M	3M	4M	5M and more	Total White Cards	Rice Quota (In Qtls)	Total (In Qtls)
13	Bachannapeta	12,150	22	2.20	1,032	361.20	1,028	1,832	1,995	3,000	3,241	11,096	1,553	1,916.68
14	Cheriyal	18,230	47	4.70	1,428	499.80	1,190	2,719	3,096	4,583	5,167	16,755	2,401	2,905.82
15	Devaruppula	12,019	49	4.90	886	310.10	877	2,149	2,249	3,303	2,506	11,084	1,505	1,819.56
16	Jangaon	20,834	50	5.00	2,028	709.80	1,380	2,989	3,733	5,590	5,064	18,756	2,644	3,359.28
17	Kodakandla	13,480	35	3.50	997	348.95	928	2,115	2,493	3,663	3,249	12,448	1,739	2,091.81
18	Lingala Ghanpur	11,139	27	2.70	980	343.00	1,041	1,886	1,933	2,871	2,401	10,132	1,362	1,707.74
19	Maddur	11,294	36	3.60	925	323.75	940	1,946	1,982	2,738	2,727	10,333	1,413	1,739.95
20	Narmetta	12,305	41	4.10	975	341.25	936	2,067	2,225	3,211	2,850	11,289	1,552	1,896.91
21	Palakurthi	15,825	50	5.00	1,258	440.30	884	2,362	2,903	4,450	3,918	14,517	2,066	2,511.58
22	Raghunatha Palle	15,132	47	4.70	1,144	400.40	1,313	2,901	2,887	3,938	2,902	13,941	1,840	2,244.62
	Total:	1,42,408	404	40.40	11,653	4,078.55	10,517	22,966	25,496	37,347	34,025	1,30,351	18,075	22,193.95

The details of Mandal wise different type of ration cards and rice allotted for Mahabubabad Division are furnished in Table 3.9

Table 3.9: Status of total BPL cards and rice allotment for Mahabubabad Division

S.No.	Name Of The Mandal	Total BPL Cards	Annapurna (AAP)		Anthyodaya (YAP)		White Cards (WAP)							
			Cards	Rice Quota (In Qtls.)	Cards	Rice Quota (In Qtls)	1M	2M	3M	4M	5M and more	Total White Cards	Rice Quota (In Qtls)	Total (In Qtls)
23	Dornakal	14,552	41	4.10	1,062	371.70	1,100	2,579	2,946	4,284	2,540	13,449	1,795	2,171.08
24	Kesamudram	17,787	31	3.10	1,111	388.85	1,149	3,205	3,619	5,416	3,256	16,645	2,252	2,644.35
25	Kuravi	18,994	37	3.70	1,351	472.85	1,433	3,655	3,887	5,497	3,134	17,606	2,320	2,797.03
26	Mahabubabad	25,228	61	6.10	1,856	649.60	1,250	3,808	5,046	8,037	5,170	23,311	3,278	3,933.78
27	Maripeda	23,002	60	6.00	1,564	547.40	1,374	4,024	4,753	6,826	4,401	21,378	2,918	3,471.00
28	Narsimhulapet	17,983	38	3.80	1,231	430.85	1,238	3,691	3,739	5,058	2,988	16,714	2,198	2,633.01
29	Nekkonda	13,422	38	3.80	951	332.85	893	2,654	2,591	3,959	2,336	12,433	1,658	1,994.25
30	Nellikudur	16,705	47	4.70	1,179	412.65	1,010	3,100	3,361	4,832	3,176	15,479	2,098	2,515.39
31	Thorrur	20,603	37	3.70	1,383	484.05	1,342	3,930	4,225	5,812	3,874	19,183	2,570	3,057.55
	Total:	1,68,276	390	39.00	11,688	4,090.80	10,789	30,646	34,167	49,721	30,875	1,56,198	21,088	25,217.44

The details of Mandal wise different type of ration cards and rice allotted for Mulugu Division are furnished in Table 3.10

Table 3.10: Status of total BPL cards and rice allotment for Mulugu Division

S.No.	Name Of The Mandal	Total BPL Cards	Annapurna(AAP)		Anthyodaya (YAP)		White Cards (WAP)							
			Cards	Rice Quota (In Qtls.)	Cards	Rice Quota (In Qtls)	1M	2M	3M	4M	5M and more	Total White Cards	Rice Quota (In Qtls)	Total (In Qtls)
32	Bhupalpalle	16,286	46	4.60	1,048	366.80	1,246	2,975	3,298	4,826	2,847	15,192	2,023	2,394.56
33	Chityal	16,861	62	6.20	1,224	428.40	1,265	3,223	3,203	5,026	2,858	15,575	2,067	2,501.16
34	Eturnagaram	10,106	10	1.00	967	338.45	667	1,788	1,935	2,647	2,092	9,129	1,242	1,581.29
35	Ghanapur	9,875	17	1.70	669	234.15	666	1,835	2,071	2,963	1,654	9,189	1,225	1,460.69
36	Govindaraopet	9,372	26	2.60	867	303.45	958	1,908	1,800	2,658	1,155	8,479	1,061	1,367.29
37	Mangapet	11,039	15	1.50	963	337.05	738	1,942	2,232	3,051	2,098	10,061	1,358	1,697.03
38	Mogullapalle	12,022	46	4.60	968	338.80	1,097	2,328	2,311	3,504	1,768	11,008	1,420	1,763.08
39	Mulugu	15,908	36	3.60	1,258	440.30	1,448	2,894	3,095	4,607	2,570	14,614	1,910	2,353.86
40	Parkal	21,526	35	3.50	1,692	592.20	1,660	4,066	4,009	6,613	3,451	19,799	2,619	3,214.74
41	Regonda	18,005	49	4.90	1,531	535.85	1,631	3,657	3,545	5,040	2,552	16,425	2,098	2,638.75
42	Shayampet	12,390	36	3.60	1,076	376.60	932	2,305	2,420	3,642	1,979	11,278	1,489	1,868.80
43	Tadvai	5,639	15	1.50	676	236.60	351	998	1,046	1,411	1,142	4,948	674	911.66
44	Venkatapur	11,471	27	2.70	864	302.40	997	2,208	2,294	3,303	1,778	10,580	1,374	1,678.98
	Total:	1,70,500	420	42.00	13,803	4,831.05	13,656	32,127	33,259	49,291	27,944	1,56,277	20,559	25,431.89

The details of Mandal wise different type of ration cards and rice allotted for Narsampet Division are furnished in Table 3.11

Table 3.11: Status of total BPL cards and rice allotment for Narsampet Division

S.No.	Name of the Mandal	Total BPL Cards	Annapurna (AAP)		Anthyodaya (YAP)		White Cards (WAP)							
			Cards	Rice Quota (In Qtls.)	Cards	Rice Quota (In Qtls)	1M	2M	3M	4M	5M and more	Total White Cards	Rice Quota (In Qtls)	Total (Qtls)
45	Chennaraopet	15,559	50	5.00	1,194	417.90	1,184	2,975	2,976	4,723	2,457	14,315	1,888	2,310.46
46	Duggondi	12,869	38	3.80	990	346.50	941	2,456	2,482	3,925	2,037	11,841	1,565	1,915.66
47	Gudur	15,335	35	3.50	1,464	512.40	970	2,458	2,997	4,505	2,906	13,836	1,895	2,410.98
48	Khanapur	9,263	37	3.70	854	298.90	679	1,644	1,853	2,667	1,529	8,372	1,112	1,414.16
49	Kothagudem	9,967	20	2.00	1,192	417.20	589	1,495	1,818	2,753	2,100	8,755	1,220	1,639.00
50	Nallabelly	11,395	33	3.30	921	322.35	992	2,134	2,106	3,402	1,807	10,441	1,367	1,692.49
51	Narsampet	17,020	39	3.90	1,349	472.15	1,077	2,647	3,099	5,559	3,250	15,632	2,166	2,642.21
	Total:	91,408	252	25.20	7,964	2,787.40	6,432	15,809	17,331	27,534	16,086	83,192	11,212	14,024.96

Table 3.12: Status of Total BPL Cards and demand FPS wise for Chennaraopet Mandal

S. No.	FP Shop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)						Total Rice Quota	
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	5M and more	Rice Quota (In Kgs.)	In Kgs.	In MTs.
1	001	498	3	5	30	45	156	1,575	38	88	103	151	70	5,908	7,513	7.513
2	002	569	1	1	10	45	136	1,575	66	105	101	187	64	6,588	8,173	8.173
3	003	617	2	2	20	53	190	1,855	59	150	113	168	72	6,920	8,795	8.795
4	004	688	0	0	0	56	188	1,960	59	122	141	205	105	8,284	10,244	10.244
5	005	396	2	2	20	38	126	1,330	20	61	73	123	79	4,992	6,342	6.342
6	006	732	4	5	40	53	155	1,855	75	125	147	224	104	8,728	10,623	10.623
7	007	713	2	2	20	72	193	2,520	76	152	115	221	75	7,936	10,476	10.476
8	008	553	4	7	40	31	98	1,085	45	100	121	158	94	6,840	7,965	7.965
9	9	714	4	4	40	60	216	2,100	57	107	127	224	135	8,892	11,032	11.032
10	010	564	1	1	10	40	125	1,400	47	93	107	175	101	7,036	8,446	8.446
11	011	589	1	1	10	40	142	1,400	40	104	115	185	104	7,412	8,822	8.822
12	012	862	2	2	20	59	215	2,065	46	210	160	259	126	10,448	12,533	12.533
13	013	469	3	4	30	34	94	1,190	54	111	83	134	50	5,244	6,464	6.464
14	014	337	0	0	0	35	89	1,225	39	74	74	90	25	3,576	4,801	4.801
15	015	576	3	3	30	41	156	1,435	43	117	102	198	72	6,940	8,405	8.405
16	016	630	1	1	10	58	203	2,030	42	126	123	186	94	7,508	9,548	9.548
17	017	445	4	4	40	28	100	980	21	57	89	130	116	6,008	7,028	7.028
18	018	744	3	3	30	68	240	2,380	48	142	156	222	105	8,852	11,262	11.262
19	019	491	3	3	30	39	144	1,365	26	89	82	168	84	6,168	7,563	7.563
20	020	367	0	0	0	33	110	1,155	50	82	52	96	54	4,096	5,251	5.251
21	021	804	2	2	20	68	219	2,380	68	165	158	235	108	9,408	11,808	11.808
22	022	616	3	3	30	46	150	1,610	24	103	131	193	116	7,900	9,540	9.540
23	023	532	0	0	0	38	131	1,330	23	125	108	153	85	6,536	7,866	7.866
24	024	449	1	1	10	26	95	910	35	79	83	125	100	5,768	6,688	6.688
25	025	405	1	1	10	33	101	1,155	29	100	83	131	28	4,568	5,733	5.733
26	026	258	0	0	0	10	33	350	7	41	57	78	65	3,588	3,938	3.938
27	027	387	0	0	0	21	74	735	24	67	63	131	81	5,104	5,839	5.839
28	028	184	0	0	0	12	43	420	6	11	35	54	66	2,716	3,136	3.136
29	029	369	0	0	0	12	42	420	17	68	74	119	79	4,984	5,404	5.404
30	060	1	0	0	0	0	0	0	0	1	0	0	0	8	8	0.008
Total		**15,559**	**50**	**57**	**500**	**1,194**	**3,964**	**41,790**	**1,184**	**2,975**	**2,976**	**4,723**	**2,457**	**188,956**	**231,246**	**231.246**

Table 3.13: Status of Total BPL Cards and demand FPS wise for Duggondi Mandal

S. No.	FP Shop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)						Total Rice Quota	
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	5M and more	Rice Quota (In Kgs.)	In Kgs.	In MTs.
1	001	232	0	0	0	22	78	770	17	62	32	59	40	2,692	3,462	3.462
2	002	255	1	2	10	22	85	770	17	47	52	78	38	3,076	3,856	3.856
3	003	289	2	2	20	19	67	665	18	59	50	88	53	3,612	4,297	4.297
4	004	590	0	0	0	43	132	1,505	60	117	113	189	68	6,916	8,421	8.421
5	005	451	4	6	40	39	119	1,365	39	93	93	114	69	5,220	6,625	6.625
6	006	251	0	0	0	12	41	420	20	50	42	71	56	3,240	3,660	3.660
7	007	488	2	2	20	34	112	1,190	37	98	108	137	72	5,860	7,070	7.070
8	008	313	2	2	20	25	85	875	21	63	64	91	47	3,752	4,647	4.647
9	009	259	0	0	0	18	62	630	19	47	59	81	35	3,156	3,786	3.786
10	010	331	1	1	10	25	94	875	33	82	61	86	43	3,756	4,641	4.641
11	011	233	0	0	0	17	49	595	20	50	54	62	30	2,720	3,315	3.315
12	012	299	0	0	0	29	96	1,015	29	59	49	79	54	3,520	4,535	4.535
13	013	378	1	1	10	24	67	840	25	89	76	121	42	4,500	5,350	5.350
14	014	193	1	1	10	18	57	630	22	51	26	55	20	2,088	2,728	2.728
15	015	442	2	2	20	37	121	1,295	32	90	91	121	69	5,256	6,571	6.571
16	016	375	0	0	0	27	91	945	16	66	80	136	50	4,728	5,673	5.673
17	017	569	0	0	0	44	123	1,540	54	92	120	166	93	6,908	8,448	8.448
18	018	515	1	2	10	49	151	1,715	53	98	99	153	62	5,872	7,597	7.597
19	019	443	1	2	10	28	98	980	39	86	91	121	77	5,412	6,402	6.402
20	020	393	2	3	20	31	105	1,085	33	84	69	121	53	4,628	5,733	5.733
21	021	423	0	0	0	32	108	1,120	23	78	97	130	63	5,220	6,340	6.340
22	022	478	2	2	20	33	79	1,155	40	105	82	159	57	5,668	6,843	6.843
23	023	360	2	8	20	29	89	1,015	13	76	79	110	51	4,388	5,423	5.423
24	024	550	2	2	20	43	155	1,505	23	79	79	191	133	7,388	8,913	8.913
25	025	416	2	2	20	35	88	1,225	23	56	77	136	87	5,380	6,625	6.625
26	026	351	0	0	0	27	80	945	14	51	59	122	78	4,684	5,629	5.629
27	027	158	0	0	0	15	56	525	6	24	30	52	31	2,028	2,553	2.553
28	028	499	2	2	20	39	123	1,365	27	76	100	160	95	6,376	7,761	7.761
29	029	479	1	3	10	39	123	1,365	30	78	82	161	88	6,064	7,439	7.439
30	030	443	2	2	20	34	127	1,190	33	68	97	120	89	5,540	6,750	6.750
31	031	498	2	2	20	35	92	1,225	27	115	93	168	58	5,992	7,237	7.237
32	032	459	0	0	0	26	76	910	53	93	92	136	59	5,416	6,326	6.326
33	033	159	0	0	0	25	84	875	5	17	31	62	19	1,900	2,775	2.775
34	034	297	3	6	30	15	49	525	20	57	55	89	58	3,780	4,335	4.335
Total		**12869**	**38**	**55**	**380**	**990**	**3162**	**34650**	**941**	**2456**	**2482**	**3925**	**2037**	**156736**	**191766**	**192**

Table 3.14: Status of Total BPL Cards and demand FPS wise for Gudur Mandal

S. No.	FP Shop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)						Total Rice Quota	
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	5M and more	Rice Quota (In Kgs.)	In Kgs.	In MTs.
1	001	457	1	1	10	42	153	1,470	45	70	97	129	73	5,428	6,908	6.908
2	002	671	1	1	10	53	188	1,855	39	87	119	216	156	8,856	10,721	10.721
3	003	593	1	1	10	50	175	1,750	36	80	127	176	123	7,584	9,344	9.344
4	004	500	1	3	10	60	227	2,100	28	54	118	140	99	6,180	8,290	8.290
5	005	345	1	1	10	43	129	1,505	32	63	68	84	54	3,872	5,387	5.387
6	006	840	0	0	0	69	241	2,415	66	166	161	237	141	10,136	12,551	12.551
7	007	416	2	2	20	41	137	1,435	39	89	80	113	52	4,676	6,131	6.131
8	008	647	0	0	0	45	166	1,575	46	100	142	210	104	8,128	9,703	9.703
9	009	572	1	3	10	59	187	2,065	45	102	104	164	97	6,808	8,883	8.883
10	010	336	2	2	20	38	119	1,330	21	50	74	107	44	3,964	5,314	5.314
11	011	316	1	1	10	44	148	1,540	18	40	75	91	47	3,688	5,238	5.238
12	012	289	2	2	20	34	129	1,190	7	34	57	93	62	3,712	4,922	4.922
13	013	616	0	0	0	56	195	1,960	29	91	102	187	151	8,080	10,040	10.040
14	014	580	1	1	10	48	152	1,680	43	97	126	182	83	7,032	8,722	8.722
15	015	368	1	4	10	46	157	1,610	34	63	78	96	50	4,112	5,732	5.732
16	016	545	0	0	0	46	173	1,610	22	89	105	154	129	7,104	8,714	8.714
17	017	592	3	8	30	62	234	2,170	13	63	99	176	176	8,080	10,280	10.280
18	018	630	4	7	40	56	231	1,960	25	104	102	166	173	8,272	10,272	10.272
19	019	334	1	1	10	31	98	1,085	23	67	52	115	45	3,992	5,087	5.087
20	020	373	0	0	0	35	119	1,225	30	70	62	123	53	4,452	5,677	5.677
21	021	224	0	0	0	20	62	700	7	24	40	71	62	3,076	3,776	3.776
22	022	309	0	0	0	42	131	1,470	27	59	59	83	39	3,396	4,866	4.866
23	023	267	1	1	10	21	63	735	7	46	56	79	57	3,472	4,217	4.217
24	024	623	1	1	10	63	201	2,205	40	131	128	156	104	7,320	9,535	9.535
25	025	175	0	0	0	14	49	490	8	25	35	56	37	2,288	2,778	2.778
26	026	508	2	8	20	66	272	2,310	39	60	77	140	124	6,280	8,610	8.610
27	027	377	2	2	20	57	196	1,995	32	54	63	114	55	4,240	6,255	6.255
28	028	538	1	2	10	65	251	2,275	18	79	97	145	133	6,848	9,133	9.133
29	029	589	0	0	0	55	164	1,925	51	104	104	186	89	7,040	8,965	8.965
30	030	198	0	0	0	7	24	245	9	43	60	53	26	2,468	2,713	2.713
31	031	198	1	1	10	14	42	490	6	32	43	61	41	2,592	3,092	3.092
32	032	293	0	0	0	13	43	455	18	53	71	81	57	3,784	4,239	4.239
33	033	380	3	4	30	28	100	980	13	52	80	117	87	5,040	6,050	6.050
34	034	271	1	4	10	26	97	910	22	44	54	91	33	3,204	4,124	4.124
35	035	365	0	0	0	15	41	525	32	73	82	113	50	4,504	5,029	5.029
Total		**15335**	**35**	**61**	**350**	**1464**	**5094**	**51240**	**970**	**2458**	**2997**	**4505**	**2906**	**189708**	**241298**	**241**

Table 3.15: Status of Total BPL Cards and demand FPS wise for Khanapur Mandal

S. No.	FP Shop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)						Total Rice Quota	
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	5M and more	Rice Quota (In Kgs.)	In Kgs.	In MTs.
1	001	480	8	9	80	38	81	1,330	73	92	117	108	44	5,040	6,450	6.450
2	002	528	0	0	0	45	110	1,575	64	109	113	140	57	5,864	7,439	7.439
3	003	497	0	0	0	35	105	1,225	44	93	102	174	49	5,908	7,133	7.133
4	004	274	0	0	0	24	87	840	17	45	62	80	46	3,372	4,212	4.212
5	005	502	3	3	30	54	168	1,890	23	64	97	170	91	6,308	8,228	8.228
6	006	286	0	0	0	34	99	1,190	27	40	59	76	50	3,352	4,542	4.542
7	007	320	5	5	50	31	77	1,085	37	65	52	94	36	3,516	4,651	4.651
8	008	381	0	0	0	34	93	1,190	39	91	78	110	29	4,160	5,350	5.350
9	009	432	0	0	0	25	70	875	37	101	98	128	43	5,040	5,915	5.915
10	010	593	0	0	0	45	134	1,575	43	113	105	176	111	7,372	8,947	8.947
11	011	561	0	0	0	47	120	1,645	48	111	106	168	81	6,660	8,305	8.305
12	012	571	8	9	80	46	130	1,610	46	89	98	150	134	7,152	8,842	8.842
13	013	501	6	6	60	83	289	2,905	22	64	87	129	110	5,908	8,873	8.873
14	014	625	0	0	0	83	309	2,905	15	86	132	164	145	7,856	10,761	10.761
15	015	588	1	1	10	47	159	1,645	18	88	126	181	127	7,724	9,379	9.379
16	016	591	0	0	0	26	67	910	38	119	114	172	122	7,664	8,574	8.574
17	017	457	0	0	0	49	125	1,715	26	72	82	139	89	5,668	7,383	7.383
18	018	510	6	6	60	48	115	1,680	32	88	99	145	92	6,180	7,920	7.920
19	019	362	0	0	0	60	164	2,100	21	61	70	99	51	4,016	6,116	6.116
20	020	204	0	0	0	0	0	0	9	53	56	64	22	2,596	2,596	2.596
Total		**9263**	**37**	**39**	**370**	**854**	**2502**	**29890**	**679**	**1644**	**1853**	**2667**	**1529**	**111356**	**141616**	**142**

Table 3.15: Status of Total BPL Cards and demand FPS wise for Kothagudem Mandal

S. No.	FP Shop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)						Total Rice Quota	
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	5M and more	Rice Quota (In Kgs.)	In Kgs.	In MTs.
1	001	1,130	1	1	10	128	409	4,480	58	164	210	347	222	14,056	18,546	18.546
2	002	665	1	1	10	71	227	2,485	44	104	130	205	110	8,048	10,543	10.543
3	003	623	0	0	0	79	238	2,765	58	115	125	159	87	6,936	9,701	9.701
4	004	857	3	4	30	105	301	3,675	61	129	148	237	174	10,324	14,029	14.029
5	005	644	3	3	30	76	248	2,660	31	102	121	192	119	7,844	10,534	10.534
6	006	628	2	2	20	85	255	2,975	56	92	95	185	113	7,320	10,315	10.315
7	007	387	0	0	0	57	213	1,995	20	63	56	98	93	4,684	6,679	6.679
8	008	240	0	0	0	24	72	840	11	42	48	55	60	3,036	3,876	3.876
9	009	320	1	2	10	41	131	1,435	21	59	49	77	72	3,816	5,261	5.261
10	010	132	0	0	0	17	80	595	10	12	28	33	32	1,640	2,235	2.235
11	011	187	0	0	0	17	54	595	5	27	39	48	51	2,492	3,087	3.087
12	012	440	2	3	20	48	162	1,680	32	60	81	130	87	5,400	7,100	7.100
13	013	139	0	0	0	18	63	630	4	19	27	34	37	1,776	2,406	2.406
14	014	299	0	0	0	32	105	1,120	11	53	57	77	69	3,764	4,884	4.884
15	015	147	0	0	0	19	80	665	3	19	19	31	56	2,008	2,673	2.673
16	016	550	1	1	10	56	186	1,960	20	79	109	122	163	7,232	9,202	9.202
17	017	840	2	2	20	95	319	3,325	33	110	160	219	221	10,856	14,201	14.201
18	018	247	0	0	0	25	88	875	20	41	53	65	43	2,944	3,819	3.819
19	019	175	1	1	10	27	92	945	9	22	30	45	41	2,112	3,067	3.067
20	020	293	0	0	0	37	131	1,295	17	46	44	81	68	3,620	4,915	4.915
21	021	186	0	0	0	32	122	1,120	10	25	32	45	42	2,184	3,304	3.304
22	022	283	0	0	0	37	110	1,295	10	40	60	86	50	3,456	4,751	4.751
23	023	309	2	4	20	39	124	1,365	29	42	50	110	37	3,552	4,937	4.937
24	024	246	1	1	10	27	89	945	16	30	47	72	53	3,080	4,035	4.035
Total		**9967**	**20**	**25**	**200**	**1192**	**3899**	**41720**	**589**	**1495**	**1818**	**2753**	**2100**	**122180**	**164100**	**164**

Table 3.17: Status of Total BPL Cards and demand FPS wise for Narsampet Mandal

S. No.	FP Shop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)						Total Rice Quota	
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	5M and more	Rice Quota (In Kgs.)	In Kgs.	In MTs.
1	001	326	7	7	70	22	60	770	13	55	57	120	52	4,136	4,976	4.976
2	002	776	0	0	0	46	112	1,610	43	110	133	278	166	10,416	12,026	12.026
3	003	466	0	0	0	41	145	1,435	48	84	89	127	77	5,504	6,939	6.939
4	004	515	0	0	0	27	88	945	21	63	92	189	123	7,176	8,121	8.121
5	005	342	0	0	0	34	93	1,190	35	48	44	132	49	4,144	5,334	5.334
6	006	660	0	0	0	37	106	1,295	45	105	120	229	124	8,604	9,899	9.899
7	007	561	0	0	0	19	60	665	33	100	131	190	88	7,304	7,969	7.969
8	008	552	0	0	0	40	113	1,400	39	82	97	173	121	7,164	8,564	8.564
9	009	561	0	0	0	25	71	875	50	85	104	183	114	7,336	8,211	8.211
10	010	415	1	1	10	59	186	2,065	20	50	59	150	76	5,108	7,183	7.183
11	011	414	0	0	0	25	64	875	30	81	63	128	87	5,312	6,187	6.187
12	012	632	0	0	0	12	33	420	37	93	147	219	124	8,640	9,060	9.060
13	013	501	2	2	20	36	131	1,260	37	80	80	156	110	6,444	7,724	7.724
14	014	457	1	1	10	37	145	1,295	43	78	90	147	61	5,448	6,753	6.753
15	015	587	4	6	40	55	167	1,925	32	92	116	174	114	7,320	9,285	9.285
16	016	590	2	3	20	47	161	1,645	19	83	123	200	116	7,736	9,401	9.401
17	017	432	1	1	10	41	160	1,435	14	69	63	144	100	5,668	7,113	7.113
18	018	546	3	3	30	45	155	1,575	39	96	109	174	80	6,616	8,221	8.221
19	019	501	3	3	30	25	93	875	23	72	87	162	129	6,884	7,789	7.789
20	020	417	0	0	0	48	170	1,680	38	63	97	111	60	4,796	6,476	6.476
21	021	547	0	0	0	47	138	1,645	53	114	95	171	67	6,340	7,985	7.985
22	022	410	0	0	0	30	73	1,050	31	83	66	140	60	5,020	6,070	6.070
23	023	549	4	5	40	47	156	1,645	26	81	74	172	145	7,292	8,977	8.977
24	024	600	0	0	0	59	218	2,065	15	70	92	183	181	8,272	10,337	10.337
25	025	307	0	0	0	28	101	980	6	25	61	104	83	4,280	5,260	5.260
26	026	281	0	0	0	15	48	525	14	35	57	100	60	3,820	4,345	4.345
27	027	492	1	1	10	43	156	1,505	23	69	97	168	91	6,316	7,831	7.831
28	028	582	3	4	30	48	153	1,680	51	110	105	173	92	6,952	8,662	8.662
29	029	485	7	8	70	47	145	1,645	38	85	85	146	77	5,728	7,443	7.443
30	030	356	0	0	0	38	130	1,330	14	56	55	109	84	4,588	5,918	5.918
31	031	269	0	0	0	24	79	840	20	42	57	99	27	3,224	4,064	4.064
32	032	557	0	0	0	84	295	2,940	37	70	83	179	104	6,648	9,588	9.588
33	033	357	0	0	0	28	75	980	26	70	61	118	54	4,364	5,344	5.344
34	034	367	0	0	0	32	96	1,120	22	53	84	115	61	4,580	5,700	5.700
35	035	350	0	0	0	29	85	1,015	23	54	71	111	62	4,392	5,407	5.407
36	036	260	0	0	0	29	82	1015	19	41	55	85	31	3044	4059	4.059
Total		**17020**	**39**	**45**	**390**	**1349**	**4343**	**47215**	**1077**	**2647**	**3099**	**5559**	**3250**	**216616**	**264221**	**264.22**

Table 3.18: Status of Total BPL Cards and demand FPS wise for Nallabelly Mandal

S. No.	FP Shop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)						Total Rice Quota	
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	5M and more	Rice Quota (In Kgs.)	In Kgs.	In MTs.
1	001	449	0	0	0	50	145	1,750	47	69	78	129	76	5,260	7,010	7.010
2	002	433	4	6	40	39	114	1,365	35	85	73	125	72	5,136	6,541	6.541
3	003	547	1	1	10	36	103	1,260	48	106	106	180	70	6,592	7,862	7.862
4	004	603	3	5	30	47	164	1,645	42	76	84	160	191	8,164	9,839	9.839
5	005	366	1	1	10	37	94	1,295	27	81	69	104	47	4,188	5,493	5.493
6	006	352	1	1	10	16	40	560	34	88	77	80	56	4,164	4,734	4.734
7	007	533	0	0	0	45	140	1,575	45	84	108	158	93	6,536	8,111	8.111
8	008	286	2	3	20	18	58	630	16	50	63	96	41	3,576	4,226	4.226
9	009	360	0	0	0	29	80	1,015	29	70	86	77	69	4,320	5,335	5.335
10	010	297	0	0	0	20	67	700	21	65	46	100	45	3,656	4,356	4.356
11	011	426	2	4	20	35	122	1,225	34	82	72	138	63	5,124	6,369	6.369
12	012	425	1	1	10	32	87	1,120	31	74	69	150	68	5,304	6,434	6.434
13	013	370	0	0	0	28	80	980	31	68	80	104	59	4,472	5,452	5.452
14	014	321	2	2	20	27	75	945	32	81	53	95	31	3,552	4,517	4.517
15	015	273	0	0	0	23	68	805	21	43	35	86	65	3,524	4,329	4.329
16	016	601	2	4	20	41	122	1,435	68	125	103	210	52	6,908	8,363	8.363
17	017	371	2	4	20	28	79	980	49	64	72	115	41	4,232	5,232	5.232
18	018	351	1	1	10	29	81	1,015	31	68	64	106	52	4,172	5,197	5.197
19	019	270	2	3	20	19	60	665	22	57	55	78	37	3,192	3,877	3.877
20	020	319	0	0	0	25	76	875	16	60	67	97	54	3,980	4,855	4.855
21	021	340	0	0	0	75	230	2,625	15	61	55	81	53	3,564	6,189	6.189
22	022	456	2	4	20	51	169	1,785	65	95	72	116	55	4,840	6,645	6.645
23	023	465	0	0	0	25	71	875	55	98	76	141	70	5,572	6,447	6.447
24	024	477	3	3	30	45	141	1,575	39	67	102	145	76	5,756	7,361	7.361
25	025	247	0	0	0	10	25	350	20	47	46	80	44	3,168	3,518	3.518
26	026	578	3	3	30	59	174	2,065	61	112	120	161	62	6,396	8,491	8.491
27	027	362	1	1	10	23	55	805	25	52	79	118	64	4,632	5,447	5.447
28	028	183	0	0	0	9	39	315	17	47	31	46	33	2,212	2,527	2.527
29	029	334	0	0	0	0	0	0	16	59	65	126	68	4,692	4,692	4.692
Total		**11395**	**33**	**47**	**330**	**921**	**2759**	**32235**	**992**	**2134**	**2106**	**3402**	**1807**	**136884**	**169449**	**169**

3.3 Inventory (Lot Sizing) Models

3.3.1 Introduction

Maintaining inventories is necessary for any company dealing with physical products, including manufacturers, wholesalers, and retailers to meet their demands. For example, manufacturers need inventories of the materials required to make their products. They also need inventories of the finished products awaiting shipment. Similarly, both wholesalers and retailers need to maintain inventories of goods to be available for purchase by customers. The costs associated with storing ("carrying") inventory are also very large, perhaps a quarter of the value of the inventory Reducing storage costs by avoiding unnecessarily large inventories can enhance any firm's competitiveness.

Some Japanese companies were pioneers in introducing the just-in-time inventory system—a system that emphasizes planning and scheduling so that the needed materials arrive "just-in-time" for their use. Huge savings are thereby achieved by reducing inventory levels to a bare minimum. The application of operations research techniques in this area (sometimes called scientific inventory management) is providing a powerful tool for gaining a competitive edge.

The companies can use operations research to improve their inventory policy for when and how much to replenish their inventory? They use scientific inventory management comprising the following steps:

1**.** Formulate a mathematical model describing the behavior of the inventory system.

2. Seek an optimal inventory policy with respect to this model.

3. Use a computerized information processing system to maintain a record of the current inventory levels.

4. Using this record of current inventory levels, apply the optimal inventory policy to signal when and how much to replenish inventory.

Inventory control is challenging in business. Managing inventory can directly affect business performance. The reason for having inventories or stocks is to buffer against demand and supply. Having too much inventory on hand means high holding cost, and having too little leads to a rise in ordering cost. Therefore, inventory management should be well planned in order to achieve the lowest possible total cost.

The classical inventory control problem is centered around the question \How much on-hand stock should we have?" There are trade-offs in using different inventory policies and determining the best policy for any one facility can be difficult. On the one hand, carrying a large amount of inventory provides protection against uncertainty in demand and allows companies to take advantage of economies of scale when ordering material **[19]**. This type of system is relatively easy to manage; however, the inventory holding costs can be very expensive. On the other hand, a distribution center may choose to carry very little inventory (similar to a Just-In-Time system). In this case, inventory holding costs are typically much lower, but managing the system to ensure parts are available when and where they are needed can be challenging.

So which is the right approach? The answer to this is dependent on the relevant inventory costs. These typically include the inventory holding costs, the order costs (which include fixed and variable components), and the penalty costs. Inventory holding costs include expenses such as storage costs, rent/depreciation, labor, and obsolescence, overhead, and opportunity costs. Ordering costs include expenses such as the labor cost of processing orders, and costs associated with quality assurance (inspections). Finally, penalty costs represent the cost of not having sufficient stock on hand to satisfy demand when it occurs. The optimal inventory policy for a company is determined by balancing these costs. Figure 3.2 below shows the general relationship between these costs, and the resulting total cost curve. As can be seen, the primary tradeoff exists between the inventory holding costs and the ordering costs.

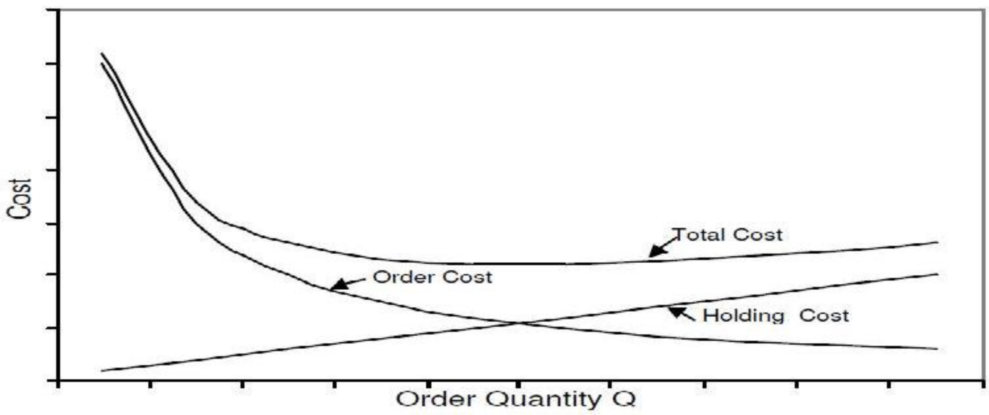


Figure. 3.2: Total Inventory Costs.

3.3.2 Types of Inventory Models

The mathematical inventory models used with this approach can be divided into two broad categories—deterministic models and stochastic models—according to the predictability of demand involved. The demand for a product in inventory is the number of units that will need to be withdrawn from inventory for some use (e.g., sales) during a specific period. If the demand in future periods can be forecast with considerable precision, it is reasonable to use an inventory policy that assumes that all forecasts will always be completely accurate. This is the case of known demand where a deterministic inventory model would be used. However, when demand cannot be predicted very well, it becomes necessary to use a stochastic inventory model where the demand in any period is a random variable rather than a known constant. There are several basic considerations involved in determining an inventory policy that must be reflected in the mathematical inventory model.

The most common inventory situation faced by manufacturers, retailers, and wholesalers is that stock levels are depleted over time and then are replenished by the arrival of a batch of new units. A simple model representing this situation is the following economic order quantity model or, for short, the EOQ model **[19]**. (It sometimes is also referred to as the economic lot-size model.)

The Economic Order Quantity (EOQ) model is a popular inventory model that focuses on this tradeoff between fixed order costs and holding costs. This model has many forms in this work author had focus on the continuous review, ($Q;R$), EOQ model, also known as a “Lot Size-Reorder Point" system. This model considers demand as it occurs and focuses on determining the optimal material order quantity (Q) and reorder level (R). When implemented, an order of Q units will be placed when the on-hand inventory decreases to R units. A notable feature of this model is its consideration of order lead times and fixed setup costs for orders. The inclusion of these costs makes this type of model more realistic and applicable to real systems.

The EOQ inventory model can be formulated assuming deterministic or stochastic demand. The deterministic case assumes the demand is fixed and known. Thus, an average demand rate parameter is included, while the variance in demand is considered to be 0. The stochastic case incorporates uncertainty in demand by considering the actual variance in demand for the customer(s). Due to the uncertainty present in the stochastic model, safety stock is usually held to prevent stock outs from occurring.

An example of each case is shown in Figures 3.3, and 3.4. In Figure 3.3 represents a deterministic EOQ model. The absence of uncertainty is evident in the steady pattern of the decrease in demand and placement of orders. Note that because uncertainty is not present, each order arrives just as the inventory level drops to zero. Similarly in Figure 3.4 represents a stochastic EOQ model. The rate of decrease in demand in this case is different from one order cycle to the next. Due to the uncertainty in demand, the inventory level sometimes drops below the safety stock level before an order arrives.

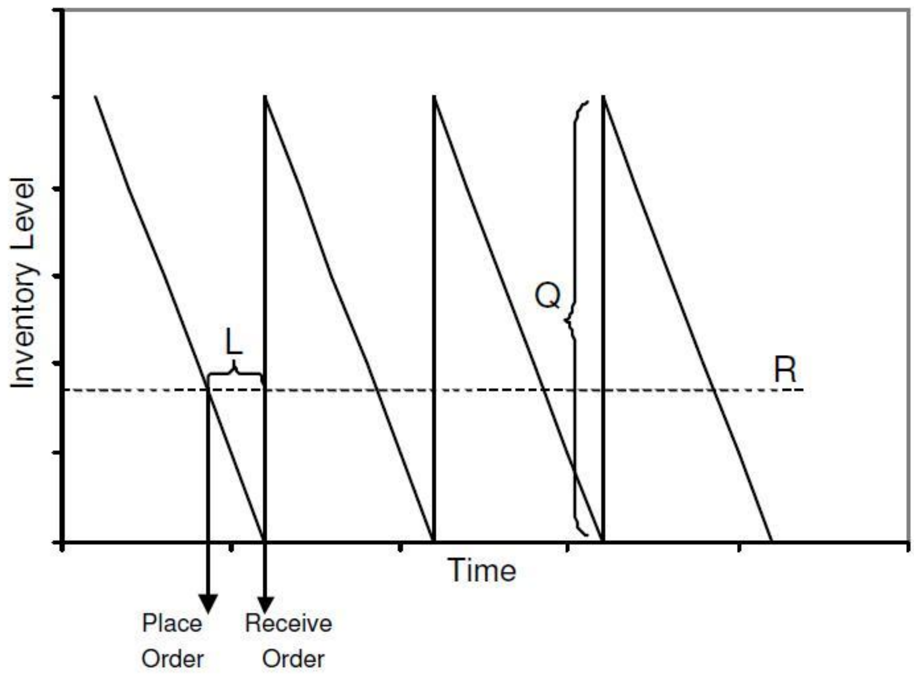


Figure. 3.3: Deterministic EOQ Model.

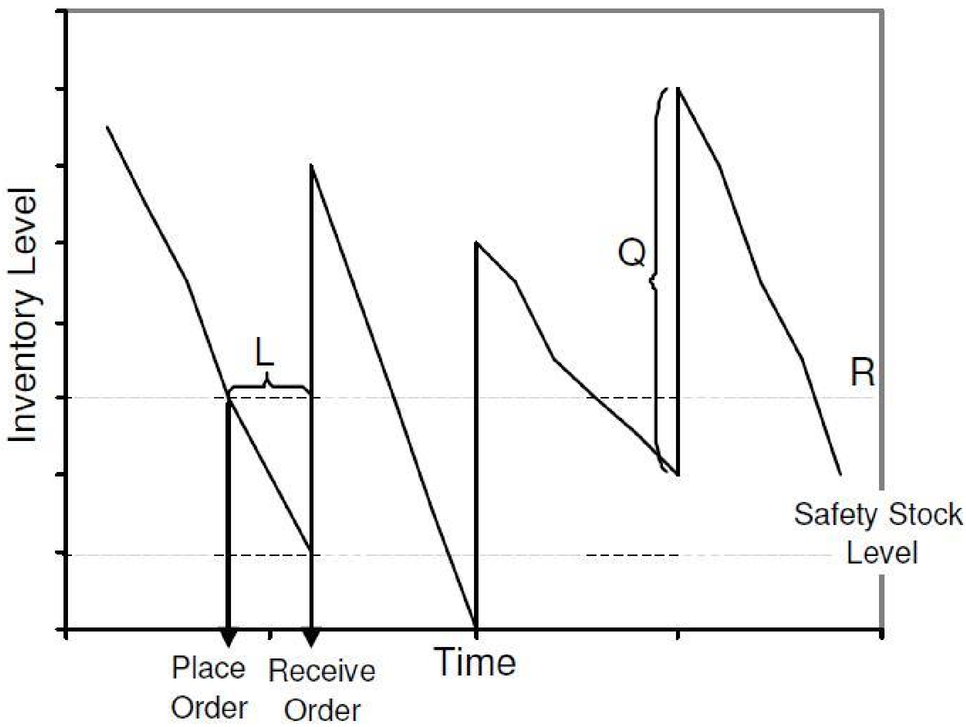


Figure 3.4: Stochastic EOQ Model

3.3.3 Deterministic EOQ Model

The deterministic case of the continuous review, inventory model is solved by minimizing the total cost function. The total inventory cost consists of inventory holding costs, fixed and variable ordering costs, and penalty costs. However, only inventory holding costs and the fixed ordering costs are considered when solving the deterministic EOQ model. A variable order cost are not considered because this cost is a constant value and does not effect the decision for Q or R. Penalty costs due to material being unavailable are not included because the deterministic case does not consider any uncertainty in demand so we can be assured that an order will always arrive before the inventory level drops below zero **[19]**.

The parameters, decision variables and total cost function for the deterministic EOQ model are described below:

Parameters:

h = holding cost per unit per unit time

D= expected demand (units per unit time)

L = order lead time

K = fixed order cost

Decision Variables:

Q = order quantity

R = reorder point, in units of inventory

Total Cost Function:

TOTAL COST: h(Q/2)+K(D/Q)……………………(3.1)

This cost function represents the average inventory holding costs and fixed order costs, respectively .The value of *Q* that will minimize the total cost function is obtained by taking the derivative of the total cost function with respect to *Q*, setting it equal to zero and solving for *Q*. The reorder point, *R*, is chosen so that the inventory level will not decrease below zero before the order lead time is over. The resulting formulation for *Q* and *R* is:

.

$$Q = \sqrt{\frac{2DK}{h}} \quad \text{……………………………….(3.2)}$$

R = DL ………………………..(3.3)

This formulation will result in a deterministic (*Q;R*) inventory policy to minimize the total inventory cost for a system by balancing the inventory holding costs and the fixed ordering costs. After solving for *Q* and *R*, these values can be substituted in (3.1) to find the total inventory cost for this policy.

In this chapter the author has discussed the existing inventory models which are relevant to the public distribution system (PDS). Probabilistic models (demand uncertain) are also existing but in the current scenario demand is known and constant over a time horizon. The above mentioned deterministic demand model is a basic concept model, based on which the researcher used the concept of Binary Particle Swarm Optimisation (BPSO) technique for finding order quantities minimising the total cost of lot size.

3.4 Inventory Terminology

Ordering costs: Cost of replenishing inventory Eg: Advertisement, postage, telephone and travelling charges etc.

Carrying/Holding costs: Cost of holding an item Eg: Rent, Insurance of stored equipment's taxes etc. In this work Rs.50 per ton per month as per the data.

Setup cost: The cost associated with the establishment of infra-structure and independent of the quantity to be ordered. During the study researcher taken labor charges from civil supplies corporation as 100000 per month.

Shortage cost: Temporary or permanent loss of sales when demand not meet. Eg: Loss of good will, permanent loss of customers and its associate lost profit in future sales.

Safety stock: Buffer added to on hand inventory during lead time

Stock out: An inventory shortage.

Service level: Probability that the inventory available during lead time will meet demand.

Reorder Point: Level of inventory at which a new order is placed

3.5 Binary Particle Swarm Optimization for Lot Sizing Problem:

3.5.1 Introduction

The lot-sizing problem attracted attention because of its impact on the inventory levels and, hence the inventory holding cost and the setup/ordering cost. It is basically concerned with finding order quantities minimizing the total cost of lot sizing decisions. Lot quantity might be either an amount of purchase or production depending on the problem domain on hand in order to meet the net requirements of the customer demand. In lot sizing problems, time horizon is defined as given time buckets in which quantity decisions are generally given at the beginning of each time bucket. Lot sizing decisions are made in such a way that all customer requirements are met at the end of the time horizon. In general, lot quantities are determined as the total requirement for a number of periods in which the total cost is minimized. It balances the tradeoff between the ordering and the holding costs. In other words, it depends on the requirement in the current period plus the requirements for the future periods [1]. So the order quantity is determined by grouping the net requirements for a number of periods ahead

Several factors should be considered when lot-sizing decisions are given. These factors are ordering cost, holding cost, shortage cost, capacity constraints, minimum order quantity, maximum order quantity, quantity discounts and so on. Combination of these factors results in different models to analyze and different solution procedures are used depending on the model employed. The model and its solution procedure can be made complicated by considering these factors in the models, which can be classified as capacitated or uncapacitated, single-level or multi-level, single-item or multi-item models.

3.5.2 Binary PSO Algorithm for Lot Sizing Problem

Particle Swarm Optimization (PSO) is one of the evolutionary optimization methods inspired by nature. In PSO algorithm, each member is called "particle", and each particle flies around in the multi- dimensional search space with a velocity, which is constantly updated by the particle's own experience and the experience of the particle's neighbors. Since PSO was first introduced by Kennedy and Eberhart (1995), it has been successfully applied to optimize various continuous nonlinear functions. Although the applications of PSO on combinatorial optimization problems are still limited, PSO has its merit in the simple concept and economic computational cost. The main idea behind the development of PSO is the social sharing of information among individuals of a population. In PSO algorithms, search is conducted by using a population of particles, corresponding to individuals as in the case of evolutionary algorithms. Unlike GA, there is no operator of natural evolution which is used to generate new solutions for future generation. Instead, PSO is based on the exchange of information between individuals, so called particles, of the population, so called swarm. Each particle adjusts its own position towards its previous experience and towards the best previous position obtained in the swarm. Memorizing its best own position establishes the particle's experience implying a local search along with global search emerging from the neighboring experience or the experience of the whole swarm. Two variants of the PSO algorithm were developed, one with a global neighborhood, and other one with a local neighborhood. According to the global neighborhood, each particle moves towards its best previous position and towards the best particle in the whole swarm, called gbest model. On the other hand, according to the local variant, called lbest model, each particle moves towards its best previous position and towards the best particle in its restricted neighborhood. Kennedy and Eberhart (1995) also developed the discrete binary version of the PSO. In a PSO algorithm, population is initiated randomly with particles and evaluated to compute fitness together with finding the particle best (best value of each individual so far) and global best (best particle in the whole swarm). Initially, each individual with its dimensions and fitness value is assigned to its particle best. The best individual among particle best population, with its dimension and fitness value is, on the other hand, assigned to the global best. Then a loop starts to converge to an optimum solution. In the loop, particle and global bests are determined to update the velocity first. Then the current position of each particle is updated with the current velocity. Evaluation is again performed to compute the fitness of the particles in the swarm. This loop is terminated with a stopping criterion predetermined in advance. The flow chart for Particle Swarm Optimization is show in Figure 3.5 [1]. In this research the author used the global variant with binary version applied to the simple lot sizing problem

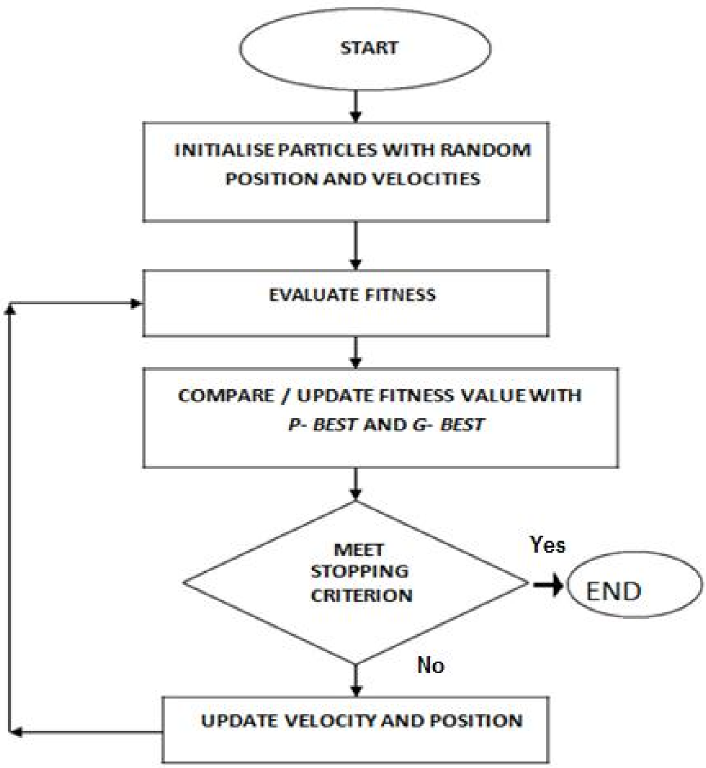


Figure 3.5 Flow chart for Particle Swarm Optimization

3.5.3 Strengths and Weakness

Strengths

One reason for PSO gaining its popularity is that it is conceptually straightforward and computationally simple. Simulating birds flocking, particle swarms fundamentally use two simple formulae to effectively search the goal. Also, research has shown that in comparing PSO with other algorithms on a variety of problems, it can perform better on some problems and be competitive on others. Since PSOs are a new search technique, much research is being targeted to improve the original PSOs for solving various problems and it has great potential for further improvement. For example, owing to its similarity to evolutionary computation (EC) methods, many successful EC techniques and ideas may be integrated to improve PSOs. Like many EC algorithms, PSO has a number of parameters to adjust. On one hand, this is beneficial for implementing adaptive systems and also shows the extensibility of PSO to other specifically designed algorithms although it may not perform as well as those algorithms. On the other hand, tuning parameters for solving a particular problem or a range of problems can be time-consuming and non-trivial. Compared with EC methods, PSO does not have as many parameters to tune in order to get acceptable performance. Hu and Eberthart [24] suggest that PSO is applicable for both constrained and unconstrained problems even without pre-transforming the constraints and the objectives of a problem.

Weaknesses

Researchers have found several issues that prevent the generic PSOs from effectively solving certain types of problems. Although the improvement has been working on to handle these issues, the solutions may not easily be applied to solve other problems; thus, we should keep these issues in mind while developing new particle swarms for solving other problems. For example, although PSO has the ability to converge quickly, it tends to wander and slow down as it approaches an optimum. Owing to the premature convergence, it gets stuck quite easily and cannot explore wide enough. This can be problematic for solving multimodal problems where the problems have multiple optimal solutions. Particularly if many of those Optima are only local rather than global, particles may get trapped at local optima. In addition, while there are not many parameters to control and as mentioned previously, these parameters open up a potential for developing adaptive PSO systems, some of the parameters are problem dependent. Some suggested values and experimental settings are still at trial-and-error stage, and it can be non-trivial to find the right settings for individual problems.

3.6 Problem Statement:

The objective of this work is to minimize the total expenditure with respect to warehouses and MLSP’s taking into account procurement costs, ordering/reordering costs and inventory holding cost for a planning horizon of 12 sub periods. The formulated problem is solved using BPSO technique through C++ code written. The code is tested on realistic data collected which is furnished in the previous section. It has been suggested that the best way to meet this problem is to set up district MLSP’s which enable the reduction of wastage and holding cost of rice. In this work, the present PDS uses several FCI owned go downs MLSP’s and which are incurring cost of holding and ordering/reordering for the shipping demands of all points, all of which are required to meet the necessary demand.

3.7 Problem Formulation and Methodology:

The main objective of this research work is to minimize the overall inventory carrying cost by estimating optimum quantity estimation and the reordering time period.

STEP 1. Calculate the overall demand

- Demand of one MLSP is the summation of demands of all the mandals under that MLSP
- Demand of one Mandal is the summation of demands of all FPS in that mandal.
- Demand of one FPS is the summation of demands of all BPL Cards of that shop.

STEP 2. Define objective function

The lot sizing problem that we considered can be described as follows. We have ‘N’ items to be produced in ‘T’ periods in a planning horizon such that a demand forecast would be attained. In a multistage production system, the planning horizon of each item depends on the production of other items, which are situated at lower levels. The resources for production and set up are limited. Lead times are assumed to be zero. No shortages are allowed and demands are deterministic. A mathematical model is formulated for the integration problem using capacity constraints, sequence dependent setup costs and times. The constraints that are included in the formulation are those of machines capacity, of non-simultaneity and of the classical inventory balance equation.

The uncapacitated single item no shortages allowed and single level lot sizing model is the simplest model in the inventory lot sizing problems. Lot sizing formulation for this kind of lot sizing problem takes the following form,

Min $(\sum_{i=1}^{n}(Ax_i + cI_i))$ ………………………….(3.4)

i = 1,2,3,…………….…n [n= 12]

n= number of periods

A= ordering cost per period

c= holding cost per unit per period

Subject to

$I_0 = 0$ ∀ i ……………………..……..(3.5)

$I_{i-1} + x_i\ Q_i - I_i = R_i$ ∀ i ………………..….(3.6)

$I_i \geq 0$ ∀ i …………………. (3.7)

$Q_i \geq 0$ ∀ i …..………………(3.8)

$x_i \in \{ 0,1 \}$ ∀ i ……………….... (3.9)

where

n=number of periods

A=ordering/setup cost per period

c=holding cost per unit per period

Ri=net requirement for period i

Qi=Order quantity for period i

Ii=projected inventory balance for period i

$X_i=1$ if an order is placed in period i, $X_i=0$ otherwise.

In the objective function (3.4), a penalty A is charged for each order placed along with a penalty c for each unit carried in inventory over the next period. Equation (3.5) guaranties that no initial inventory is available. Equation (3.6) is the inventory balance equation in which the order quantity Q_i covers all the requirements until the next order. Equation (3.7) satisfies the condition that no shortages are allowed. And finally, equation (3.8) shows the decision variable x_i to be either 1 (place an order) or 0 (do not place an order). It should be noted that initial inventory is zero, $I_o=0$, such that $x_1=0$ by equation (3.6) if $R_i>0$. Because of the minimization nature of the problem, the ending inventory at each period is minimized to avoid the penalty charge c, particularly $I_n=0$ [24].

3.8 Binary Particle Swarm Optimization (BPSO)

3.8.1 BPSO approach for Lot Sizing Problem

A . Algorithm

The simple algorithm of BPSO is shown in Figure 3.6.

```
Initialize parameters
Initialize population
Evaluate

Do{
        Find particlebest
        Find globalbest
        Update velocity
        Update position
        Evaluate
    }While (Termination)
```

Figure 3.6 Simple BPSO algorithm

The basic elements of PSO algorithm is summarized as follows:

- *Particle*: X_i^k is a candidate solution *i* in swarm at iteration *k*. The i^{th} particle of the swarm is represented by a *d*-dimensional vector and can be defined as $X_i^k = [x_{i1}^k, x_{i2}^k, ..., x_{id}^k]$, where *x*'s are the optimized parameters and x_{id}^k is the position of the i^{th} particle with respect to d^{th} dimension. In other words, it is the value d^{th} optimized parameter in the i^{th} candidate solution.
- *Population:* pop^k is the set of *n* particles in the swarm at iteration *k*, i.e. $pop^k = [x_1^k, x_2^k, ..., x_n^k]$
- *Particle velocity*: V_i^k is the velocity of particle *i* at iteration *k*. It can be described as $V_i^k = [v_{i1}^k, v_{i2}^k, ..., v_{id}^k]$, where v_{id}^k is the velocity with respect to d^{th} dimension.
- *Particle best:* PB_i^k is the best value of the particle *i* obtained until iteration *k*. The best position associated with the best fitness value of the particle *i* obtained so far is called particle best and defined as with the $PB_i^k = [pb_{i1}^k, pb_{i2}^k, ..., pb_{id}^k]$ fitness function $f(PB_i^k)$
- *Global best:* GB^k is the best position among all particles in the swarm, which is achieved so far and can be expressed as $GB_i^k = [gb_1^k, gb_2^k, ..., gb_d^k]$ with the fitness function $f(GB^k)$
- *Termination criterion*: it is a condition that the search process will be terminated. In this study, search is terminated when the number of iteration reaches a predetermined value, called maximum number of iteration [24].

B. Solution representation

Solution representation of particle *i*, X_i^k, for the binary PSO is given in Figure 3.7. This representation is due to Hernandez and Suer (1999). Each particle has *d* dimensions referring to as the number of periods in the lot sizing problem. The dimension x_{id}^k indicates if an order is placed for particle *i* in period *d* at iteration *k*. In other words, x_{id}^k is a binary value such that $x_{id}^k = 1$ if lot sizing decision is given, $x_{id}^k = 0$ otherwise. R_d denotes the net requirements for the period *d*. v_{id}^k is the velocity of the particle *i* in period *d* at iteration *k*. Q_{id}^k is the lot size of the particle *i* in period *d* at iteration *k* and I_{id}^k is the inventory balance of particle *i* in period *d* at iteration *k*. Then the calculation of the cost of the ordering plan is trivial as shown in Figure 3.7 assuming the *c=Rs1* per unit per period and *A=Rs100* per order.

d	**1**	**2**	**3**	**4**	**5**	**6**	$f(X_i^k)$
R_d	100	60	40	50	80	70	
x_{id}^k	1	0	1	0	1	0	
v_{id}^k	3.8	2.9	3.0	-0.7	-1.2	3.1	
Q_{id}^k	160		90		150		
I_{id}^k	60		50		70		
cI_{id}^k	60		50		70		
Ax_{id}^k	100		100		100		
$C(X_i^k)$	160		150		170		480

Figure 3.7 Representation of the Solution

C. Initial Population

A population of particles is constructed randomly for the binary PSO algorithm for lot sizing problem. The values of dimensions are established randomly. For each dimension of a particle, a binary value of 0 or 1 is assigned with a probability of 0.5. In particular,

if U(0.1)>0.5, then $x_{id}^0 = 1$

else $x_{id}^0 = 0$

Velocity values are restricted to some minimum and maximum values, namely $V_i^k = [V_{\min}, V_{\max}] = [-4,4]$ where $V_{\min} = -V_{\max}$. The velocity of particle i in the d^{th} dimension is established by $v_{id}^0 = V_{\min} + (V_{\max} - V_{\min}) * rand()$. This limit enhances the local search exploration of the problem space. Population size is twice the number of dimensions. As the formulation of the lot sizing problem suggests, the objective is to minimize the total ordering and holding costs, the fitness function value for the particle i is given as follows:

$$f(X_i^k) = \sum_{j=1}^{d} \left(Ax_{ij}^k + cI_{ij}^k \right)$$

D. Finding new solutions

Since the binary version of the PSO algorithm is employed in this study, we need to use two useful functions for generating new solutions, namely a sigmoid function to force the real values between 0 and 1, and a piece-wise linear function to force velocity values to be inside the maximum and minimum allowable values. So whenever a velocity value is computed, the following piece-wise function, whose range is closed interval $[V_{\min}, V_{\max}]$, is used to restrict them to minimum and maximum value.

$$h\left(v_{id}^{k}\right)=\begin{cases} V_{\max}, \ if\ v_{id}^{k} > V_{\max} \\ v_{id}^{k}, \ if\ \left|v_{id}^{k}\right| \le V_{\max} \\ V_{\min}, \ if\ v_{id}^{k} < V_{\min} \end{cases}$$

After applying the piece-wise linear function, the following sigmoid function is used to scale the velocities between 0 and 1, which is then used for converting them to the binary values. That is,

$sigmoid\left(v_{id}^{k}\right)=\dfrac{1}{1+e^{-v_{id}^{k}}}$. So, new solutions are found by updating the velocity and dimension respectively. First, we compute the change in the velocity v_{id}^{k} such that

$$\Delta v_{id}^{k-1} = c_1 r_1\left(pb_{id}^{k-1} - x_{id}^{k-1}\right) + c_2 r_2\left(gb_{d}^{k-1} - x_{id}^{k-1}\right)$$

Then we update the velocity v_{id} by using the piece-wise linear function such that

$$v_{id}^{k-1} = h\left(v_{id}^{k-1} + \Delta v_{id}^{k-1}\right)$$

Finally we update the dimension *d* of the particle *i* such that

$$x_{id}^{k} = \begin{cases} 1, \ if\ U(0,1) < sigmoid\left(v_{id}^{k}\right) \\ 0, \ \ otherwise \end{cases}$$

The complete computational flow of the binary PSO algorithm is given below:

Step 1: Initialization

Set *k*=0,*n*=twice the number of dimensions

- Generate *n* particles randomly as explained before, $\left\{X_i^0, i = 1,2,...,n\right\}$, where $X_i^0 = \left[x_{i1}^0, x_{i2}^0, ..., x_{id}^0\right]$.

- Generate the initial velocities of all particles randomly, $\{V_i^0, i = 1,2,...,n\}$, where $V_i^0 = [v_{i1}^0, v_{i2}^0,..., v_{id}^0]$. v_{id}^0 is generated randomly with $v_{id} = V_{\min} + (V_{\max} - V_{\min}) * rand()$
- Evaluate each particle in the swarm using the objective function, $f(X_i^0)$.
- For each particle *i* in the swarm, set $PB_i^0 = X_i^0$, where $PB_i^0 = [pb_{i1}^0 = x_{i1}^0, pb_{i2}^0 = x_{i2}^0,..., pb_{id}^0 = x_{id}^0]$ along with its best fitness value, $f_i^{pbest}(PB_i^0, i = 1,2,...,n)$
- Set the global best to, $f^{pbest}(GB^0) = \min\{f_i^{pbest}(PB_i^0, i = 1,2,...,n)\}$ with $GB^0 = [gb_1, gb_2,..., gb_d]$

Step 2: Update iteration counter

- *k=k+1*

Step 3: Update velocity by using the piece-wise linear function

- $\Delta v_{id}^{k-1} = c_1 r_1 (pb_{id}^{k-1} - x_{id}^{k-1}) + c_2 r_2 (gb^{k-1} - x_{id}^{k-1})\ v_{id}^k = h(v_{id}^{k-1} + \Delta v_{id}^{k-1})$

c_1 and c_2 are social and cognitive parameters and r_1 *and* r_2 are uniform random numbers between (0,1)

Step 4: Update dimension (position) by using the sigmoid function

- $x_{id}^k = \begin{cases} 1, \text{ if } U(0,1) < sigmoid(v_{id}^k) \\ 0, \quad otherwise \end{cases}$

Step 5: Update particle best

- Each particle is evaluated again with respect to its updated position to see if particle best will change. That is,

  if $f_i^k(X_i^k, i = 1,2,...,n) < f_i^{pbest}(PB_i^{k-1}, i = 1,2,...,n)$

  then

$$f_i^{pbest}\left(PB_i^k, i = 1,2,...,n\right) = f_i^k\left(X_i^k, i = 1,2,...,n\right)$$

else

$$f_i^{pbest}\left(PB_i^k, i = 1,2,...,n\right) = f_i^{pbest}\left(PB_i^{k-1}, i = 1,2,...,n\right)$$

Step 6: Update global best

$$f^{gbest}\left(GB^k\right) = \min\left\{f_i^{lbest}\left(PB_i^k, i = 1,2,...,n\right)\right\}$$

If $f^{gbest}\left(GB^k\right) < f^{gbest}\left(GB^{k-1}\right)$

then

$$f^{gbest}\left(GB^k\right) = f^{gbest}\left(GB^k\right)$$

else

$$f^{gbest}\left(GB^k\right) = f^{gbest}\left(GB^{k-1}\right)$$

Step 7: Stopping criterion

- If the number of iteration exceeds the maximum number iteration, then stop, otherwise go to step 2.

The objective function is optimized wherein by using binary particle swarm optimization technique (BPSO) in equation (3.3). The proposed model is used for estimation of total variable cost approach and optimum quantity estimation to the integrated procurement distribution problem. The resulting solution expenditure is less than the original problem expenditure.

3.8.2 Application of BPSO to PDS

The Figure 3.8 shows the structure of PDS. The holding and setup cost taken into consideration. The below numerical example exactly similar to the PDS problem,

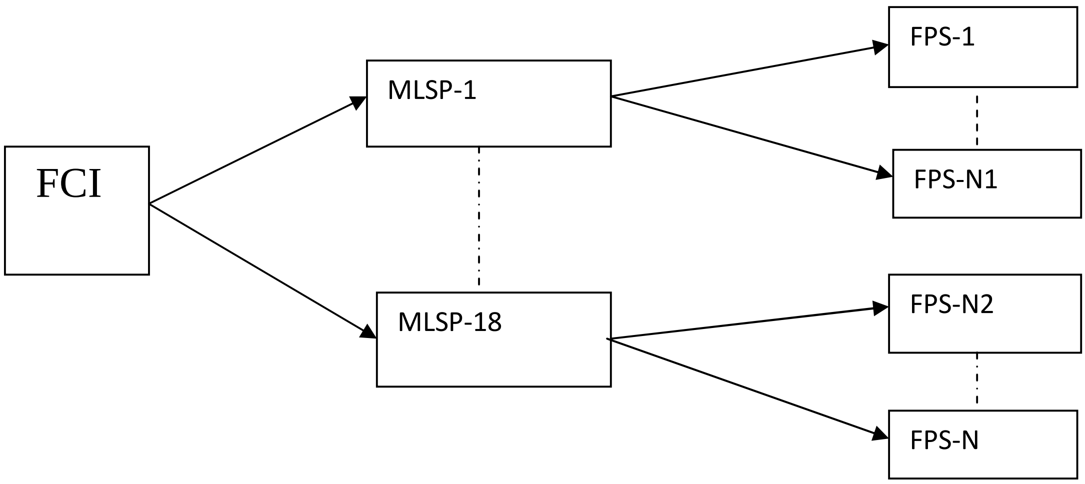


Figure 3.8 Structure of PDS in Warangal District

3.9. Numerical Example

In order to illustrate how the binary PSO algorithm solves the lot sizing problem, the following problem with d=5 periods, c=Rs1, A=Rs100 is constructed as well as the net requirements given in Figure 3.7. The complete computational flow for illustration purpose is given below:

Step 1: Initialization

- k=0, and n=3
- The initial particles in the swarm generated randomly are $X_1^0, X_2^0, and\ X_3^0$, and corresponding velocities $V_1^0, V_2^0, and\ V_3^0$, which are given as follows:

	d	**1**	**2**	**3**	**4**	**5**
X_1^0	x_{1d}	1	1	0	0	0
V_1^0	v_{1d}	2.90	1.60	-1.80	6.5	-1.60
X_2^0	x_{2d}	1	0	1	0	0
V_2^0	v_{2d}	3.80	2.90	3.00	-0.70	-1.20
X_3^0	x_{3d}	1	0	0	1	1
V_3^0	v_{3d}	-3.0	1.50	-2.70	2.00	1.40

- Details of the computation of the fitness function for the particles are given in Figure 3.7. Now considering the first 5 periods of Figure 3.7, the fitness values of the particles in the swarm are:
  $f_1^0\left(X_1^0\right) = 580,\; f_2^0\left(X_2^0\right) = 470,\; f_3^0\left(X_3^0\right) = 440$

- For each particle in the swarm, set the particle best to:
  $PB_1^0 = \left[pb_{11}^0 = x_{11}^0,\, pb_{12}^0 = x_{12}^0, \ldots,\, pb_{1d}^0 = x_{1d}^0\right]$
  $with\;\; f_1^{pbest}\left(PB_1^0 = X_1^0\right) = 580$
  $PB_2^0 = \left[pb_{21}^0 = x_{21}^0,\, pb_{22}^0 = x_{22}^0, \ldots,\, pb_{2d}^0 = x_{2d}^0\right]$
  $with\;\; f_2^{pbest}\left(PB_2^0 = X_2^0\right) = 470$
  $PB_3^0 = \left[pb_{31}^0 = x_{31}^0,\, pb_{32}^0 = x_{32}^0, \ldots,\, pb_{3d}^0 = x_{3d}^0\right]$
  $with\;\; f_3^{pbest}\left(PB_3^0 = X_3^0\right) = 440$, so

	d	**1**	**2**	**3**	**4**	**5**	$f_i^{pbest}\left(PB_i^0\right)$
PB_1^0	pb_{1d}	1	1	0	0	0	580
PB_2^0	pb_{2d}	1	0	1	0	0	470
PB_3^0	pb_{3d}	1	0	0	1	1	440

- Set the global best to:

  $f^{gbest}\left(GB^0\right)=\min\left\{f_i^{pbest}\left(PB_i^0\right)\right\}= f_3^{pbest}\left(PB_3^0\right)=440$

  with $GB^0=\left[gb_1, gb_2,..., gb_d\right]$. So

	d	**1**	**2**	**3**	**4**	**5**	$f_i^{gbest}\left(PB^0\right)$
GB^0	gb_d	1	0	0	1	1	440

Step 2: Update the iteration number

- *k=0+1=1*

Step 3: Update velocity by using the piece-wise linear function.

- Assume $c_1=c_2=r_1=r_2=0.5$. As an example for particle 1, second dimension is updated as follows:

  $\Delta v_{12}^0=0.5*0.5\left(pb_{12}^0-x_{12}^0\right)+0.5*0.5\left(gb_2^0+x_{12}^0\right)$

  $\Delta v_{12}^0=0.5*0.5(1-1)+0.5*0.5(0-1)=-0.25$

  $v_{12}^1=h\left(v_{12}^0+\Delta v_{12}^0\right)=h(1.6+(0-0.25))=1.35$

Step 4: Update position by using the sigmoid function

Since $U(0.1)=0.99, sigmoid\left(v_{12}^1=1.35\right)=0.79$

$x_{12}^1=0$

- After completing all the calculations for velocity and dimensions we have the following particles updated in the first iteration:

	d	**1**	**2**	**3**	**4**	**5**
X_1^1	x_{1d}^1	1	0	0	1	0
V_1^1	v_{1d}^1	2.90	1.35	-1.80	3.75	-1.60
	$sigmoid\left(v_{1d}^1\right)$	0.95	0.79	0.14	0.98	0.17
	$u(0,1)$	0.12	0.99	0.90	0.60	0.34
X_2^1	x_{2d}^1	1	0	1	1	0
V_2^1	v_{2d}^1	3.10	2.17	2.25	-0.27	-0.90

	$sigmoid(v_{2d}^1)$	0.96	0.90	0.90	0.43	0.29
	$u(0,1)$	0.89	0.99	0.12	0.21	0.63
X_3^1	x_{3d}^1	1	0	0	1	1
V_3^1	v_{3d}^1	-3.00	1.50	-2.70	2.00	0.90
	$sigmoid(v_{3d}^1)$	0.05	0.82	0.06	0.88	0.71
	$u(0,1)$	0.02	0.98	0.19	0.34	0.49

Step 5: Update particle best

- Each particle updated is evaluated for first its new positions and then for finding the particle best as follows:

  $f_1^1(X_1^1) = 420$, $f_2^1(X_2^1) = 440$, $f_3^1(X_3^1) = 440$,

  Since $f_1^1(X_1^1) = 420 < f_1^{pbest}(PB_1^0 = X_1^0) = 580$, $f_1^{pbest}(PB_1^1) = f_1^1(X_1^1) = 420$ with $PB_1^1 = X_1^1$.

  Since $f_2^1(X_2^1) = 440 < f_2^{pbest}(PB_2^0 = X_2^0) = 470$, $f_2^{pbest}(PB_2^1) = f_2^1(X_2^1) = 440$ with $PB_2^1 = X_2^1$.

  Since $f_3^1(X_3^1) = 440 = f_3^{pbest}(PB_3^0 = X_3^0) = 440$, $f_3^{pbest}(PB_3^1) = f_3^1(X_3^1) = 440$ with $PB_3^1 = X_3^1$

Note that neutral moves are allowed. After completing the similar comparisons for the other particles, we have

	d	**1**	**2**	**3**	**4**	**5**	$f_i^{pbest}(PB_i^1)$
PB_1^1	pb_{1d}	1	0	0	1	0	420
PB_2^1	pb_{2d}	1	0	1	1	0	440
PB_3^1	pb_{3d}	1	0	0	1	1	440

Step 6: Update global best

$$f^{pbest}(GB^1) = \min\{f_1^{pbest}(PB_1^1), f_2^{pbest}(PB_2^1), f_3^{pbest}(PB_3^1)\}$$

$$= f_3^{pbest}(PB_3^1) = 420$$

Since, $f^{gbest}(GB^1) = 420 < f^{gbest}(GB^0) = 440$, then

$$f^{gbest}\left(GB^{1}\right) = f^{gbest}\left(GB^{1}\right) = 420$$

With $GB^1 = \{gb_1^1, gb_2^1, ..., gb_d^1\}$

So, the global best is:

	d	**1**	**2**	**3**	**4**	**5**	$f^{gbest}\left(GB^{0}\right)$
GB^0	gb_d	1	0	0	1	0	420

Step7: Stopping criterion

If k < max iteration, goto step 2
else stop

In this research discussed about the mathematical model for finding optimum quantity estimation and for the estimation of cost. The input data of FCI represents like holding cost, setup cost, procurement and used quantity. Implementation of BPSO to the present problem by using equation constraints. This information taken as a input in the C++ coding for getting optimum quantities and total variable cost.

3.10 Results and Discussions

As mentioned in the previous section, a full-fledged computer code in C++ is written for obtaining the solution to the present problem. The present section gives details of parametric studies executed making use of the above code.

3.10.1 Allotment of Rice and Variable Cost for Existing Model

Table 3.19 Allotment of rice and variable costs for Existing Model

Divisions in Warangal District					
Warangal	Jangaon	Mah'bad	Mulug	Narsampet	Total(Qtls)
50,484	23,280	26,475	14,338	27,572	142,149.11
47,593	22,873	25,507	13,909	26,997	136,878.45
47,594.90	22,873.50	25,509.15	13,912.00	27,000.70	136,890.25
48380.70	22791.65	25321.00	14148.10	26125.50	136,766.95
48374.20	22927.70	25293.15	14127.95	45527.90	156,250.90
48,054.06	22,084.83	25,033.23	25,347.67	14,130.18	134,649.97

48,147.73	21,976.39	25,054.67	24,967.34	13,653.55	133,799.68
48,346.59	22,146.47	25,066.10	25,002.01	13,626.49	134,187.66
48,445.27	22,228.15	25,260.18	25,012.75	13,628.50	134,574.85
48,209.95	22,179.47	25,222.94	25,411.49	13,987.63	135,011.48
48,207.99	22,172.09	25,207.96	25,406.49	13,982.60	134,977.13
48,324.27	22,193.95	25,217.44	25,431.89	14,024.96	135,192.51

Rice allotment to various divisions in Warangal district under PDS in year 2010

Demands for five divisions are considered and total annual demand is calculated in Qtls.

Table 3.20 An ordering, carrying cost and cost of Rice per Qtl are as below.

The cost mentioned in the table is taken from the department of Civil Supplies Corporation.

COSTS	INR
ordering cost	1,00,000
carrying cost (Per Qtl)	5
Cost of Rice (Per Qtl)	500

3.10.2 Allotment of Rice According to Data of the year (2010)

Table 3.21 Allotment of rice according to data (2010)

Month	Inventory Needed(Qtls)	Inventory Maintained at FCI (Qtls.)	Carrying Inventory(Qtls.)
Jan	142149	200000	57851
Feb	136878	200000	120972
Mar	136890	200000	184082
Apr	136767	200000	247315
May	156251	200000	291064
Jun	134650	200000	356414
Jul	133800	200000	422615
Aug	134188	200000	488427
Sep	134575	200000	553852
Oct	135011	200000	618841
Nov	134977	200000	683864
Dec	135193	200000	748671

Table showing the inventory needed, carrying and inventory maintained at FCI

3.10.3 Evaluation of Carrying, Ordering and Total Cost of Existing Model

Table 3.22 Evaluation of carrying, ordering and total cost

Month	Rice Cost (Rs)	CarryingCost (Rs.5/Qtl)	Ordering Cost(Rs)	Total Cost(Rs)
Jan	100000000.00	289254.45	100000.00	100389254.45
Feb	100000000.00	604862.20	100000.00	100704862.20
Mar	100000000.00	920410.95	100000.00	101020410.95
Apr	100000000.00	1236576.20	100000.00	101336576.20
May	100000000.00	1455321.70	100000.00	101555321.70
Jun	100000000.00	1782071.85	100000.00	101882071.85
Jul	100000000.00	2113073.45	100000.00	102213073.45
Aug	100000000.00	2442135.15	100000.00	102542135.15
Sep	100000000.00	2769260.90	100000.00	102869260.90
Oct	100000000.00	3094203.50	100000.00	103194203.50
Nov	100000000.00	3419317.85	100000.00	103519317.85
Dec	100000000.00	3743355.30	100000.00	103843355.30

Table showing cost of ordering, carrying, rice cost, total cost according to Monthly demand.

Total Cost is the summation of Rice cost, Carrying cost and Ordering cost.

Table 3.23 Allotment of rice and variable costs for BPSO Model

Demand Matrix Showing Ordering and Carrying				
Month	Demand (Qtls)	Order Decision	Inventory (Ordering)	Inventory (Carrying)
Jan	142149	1	142149	0
Feb	136878	1	136878	0
Mar	136890	1	429908	293018
Apr	136767	0	0	156251
May	156251	0	0	
Jun	134650	1	672224	537574
Jul	133800	0	0	403774
Aug	134188	0	0	269586
Sep	134575	0	0	135011
Oct	135011	0	0	
Nov	134977	1	134977	0
Dec	135193	1	135193	0

Table showing demand and order decision matrix according to Months in year 2010.

Allotment of Rice at every month is calculated with Binary Values(1,0).Binary digit “1” is suggesting for order and Ordering cost incurred at that particular time and Binary digit “0” suggesting for no order, i.e., at that time carrying Cost of Rice is incurred. In March 429908 Qtls of Rice is ordered in order to serve for April and May. In June 672224 Qtls of Rice is Ordered in order to serve for July, August, September and October.

Table 3.24 An ordering quantity and carrying quantity at respective months.

Inventory Maintained (Qtls)		
Month	Ordered	Carrying
Jan	142149	0
Feb	136878	0
Mar	429908	0
Apr	0	293018
May	0	156251
Jun	672224	0
Jul	0	537574
Aug	0	403774
Sep	0	269586
Oct	0	135011
Nov	134977	0
Dec	135193	0

Table showing what quantity is ordered and carrying at every month in year 2010

3.10.4 Allotment after Applying BPSO

Table 3.25 The inventory needed, carrying and inventory maintained at FCI after the application of BPSO.

Month	Inventory needed	Ordering Inventory	Carrying Inventory
Jan	142149	142149	0
Feb	136878	136878	0
Mar	136890	429908	293018
Apr	136767	0	156251
May	156251	0	0
Jun	134650	672224	537574
Jul	133800	0	403774
Aug	134188	0	269586
Sep	134575	0	135011
Oct	135011	0	0
Nov	134977	134977	0
Dec	135193	135193	0

3.10.5 Evaluation of carrying, ordering and total costs

Table 3.26 The various costs after the application of BPSO

Month	Rice cost	Ordering cost	Carrying cost(inr 5/qtl)	Total cost
Jan	71074555	100000	0	71174555.00
Feb	68439225	100000	0	68539225.00
Mar	214954000	100000	1465090	216519090.00
Apr	0	0	781255	781255.00
May	0	0	0	0.00
Jun	336112000	100000	2687870	338899870.00
Jul	0	0	2018870	2018870.00
Aug	0	0	1347930	1347930.00
Sep	0	0	675055	675055.00
Oct	0	0	0	0.00
Nov	67488565	100000	0	67588565.00
Dec	67596255	100000	0	67696255.00

3.10.6 Comparison of results EXISTING vs BPSO (Comparison of Monthly Budget)

Table 3.27 Comparison of total cost with and without BPSO application

Variable Cost (Monthly)(INR)				
Month	Before BPSO	After BPSO	Difference	(%)Reduction
Jan	100389254.45	71174555.00	29214699.45	29%
Feb	100704862.20	68539225.00	32165637.20	32%
Mar	101020410.95	216519090.00	-115498679.05	-114%
Apr	101336576.20	781255.00	100555321.20	99%
May	101555321.70	0.00	101555321.70	100%
Jun	101882071.85	338899870.00	-237017798.15	-233%
Jul	102213073.45	2018870.00	100194203.45	98%
Aug	102542135.15	1347930.00	101194205.15	99%
Sep	102869260.90	675055.00	102194205.90	99%
Oct	103194203.50	0.00	103194203.50	100%
Nov	103519317.85	67588565.00	35930752.85	35%
Dec	103843355.30	67696255.00	36147100.30	35%

3.10.7 Comparison of Annual Budget

Table 3.28 Comparison of annual cost budget with and without application of BPSO

Annual Cost Budget(INR)			
Without BPSO	With BPSO	Difference	(%) Reduction
1225069843.50	835240670.00	389829173.50	31.82%

Annual Cost difference of 38,98,29,173 (nearly 39 crores) is observed by BPSO model and the reduction observed is 31.82% decrease annually.

3.10.8 Graphs comparing Monthly and Annual Budget.

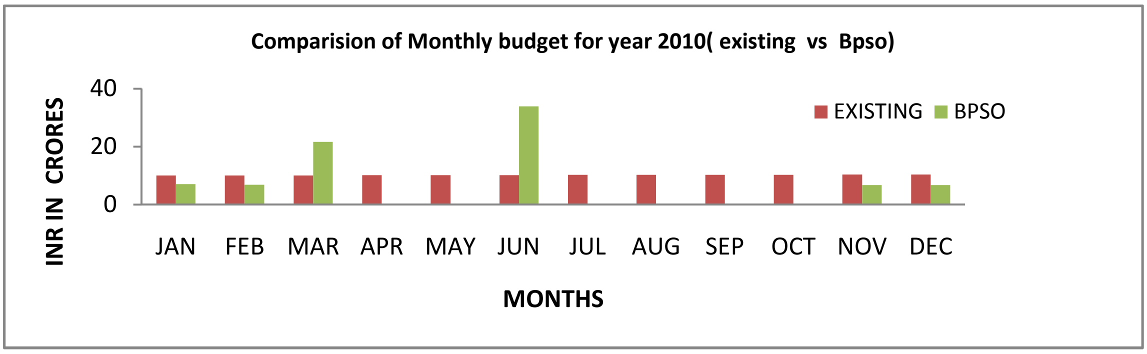


Figure 3.9 Comparison of monthly budget for the year 2010. (Before applying BPSO (Existing) vs After applying BPSO)

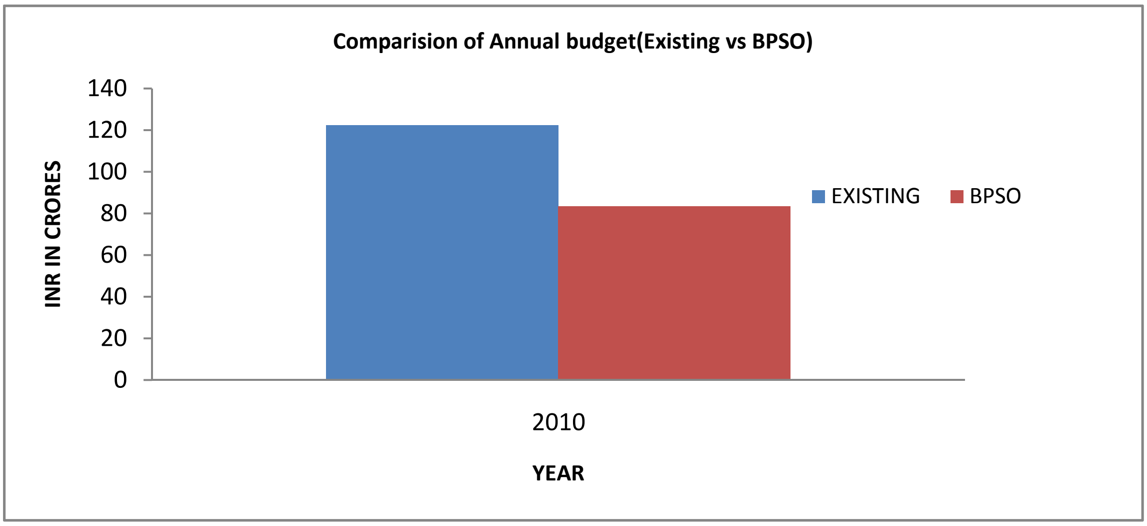


Figure 3.10 Comparison of annual budget for the year 2010. (Before applying BPSO (Existing) vs After applying BPSO)

The total variable cost of the presently used system (before BPSO) is 122,50,69,843.50 and the total variable cost of the optimized inventory cost is 83,52,40,670.00 (after BPSO). The cost difference between the before and after BPSO is 38,98,29,173.50 (nearly thirty nine crores).

3.11 Summary

The flow of material in various stages of PDS and supply chain network for Warangal district is discussed. The data collected also presented in the tables. An inventory model is developed for minimization of warehouse expenditure under PDS. The developed model has determined at FCI, the optimum inventory at the end of each time period, total variable cost estimate for FCI by taking into account realistic available data by implementation of BPSO technique with using C++ coding.

a) BPSO technique have been successfully employed to model and simulate lot sizing problem such as single item single level, capacitated problems under consideration to minimize total cost.
b) The total cost obtained for the PDS problem under consideration by BPSO method it is observed that reduced cost is nearly thirty two cores and there is a reduction of 31.82 % compared to the total cost of existing system.

Transportation Model in PDS in Warangal District and Solution Development

4.1 Introduction

In this chapter it is proposed to develop a transportation model for movement from FCI godowns to MLSP and from MLSP to FSP. In PDS it is necessary to enhance the efficiency in delivery of goods from FCI godowns to all depots (FPS). Naturally, delivery cost is key factor in the pricing of delivery services. To reduce this cost research has tended to focus on the Vehicle Routing Problem (VRP) as a key factor in delivery efficiency. The VRP is complex Non-deterministic Polynomial (NP-hard) [14] question as this is a large-scale problem, as things stand the best and most feasible way to deal with it is to use a heuristic searching algorithm. This work addresses an empirical multi-depot vehicle routing case for a fixed-route trucking carrier. In this case, the characteristics of vehicle routing problems, including multi-depots, dispatching quantity, routes arrangement and time-window constraints, are considered in order to reduce the delivering cost. A hybrid heuristic algorithm is developed in order to solve this practical problem. The developed algorithm first employs the nearest-neighbor heuristic to search for feasible solutions based on the constraints of both the time-window and loading capacity in the routing problem. And use these solutions as input for best case search algorithm to improve the initial solutions. The developed algorithm is able to further enhance the final solutions so as to avoid local optimization and gain a better solution in the problem domain.

4.2 Vehicle routing Problem

The Vehicle-Routing Problem (VRP) [51] is a common name for problems involving the construction of a set of routes for a fleet of vehicles. The vehicles start their routes at a depot, call at customers to whom they deliver goods and return to the depot. The objective function for the vehicle-routing problem is to minimize costs by finding optimal routes, which are usually the shortest routes. The basic VRP consists of designing a set of delivery or collection routes, such that (1) each route starts and ends at the depot, (2) each customer is called at exactly once and by only one vehicle, (3) the total demand on each route does not exceed the capacity of a single vehicle, and (4) the total routing distance is minimized. It is common to address the basic VRP as Capacitated Vehicle-Routing Problem (CVRP).

In this work, author considers only the problems concerning the distribution of goods between depots and final users (customers). The models and algorithms proposed for the solution of VRP’s or vehicle scheduling problems, presented in detail in this work, can effectively not only find solution of problems concerning the delivery or collection of goods but also the solution of different real-world application arising in transportation systems as well. Typical applications of this type are, for instance, solid waste collection, street cleaning, school bus routing, dial-a-ride systems, transportation of handicapped persons, routing of sales people, and of maintenance units.

The distribution of goods concerns the service, in a given time period, of a set of customers by a set of vehicles, which are located in one or more depots, are operated by a set of crews (drivers), and perform their movements by using an appropriate road network. In particular, the solution of a VRP calls for the determination of a set of routes, each performed by a single vehicle that starts and ends at its own depot, such that all the requirements of the customers are fulfilled, all the operational constraints are satisfied, and the global transportation cost is minimized. In this work, it is described the typical characteristics of the routing and scheduling problems by considering their main components (road network, customers, depots, vehicles, and drivers), the different operational constraints that can be imposed on the construction of the routes, and the possible objectives to be achieved in the optimization process.

The road network, used for the transportation of goods, is generally described through a graph, whose arcs represent the road sections and whose vertices correspond to the road junctions and to the depot and customer locations. The arcs (and consequently the corresponding graphs) can be directed or undirected, depending on whether they can be traversed in only one direction (for instance, because of the presence of one-way streets, typical of urban or motorway networks) or in both directions, respectively. Each arc is associated with a cost, which generally represents its length, and a travel time, which is possibly dependent on the vehicle type or on the period during which the arc is traversed.

Typical characteristics of customers are:

• Vertex of the road graph in which the customer is located;
• Amount of goods (demand), possibly of different types, which must be delivered or collected at the customer;
• Periods of the day (time windows) during which the customer can be served (for instance, because of specific periods during which the customer is open or the location can be reached, due to traffic limitations);
•Times required to deliver or collect the goods at the customer location (unloading or loading times, respectively), possibly dependent on the vehicle type; and
• Subset of the available vehicles that can be used to serve the customer (for instance, because of possible access limitations or loading and unloading requirements).

The routes performed to serve customers start and end at one or more depots, located at the vertices of the road graph. Each depot is characterized by the number and types of vehicles associated with it and by the global amount of goods it can deal with. In some real-world applications, the customers are partitioned among the depots, and the vehicles have to return to their home depot at the end of each route. In these cases, the overall VRP can be decomposed into several independent sub problems, each associated with a different depot [55].

Transportation of goods is performed by using a fleet of vehicles whose composition and size can be fixed or can be defined according to the requirements of the customers.

Typical characteristics of the vehicles are:

- home depot of the vehicle, and the possibility to end service at a depot other than the home one;
- capacity of the vehicle, expressed as the maximum weight, or volume, or number of pallets, the vehicle can load;

- possible subdivision of the vehicle into compartments, each characterized by its capacity and by the types of goods that can be carried;
- devices available for the loading and unloading operations;
- subset of arcs of the road graph which can be traversed by the vehicle; and
- Costs associated with utilization of the vehicle (per distance unit, per time unit, per route, etc.)

The routes must satisfy several operational constraints, which depend on the nature of the transported goods, on the quality of the service level, and on the characteristics of the customers and the vehicles. Some typical operational constraints are the following: along each route, the current load of the associated vehicle cannot exceed the vehicle capacity; the customers served in a route can require only the delivery or the collection of goods, or both possibilities can exist; and customers can be served only within their time windows and the working periods of the drivers associated with the vehicles visiting them. Precedence constraints can be imposed on the order in which the customers served in a route are visited. One type of precedence constraint requires that a given customer be served in the same route serving a given subset of other customers and that the customer must be visited before (or after) the customers belonging to the associated subset. This is the case, for instance, of the so-called pickup and delivery problems, wherein the routes can perform both the collection and the delivery of goods, and the goods collected from the pickup customers must be carried to the corresponding delivery customers by the same vehicle. Another type of precedence constraint imposes that if customers of different types are served in the same route, the order in which the customers are visited is fixed. This situation arises, for instance, for the so-called *VRP* with Backhauls, wherein again, the routes can perform both the collection and the delivery of goods, but constraints associated with the loading and unloading operations, and the difficulty in rearranging the load of the vehicle along the route, mean that all deliveries must be performed before the collections.

Evaluation of the global cost of the routes, and the check of the operational constraints imposed on them, requires knowledge of the travel cost and the travel time between each pair of customers and between the depots and the customers. To this end, the original road graph (which often is very sparse) is generally transformed into a complete graph, whose vertices are the vertices of the road graph corresponding to the customers and the depots. For each pair of vertices i and j of the complete graph, an arc (i, j) is defined whose cost C_{ij} is given by the cost of the shortest path starting from vertex i and arriving at vertex j in the road graph. The travel time tij, associated with each arc (i, j) of the complete graph, is computed as the sum of the travel times of the arcs belonging to the shortest path from i to j in the road graph. In the following, instead of the original road graph, we consider the associated complete graph, which can be directed or undirected, depending on the property of the corresponding cost and travel-time matrices to be asymmetric or symmetric, respectively. Several, and often contrasting objectives, can be considered for the vehicle routing problems.

Typical objectives are:

- minimization of the global transportation cost, dependent on the global distance travelled (or on the global travel time) and on the fixed costs associated with the used vehicles (and with the corresponding drivers);
- minimization of the number of vehicles (or drivers) required to serve all the customers;
- balancing of the routes, for travel time and vehicle load;

In some applications, each vehicle can operate more than one route in the considered time period, or the routes can last for more than 1 day. In addition, sometimes it is necessary to consider stochastic or time-dependent dynamic versions of the problem, i.e., problems for which, a priori, there is only partial knowledge of the demands of the customers or of the costs (and the travel times) associated with the arcs of the road network.

4.2.1 Definition and Basic Notation on VRP

This section gives a formal definition, as graph theoretic models, of the basic problems of the vehicle routing class [55]. These problems, which have received the greatest attention in the scientific literature, are examined in detail. The Capacitated VRP is first described, which is the simplest and most studied member of the family, and then it is introduced the Distance-Constrained VRP, the VRP with Time Windows, the VRP with Backhauls, and the VRP with Pickup and Delivery.

For each of these problems, several minor variants have been proposed and examined in the literature, and often different problems are given the same name. Although in many cases the solution methods, particularly the heuristic ones, may be adapted to incorporate additional features, this indeterminacy in problem definition generally causes much confusion In addition; we make an explicit distinction between the symmetric and asymmetric versions of a problem only, if models and solution approaches proposed in the literature make use of this distinction.

Also in this section, we introduce all the relevant notation and terminology used throughout the work. Additional notation and definitions required describing particular variants and practical VRP problems are given in the appropriate problems. Figure4.1 summarizes the main problems described in this section and illustrates their connections. In the figure, an arrow moving from problem *A* to problem *B* means that *B* is an extension of A.

4.2.2. Capacitated and Distance-Constrained VRP (CVRP)

In the CVRP, all the customers correspond to deliveries and the demands are deterministic, known in advance, and may not be split. The vehicles are identical and based at a single central depot, and only the capacity restrictions for the vehicles are imposed. The objective is to minimize the total cost (i.e., a weighted function of the number of routes and their length or travel time) to serve all the customers.

The CVRP may be described as the following graph theoretic problem. Let G =$(V$, A) be a complete graph, where $V = \{0,...\infty\}$ is the vertex set and A is the arc set. Vertices $i = 1,\ldots,n$ correspond to the customers, whereas vertex 0 corresponds to the depot. Sometimes the depot is associated with vertex $n + 1$.

A nonnegative cost, C_{ij}, is associated with each arc (i,j) Є A and represents the travel cost spent to go from vertex i to vertex j. Generally, the use of the loop arcs, (i, i),*is* not allowed and this is imposed by defining $C_{ij} =+\infty$ for all $i \in V$. If G is a directed graph, the cost matrix c is asymmetric, and the corresponding problem is called asymmetric CVRP (ACVRP). Otherwise, we have $C_{ij} = C_{ji}$ for all (i, j) Є A, the problem is called symmetric CVRP (SCVRP).

In several practical cases, the cost matrix satisfies the triangle inequality,

$$C_{ij}+C_{jk} \geq C_{ik} \text{ for all } i,j,k \in V.$$

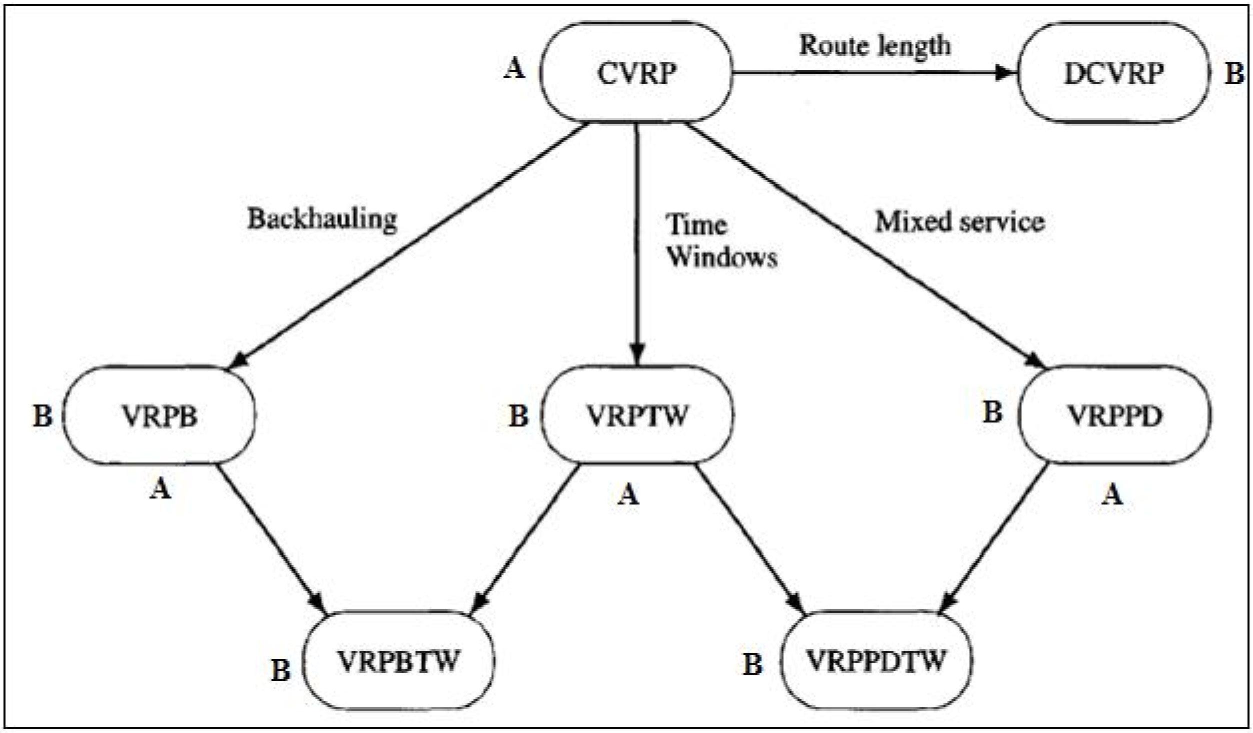


Figure 4.1 The basic problems of the VRP class and their interconnections

The CVRP consists of finding a collection of exactly *K* simple *circuits* (each corresponding to a vehicle route) with minimum cost, defined as the sum of the costs of the arcs belonging to the circuits, and such that,

i. each circuit visits the depot vertex;
ii. each customer vertex is visited by exactly one circuit; and
iii. the sum of the demands of the vertices visited by a circuit does not exceed the vehicle capacity, C.

A set of K identical vehicles, each with capacity C, is available at the depot. To ensure feasibility we assume that , d_i< C for each i = 1,…n. Each vehicle may perform at most one route, and we assume that K is not smaller than Kmin, where Kmin is the minimum number of vehicles needed to serve all the customers. Several variants of the basic versions of CVRP have been considered in the literature. First, when the number *K* of available vehicles is greater than K_{min}, it may be possible to leave some vehicles unused, and thus at most *K* circuits must be determined. In this case, fixed costs are often associated with the use of the vehicles, and the additional objective requiring minimization of the number of circuits (i.e., of the vehicles used) is added to that requiring minimization of the total cost. Another frequently considered variant arises when the available vehicles are different, i.e., have different capacities CV, $k = 1, \ldots, K$. Finally, routes containing only one customer may not be allowed.

The CVRP is known to be NP-hard (in the strong sense) and generalizes the well-known Traveling Salesman Problem (TSP), calling for the determination of a minimum-cost simple circuit visiting all the vertices of G and arising when $C > d(V)$and $K = 1$. Therefore, all the relaxations proposed for the TSP are valid for the CVRP. The first variant of CVRP we consider is the so-called Distance-Constrained *VRP*(DVRP), where for each route the capacity constraint is replaced by a maximum length (or time) constraint.

4.2.3. VRP with Time Window (VRPTW)

The VRP with Time Windows (VRPTW) is the extension of the CVRP in which capacity constraints are imposed and each customer *i* is associated with a time interval $[a_i, b_j]$, called a time window. The time instant in which the vehicles leave the depot, the travel time, t_{ij} for each arc (i, j) € A (or t_e for each e €E) and an additional service time s_i for each customer *i* are also given. The service of each customer must start within the associated time window, and the vehicle must stop at the customer location for s_i time instants. Moreover, in case of early arrival at the location of customer *i*, the vehicle generally is allowed to wait until time instant a_i, i.e., until the service may start.

Normally, the cost and travel-time matrices coincide, and the time windows are defined by assuming that all vehicles leave the depot at time instant 0. Moreover, observe that the time window requirements induce an implicit orientation of each route even if the original matrices are symmetric. Therefore, VRPTW normally is modeled as an asymmetric problem [55].

VRPTW consists of finding a collection of exactly *K* simple circuits with minimum cost, and such that,

(i) each circuit visits the depot vertex;

(ii) each customer vertex is visited by exactly one circuit;

(iii) the sum of the demands of the vertices visited by a circuit does not exceed the vehicle capacity, C; and

(iv) For each customer *i*, the service starts within the time window, [a_i, b_j], and the vehicle stops for S_i time instants.

The so-called TSP with Time Windows (TSPTW) is the special case of VRPTW in which C ≥d (V) and K = 1.

4.2.4. VRP with Backhauls (VRPB)

The VRP with Backhauls (VRPB) is the extension of the CVRP in which the customer set V \ {0} is partitioned into two subsets. The first subset, L, contains n linehaul customers, each requiring a given quantity of product to be delivered. The second subset, *B*, contains m Backhaul customers, where a given quantity of inbound product must be picked up. Customers are numbered so that

L = {1, . . . ,*n]* and fi = {n+ 1 , . . . , n+ *m*}

In the VRPB, a precedence constraint between linehaul and backhaul customers exists: whenever a route serves both types of customer, all the linehaul customers must be served before any backhaul customer may be served. A nonnegative demand, d_i, to be delivered or collected depending on its type, is associated with each customer *i*, and the depot is associated with a fictitious demand

d_o = 0. When the cost matrix is asymmetric, the problem is called Asymmetric VRP with Backhauls (AVRPB). VRPB (and AVRPB as well) consists of finding a collection of exactly *K* simple circuits with minimum cost, and such that

(i) each circuit visits the depot vertex;

(ii) each customer vertex is visited by exactly one circuit;

(iii) the total demands of the linehaul and backhaul customers visited by a circuit do not exceed, separately, the vehicle capacity C; and

(iv) In each circuit all the linehaul customers precede the backhaul customers.

4.2.5. VRP with Pickup and Delivery (VRPPD)

In the basic version of the *VRP* with Pickup and Delivery (VRPPD), each customer *i* is associated with two quantities d_i and p_i, representing the demand of homogeneous commodities to be delivered and picked up at customer i, respectively. Sometimes, only one demand quantity

$d_i = d_i - p_i$ used for each customer i, indicating the net difference between the delivery and the pickup demands (thus being possibly negative). For each customer *i*, O_i denotes the vertex that is the origin of the delivery demand, and D_i denotes the vertex that is the destination of the pickup demand.

It is assumed that, at each customer location, the delivery is performed before the pickup; therefore, the current load of a vehicle before arriving at a given location is defined by the initial load minus all the demands already delivered plus all the demands already picked up [55].

The VRPPD consists of finding a collection of exactly *K* simple circuits with minimum cost, and such that

(i) each circuit visits the depot vertex;

(ii) each customer vertex is visited by exactly one circuit;

(iii) the current load of the vehicle along the circuit must be nonnegative and may never exceed the vehicle capacity *C;*

(iv) for each customer i, the customer O_i, when different from the depot, must be served in the same circuit and before customer *i*; and

(v) For each customer *i*, the customer D_i, when different from the depot, must be served in the same circuit and after customer *i*.

Traditionally, vehicle routing plans are based on deterministic information about demands, vehicle locations and travel times on the roads. What is likely to distinguish most distribution problem today from equivalent problems in the past, is that information that is needed to come up with a set of good vehicle routes and schedules is dynamically revealed to the decision maker. Until recently, the cost of obtaining real time traffic information was deemed too high to compare to the benefits of the real time control of the vehicles. Also, some of the information needed for the real time routing was impossible to acquire. Advancement of the technology in communication systems, the geographic information system (GIS) and the intelligent transportation system (ITS) make is possible to operate vehicles using the real-time information about the travel times and the vehicles locations.

While traditional VRPs have been thoroughly studied, limited research has, to date, been devoted to multi-objectives real-time management of vehicles during the actual execution of the distribution schedule in order to respond to unforeseen events that often occur and may deteriorate the effectiveness of the predefined and static routing decisions. Also, in cases when traveling time is a crucial factor, ignoring travel time fluctuations (due to various factors, such as peak hour traveling time, accidents, whether conditions, etc) can result in route plans that can take the vehicles into congested urban traffic conditions. Considering time-dependent travel times as well as information regarding demands that arise in real time in solving VRPs can reduce the costs of ignoring the changing environment.

The problem considered in this research proposal is the Real-Time Multi-Objectives VRP. The Real-Time Multi-Objectives VRP is defined as a vehicle fleet that has to serve customers of fixed demands from a central depot. Customers must be assigned to vehicles and the vehicles routed so that the number of objectives are minimized/maximized. The travel time between to customers or a customer and depot depends on the distance between the points and the time of day, and it is also has stochastic properties.

In this research work author attempts to adjust the vehicles' routes at certain times in a planning period. This adjustment consider new information about the travel times, current location of vehicles, and new demands requests (that can be deleted after being served, or added since they arise after the initial service began) and more. This results in a dynamic change in the demand and traveling time information as time changes which has to be taken into consideration in order to provide optimized real-time operation of vehicles.

4.3 Problem Statement

The objective of the research is usually to solve the VRP for a large region and apply the same for Public Distribution System. The region is so widely spread that the delivering cost is almost always tremendously high if only a single Distribution Centre (DC) is in charge of all deliveries. It has been suggested that the best way to meet this problem is to set up district DCs which enable the reduction of shipping cost. In this work, we have a scenario in which PDS has set up several DCs(FCI owned godowns and MLSP) which are incharge of delivering all of the shipping demands of all points, all of which are required to be completed within the time window of 10 days (i.e. every month 20^{th} -30^{th}). The VRP is the Multi-Depot Vehicle Routing Problem with Time Window (MDVRPTW) problem. This work proposes a hybrid heuristic approach to solve the MDVRPTW problem. This heuristic method first employs the nearest-neighbor searching algorithm, starting from the initial DC, and then assigns the nearest depots to the DC. The initial solution plan is then generated using this algorithm. Later this initial solution plan provided as input to best case selection algorithm to optimize the results. The transportation starts from the delivering rice from FCI owned godowns to MLSP and again from MLSP to FPS.

4.4 Objectives

The primary objectives of this work are summarized as follows:

1. To construct and analyzing the transportation network for PDS to minimize total traveling distance/time.
2. To develop a search algorithm to generate a feasible vehicle routing plan.
3. To minimize the number of vehicles for transportation under PDS with in time window.
4. The sample data of the PDS is applied to validate the system in solving the routing problem. Three different algorithms are individually tested to evaluate the system performance during problem solving.

4.5 Methodology

4.5.1. Assumptions and Constraints

The basic assumptions of the problem are addressed as follows:

1. DC locations, shipping demand and destination locations are known.
2. For our work we considered only one type of vehicle for cargo delivery in network. All vehicles have the same loading capacity.
3. Shipping time is in proportion to the shipping distance, with no consideration of traffic conditions.
4. All service vehicles have the same maintenance status. No breakdown or maintenance issues are considered in the routing process.

The constraints of the problem include:

1. No repeat dispatching, a vehicle can only serve one route at a time.
2. All vehicles will complete all cargo shipments in compliance with the hard time-window constraint.
3. The shipping demand of a depot cannot be divided. It should be delivered by the same vehicle, unless the shipping demand of the depot exceeds the loading capacity of a vehicle.
4. The time-window constraint is known. The driver will be given the time limitation so that over-time driving can be eliminated.
5. The types and sizes of vehicles are known. This work does not consider driving with additional "tail" containers.
6. The cargo loading cannot exceed the vehicle loading capacity at each delivery.

4.5.2 Mathematical Model Formulation

The objective is to minimize the overall transportation cost and total distance travelled. The vehicles cannot deliver over the maximum loading capacity and working hours

STEP 1: Calculate the overall demand.

- Demand of one MLSP is the summation of demands of all the mandals under that MLSP
- Demand of one Mandal is the summation of demands of all FPS in that mandal.
- Demand of one FPS is the summation of demands of all BPL cards of that shop.

STEP 2: Define objective function.

The objective of this research is to minimize the shipping costs, including loading/unloading costs, fixed costs and variable costs of vehicles, while the vehicles cannot deliver over the maximum loading capacity and working hours. The cost formulation and its relevant notations are denoted as following:

N	Set of all Depots, *N= {1,2,3….n}*
L	Set of all DCs, *L={1,2,3…l}*
K	Set of all vehicles, *K = {1,2,3…k}*
n	Number of depots
l	Number of DCs
k	Number of vehicles
T	The maximum working hours for vehicles
Q	The maximum loading capacity of vehicles
c_{ijl}	The shipping cost starting from DC, Depot i to Depot j
a_i	The shipping demand of Depot i
S_i	The service time
t_{ij}	The delivery time from depot i to j
(i,j)	Indicates the route from Depot i to j
b_{ikl}	Starting from DC 1, the time needed for vehicle to deliver to Depot j
X_{ijkl}	= 1 DC l, the vehicle k delivers cargo from i to j
	= 0, Otherwise

The objective function:

$$\text{Cost} = \sum_{i=0}^{n} \sum_{j=o}^{n} \sum_{k=1}^{k} \sum_{l=1}^{l} C_{ijl} X_{ijkl} + \sum_{k=1}^{k} F_k \qquad (4.1)$$

Subject to:

$$\sum_{i=0}^{i} \sum_{k=1}^{k} \sum_{l=1}^{l} X_{ijkl} = 1 \quad j=1,\ldots\ldots,n \qquad (4.2)$$

$\sum_{i=0}^{n} X_{ijkl} <= 1$ K = 1,….k (4.3)

$\sum_{i=0}^{n} a_i \sum_{j=0}^{n} x_{ijkl} <= Q$ K = 1,…..k (4.4)

X_{ijkl} = 0 or 1, i=0,……n ; j=0,……,n ; K= 1,2,…..,k ; L=1,2,…l (4.5)

- Objective function (4.1) includes variable cost and fixed cost ($\sum_{k=1}^{k} F_k$). In order to achieve an optimal plan, the objective function is minimized.

- Formula (4.2) requires that the depot is the starting point for all shipments, which can be served only by one vehicle at one time. If the shipping demand exceeds the vehicle capacity, it must be delivered by another vehicle.

- Formula (4.3) has the constraint that one vehicle can only cover a route (i,j) one time at most.

- Formula (4.4) has the constraint that the loading of each vehicle ($\sum_{i=0}^{n} a_i \sum_{j=0}^{n} x_{ijkl}$) cannot exceed the loading capacity (Q) [67].

- Formula F_k represent the fixed cost for vehicle which includes salary for driver , road tax , misc. expenditure, interest on cost of vehicle as 4,00,000/- @12% per annum per month.

4.5.3 The Heuristic Algorithms

In order to solve this multi-depot vehicle routing problem with time-window, a hybrid genetic algorithm has been developed in which the solving process is divided into three stages as shown in Figure 4.2. Based on the distances to the DCs, the first stage uses the "cluster-first and route-second" principle to assign depots to specific DCs. In the second stage, the nearest-neighbor searching algorithm is used to generate an initial routing plan which assigns the vehicles and configures the routes used to deliver the cargo. In final stage, a Best case selection algorithm is used to fine tune the initial plan. The development of the heuristic algorithms used in each of the three stages is further discussed below.

4.5.3.1 The Depot Assignment

The “cluster-first and route-second” method is used to calculate all distances from depots to a DC. Then, the nearest depots are assigned to be served by the DC. This process does not stop until all the depots are assigned to their nearest DCs. Therefore the multi-depot routing problem can be simplified into several independent single-depot vehicle routing problems.

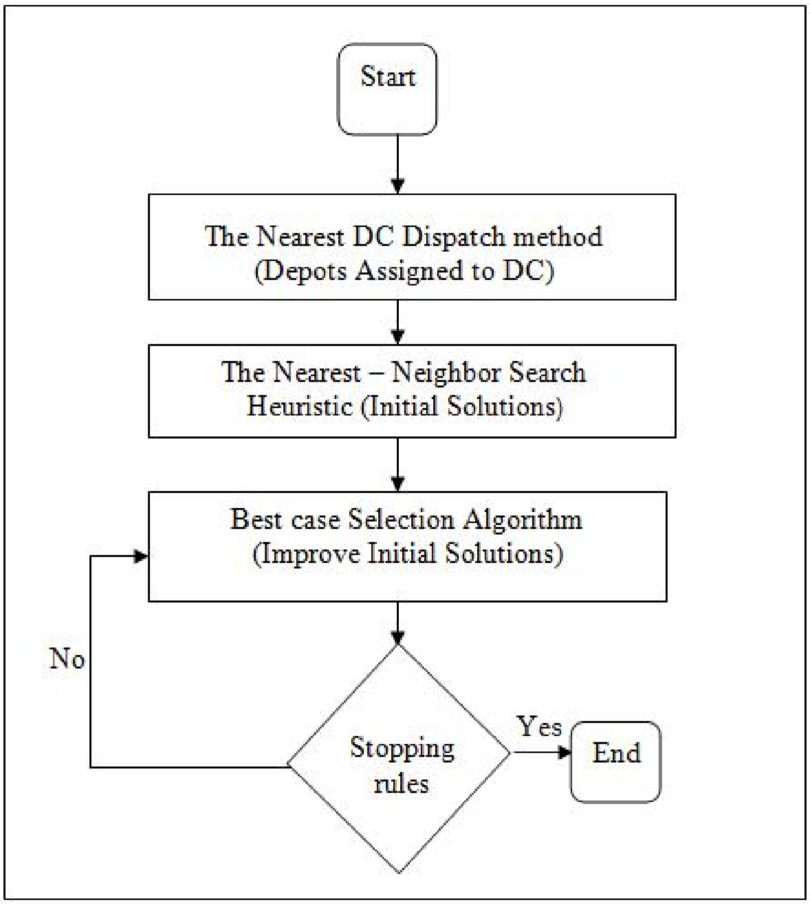


Figure 4.2 The Hybrid heuristic algorithms

During the depot assignment task, a data processing task needs to be implemented to determine if any possible direct shipment is possible based on the vehicle’s loading capacity: if the shipping demand of one depot exceeds 80% of the vehicle’s maximum load, this vehicle is used to directly deliver the cargo to its destination DC.

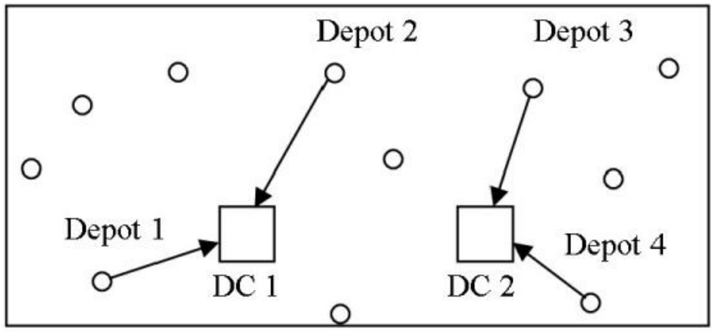


Figure 4.3 The Cluster-first and route-second method.

Figure 4.3 shows the process of this algorithm .First, the distance is calculated from depots to DCs. Depot 1 is closer to DC 1 than Depot 2 to DC 1, therefore Depot 1 is assigned to DC 1. The process continues until the completion of all searches.

4.5.3.2 The Nearest Neighbor Searching Algorithm

As explained in the previous section, in stage1 depots are assigned to a DC. This means that the multi-depot vehicle routing problems have been simplified into several single-depot vehicle routing problems. In formulation of objective function the multi-depot delivering cost of $\sum_{i=0}^{n}\sum_{j=o}^{n}\sum_{k=1}^{k}\sum_{l=1}^{l} C_{ijl}X_{ijkl}$is transformed into the cost of$\sum_{i=0}^{n}\sum_{j=o}^{n}\sum_{k=1}^{k} C_{ijl}X_{ijkl}$. The formulation of the multi-depot problem is revised as shown in the following.

NN$_{cost}$= $\sum_{i=0}^{n}\sum_{j=o}^{n}\sum_{k=1}^{k} C_{ijl}X_{ijkl} + \sum_{k=1}^{k} F_k$ (4.6)

Subject to:

$\sum_{i=0}^{n} a_i \ \sum_{j=0}^{n} x_{ijk} \leq$ QK = 1,…..k (4.7)

X_{ijk} = 0 or 1, i=0,……n ; j=0,……,n ; K= 1,2,…..,k ; (4.8)

The new objective function (6) contains the variable cost, $\sum_{i=0}^{n}\sum_{j=o}^{n}\sum_{k=1}^{k} C_{ijl}X_{ijkl}$ and the fixed cost, $\sum_{k=1}^{k} F_k$.

After the depot assignment process, the nearest-neighbor searching algorithm is used to minimize the delivery cost, and subsequently generate the initial routing plan. The algorithm arranges the nearest depot from the DC into the delivery route at the first priority, i.e. the depot with the smallest NN_{cost} is figured into the rout first [67].

The searching process contains the following six steps, also shown in Figure 4.4.

1. Number all possible delivering nodes sequentially starting from 0, and calculate the corresponding cost NN for each node.
2. Starting from a DC, assign the depot with the smallest cost NN as the first stop in the delivery route.
3. Take the assigned depot away, and search for the next stopping node with the minimum cost in the rest of the nodes. The searching process iterates while complying with the constraints and vehicle loading capacity.
4. Repeat Step 3 to build a new vehicle route from the DC until all the shipping demand of the DC are met.
5. Step 4 does not begin until there is no depot left for the DC.
6. Repeat Steps 2 to 5 to build a new route for another DC. The process is not terminated until all shipping demands at DCs are delivered.

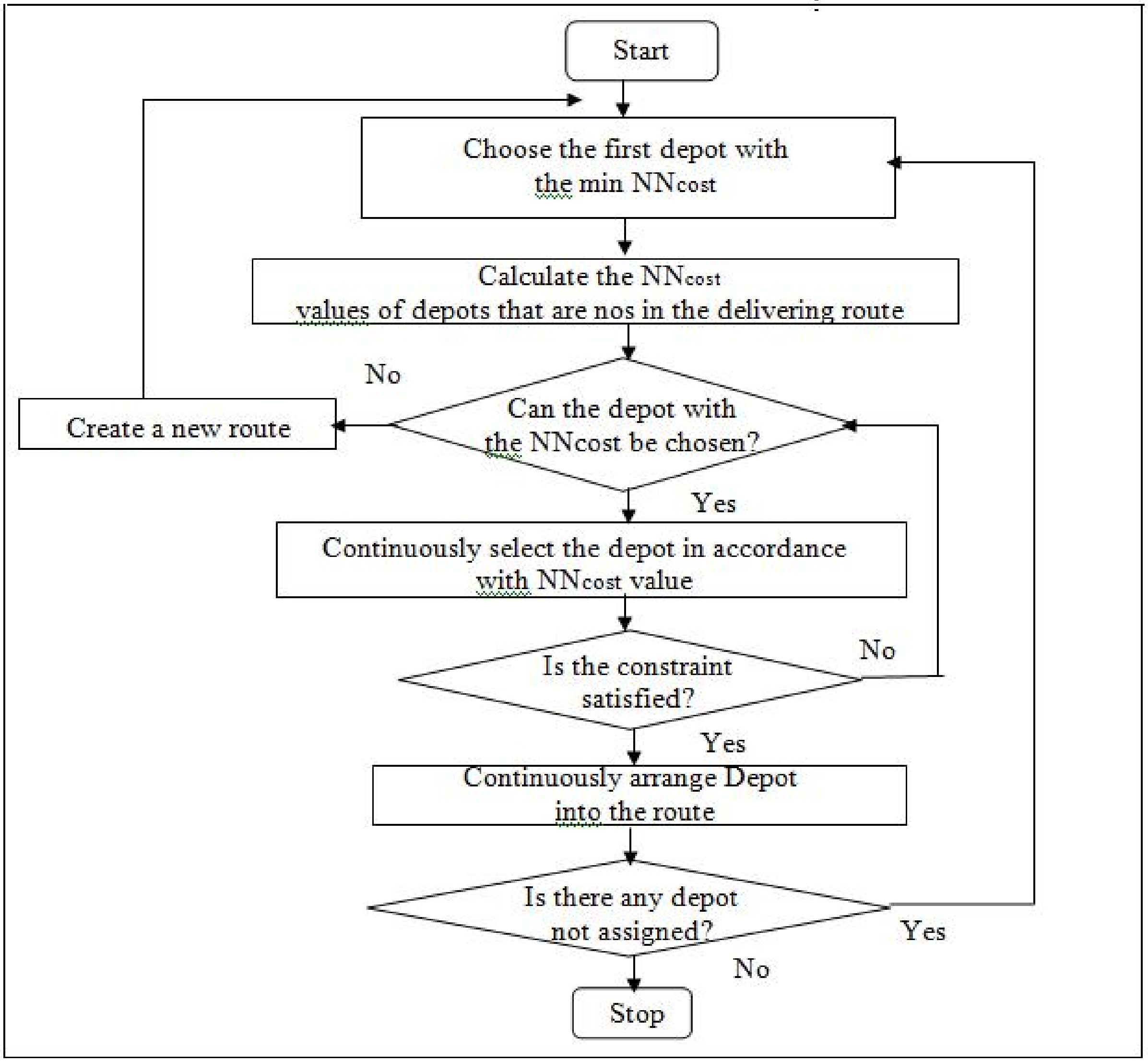


Figure 4.4 The Nearest Neighbor Algorithm

4.5.3.3 Best Case Selection Algorithm

After the initial solution is generated, a Best Case Selection algorithm is developed to implement the fine tuning task so as to get an improved routing plan. In this algorithm all point on one route are arranged and all possible routes are generated for the initial combination. Later distances are calculated for each route and best case i.e. route with least distance is selected. This algorithm is preferred because of truck capacity and demand of supply points maximum 3-4 points generated in initial solution. The process of this algorithm is shown in Fig. 4.5.

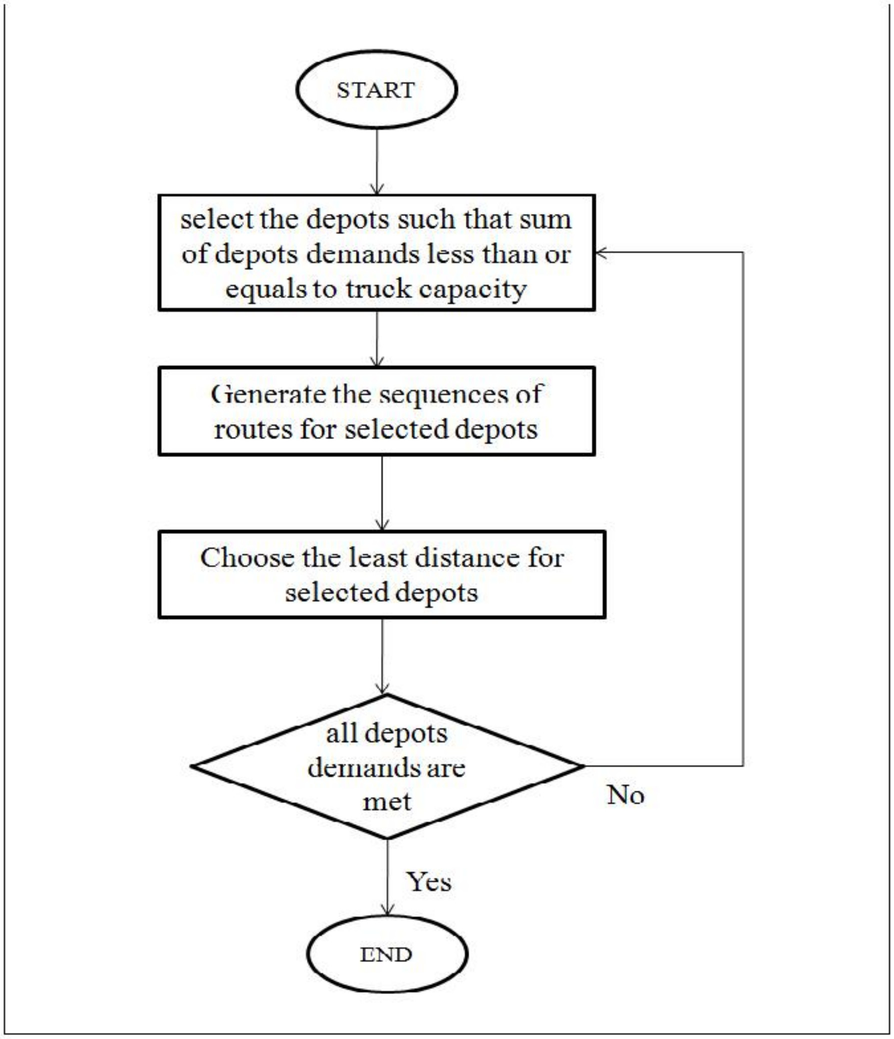


Figure 4.5 Best Case Selection Algorithm

4.6 Result and Discussion

4.6.1 Stage 1 Solution

By using Least Cost Method we first get which Mandal Level Service Point (MP) is to be served by which FCI owned godowns. Later the same is done by using CPLEX Solver 12.1. In both the cases least distance travelled is calculated. The result generated by program by using Least Cost method is shown in Table 4.1

4.6.1.1 Result generated by program by using Least Cost method.

Table 4.1 Allocation of demand of MLSP

Result using programme																			
MLSP's (18 Numbers) demand D (Qtls)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	S(FCI) (Qtls)
1	6	11	22	35	52	74	83	95	58	93	74	58	40	65	117	53	45	66	883400
2	14	5	37	29	67	76	98	86	53	88	68	53	44	59	112	60	36	57	85000
3	14	5	37	29	67	76	98	86	53	88	68	53	44	59	112	60	36	57	100000
4	18	9	41	33	71	80	102	76	57	92	72	57	48	63	116	64	26	47	200000
5	51	57	22	46	8	55	40	138	72	107	107	102	84	109	161	87	89	110	300000
6	94	88	121	93	141	94	160	5	47	35	24	90	103	128	150	116	53	52	100000
7	5	3	30	27	60	76	91	87	51	85	66	59	38	63	115	58	37	58	25000
D Qtls	16222	14334	5807	11964	7312	6423	8460	8902	3058	6105	7154	3722	10947	4896	5869	950	10972	3054	

As per the result generated above the quantities allocated from each FCI godowns to each MLSP's and equivalent truck loads (in numbers) are shown in Table 4.2.

Table 4.2 Individual allocation and equivalent truck load of each MLSP

MLSP	FCI Godowns	Equivalent Truck Load (numbers)
1	1->5556, 7->10666	28, 54
2	7->14334	72
3	1->5807	29
4	2->11964	60
5	5->7312	37
6	5->6423	32
7	5->8460	43
8	6->8902	45
9	6->3058	16
10	6->6105	31
11	6->7154	36
12	2->9000	45
13	1->7500	38
14	2->3000	15
15	2->5000	25
16	1->950	5
17	4->10972	55
18	4->3054	16

The distance travelled from FCI godowns to MLSP's to fulfill demands are shown in Table 4.3.

Table 4.3 Distance travelled from FCI godowns to fulfill demand of allotted MLSP.

FCI Owned Godown	Minimum distance travelled to fulfill demand of allotted MLPS	
1	28X6+29X22+40X38+5X33	2591
2	29X16+53X45+59X15+112X25	7810
4	26X55+47X16	2182
5	8X37+55X32+40X43	3776
6	5X45+47X16+35X31+24X36	2926
7	5X54+3X72	486
		=19771 km

As per the result generated by the LCM method the minimum number of trucks to fulfill the demand in given time window are shown in Table 4.4

Table 4.4 Minimum Trucks required at every FCI godowns

FCI owned Godown		Delivery Time using 1 truck	Delivery Time using 2 truck	Delivery Time using 3 truck	Delivery Time using 4 truck	minimum no. of truck to fulfil demand in given time window
1		45	24			2
2		89	45	30	23	4
4		30	15			2
5		54	29	16		3
6		68	36	23		3
7		42	21			2

The minimum number of trucks are arrived at each FCI assuming 6 days as safety period for unforeseen reasons like vehicle break down and absent of driver and handling labor etc.

The comparison of transportation cost from each FCI godowns to MLSP's by using different number of trucks with fixed cost per truck is shown in Table 4.5.

Table 4.5 Comparison of transportation cost for moving allotted quantities from various FCI godowns to MLSP using different number of trucks with fixed cost per truck Rs. 13875

Comparison of Transportation Cost (in Rs.)				
Using 1 Truck	Using 2 Truck	Using 3 Truck	Using 4 Truck	Using Best case as per the Table 4.4
42927	56802	70677	84552	56802
101444	115319	129194	143069	143069
38341	52216	66091	79966	52216
56214	70089	83964	97839	83964
46683	60558	74433	88308	74433
19325	33200	47075	60950	33200
304934	388184	471434	554684	443685

As per the result the optimum number of trucks to be engaged for minimum transportation cost within time window are shown in Table 4.6

Table 4.6 Minimum transportation cost for moving allotted quantities from various FCI godowns to MLSP using least no. of trucks within given time window (30 days)

Total Transportation Cost (in Rs.)					
FCI owned Godown	No. of vehicle	Fixed cost per vehicle	Total fixed cost (TFC)	Variable cost (VC)	Total cost = TFC+VC
1	2	13875	27750	29052	56802
2	4	13875	55500	87569	143069
3	2	13875	27750	24466	52216
4	3	13875	41625	42339	83964
5	3	13875	41625	32808	74433
6	2	13875	27750	5450	33200
			Total (in Rs.)		443684

The minimum transportation cost to move the goods from FCI godowns to MLSP is Rs 4,43,684 only.

The comparison of delivery time by using different number of trucks from each FCI godowns to MLSP's are shown in Figure 4.6.

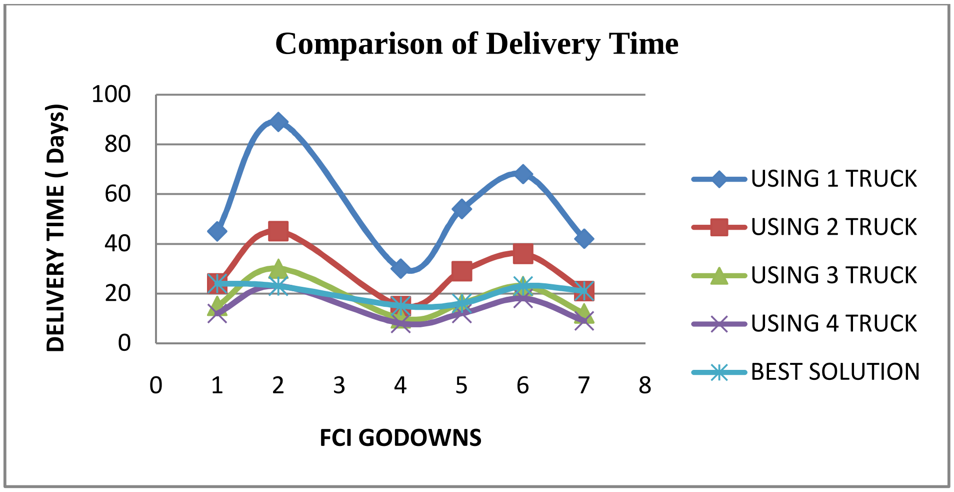


Figure4.6 Comparison of Delivery Time using Least Cost Method

The comparison of transportation cost by using different number of trucks from each FCI godowns to MLSP's are shown in Figure 4.7

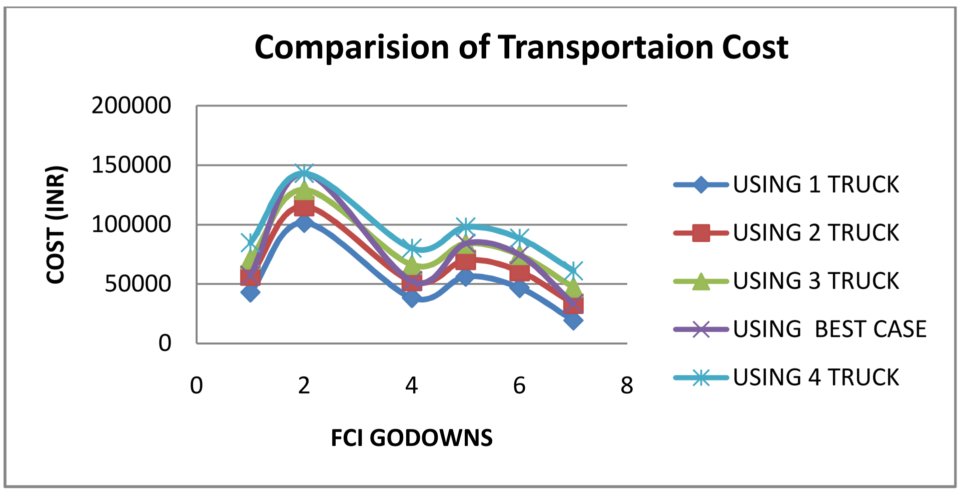


Figure 4.7 Comparison of Transportation Cost Using Least Cost Method

4.6.1.2 Result generated by using CPLEX 12.1

The result generated by program by using Cplex 12.1 solver is shown in Table 4.7

Table 4.7 Allocation of demand of MLSP

Result using CPLEX 12.1																			
MLSP's (18 Numbers) demand D (Qtls)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	S(FCI) (Qtls)
1	6	11	22	35	52	74	83	95	58	93	74	58	40	65	117	53	45	66	883400
2	14	5	37	29	67	76	98	86	53	88	68	53	44	59	112	60	36	57	85000
3	14	5	37	29	67	76	98	86	53	88	68	53	44	59	112	60	36	57	100000
4	18	9	41	33	71	80	102	76	57	92	72	57	48	63	116	64	26	47	200000
5	51	57	22	46	8	55	40	138	72	107	107	102	84	109	161	87	89	110	300000
6	94	88	121	93	141	94	160	5	47	35	24	90	103	128	150	116	53	52	100000
7	5	3	30	27	60	76	91	87	51	85	66	59	38	63	115	58	37	58	25000
D	16222	14334	5807	11964	7312	6423	8460	8902	3058	6105	7154	3722	10947	4896	5869	950	10972	3054	

As per the result generated above the quantities allocated from each FCI godowns to each MLSP's and equivalent truck loads (in numbers) are shown in Table 4.8

Table 4.8 Individual allocation and equivalent truck load of each MLSP

MLSP	FCI GODOWNS	Equivalent Truck Load (numbers)
1	1->161222	81
2	2->1298, 7->13036	7,65
3	1->5807	29
4	7->11964	60
5	5->7312	37
6	5->6423	32
7	5->8460	43
8	6->8902	45
9	6->3058	16
10	6->6105	31
11	6->7154	36
12	2->9000	45
13	1->7500	38
14	2->3000	15
15	2->5000	25
16	1->950	5
17	4->10972	55
18	4->3054	16

The distance travelled from FCI godowns to MLSP's to fulfill demands are shown in Table 4.9

Table 4.9 Minimum distance travelled from FCI godowns to fulfill demand of allotted MLSP.

FCI Godown	Minimum distance travelled to fulfill demand of allotted MLPS	
1	81X6+22X29+40X38+5X53	2909
2	5X7+53X45+59X15+112X25	6105
4	26X55+47X16	2182
5	8X37+55X32+40X43	3776
6	5X45+47X16+35X31+24X36	2926
7	3X65+27X60	1815
		=19713 km

As per the result generated the minimum number of trucks to fulfill the demand in given time window are shown in Table 4.10

Table 4.10 Minimum Trucks required at every FCI godowns

FCI owned Godown	Delivery Time using 1 truck	Delivery Time using 2 truck	Delivery Time using 3 truck	Minimum no. of truck to fulfill demand in given time window
1	62	32	16	3
2	68	35	24	3
3	30	15	8	2
4	56	29	16	3
5	68	36	23	3
6	42	21	14	2

The minimum number of trucks are arrived at each FCI assuming 6 days as safety period for unforeseen reasons like vehicle break down and absent of driver and handling labor etc.

The comparison of transportation cost from each FCI godowns to MLSP's by using different number of trucks with fixed cost per truck is shown in Table 4.11

Table 4.11 Comparison of transportation cost for moving allotted quantities from FCI godowns to MLSP's using different numbers of trucks with fixed cost per truck Rs. 13875

Comparison of Transportation Cost (in Rs.)			
1 Truck	2 Truck	3 Truck	Best Solution as per the Table 4.10
46492	60367	74242	74242
82327	96202	110077	110077
38341	52216	66091	52216
56214	70089	83964	83964
46683	60558	74433	74433
34226	48101	61976	48101

As per the result the optimum number of trucks to be engaged for minimum transportation cost within time window are shown in Table 4.12

Table 4.12 Minimum transportation cost for moving allotted quantities from various FCI godowns to MLSP using least no. of trucks within given time window (30 days)

Total Transportation Cost (in Rs.)					
FCI owned Godown	No. of vehicle	Fixed cost per vehicle	Total fixed cost (TFC)	Variable cost (VC)	Total cost = TFC+VC
1	3	13875	41625	32617	74242
2	3	13875	41625	68452	110077
4	2	13875	27750	24466	52216
5	3	13875	41625	42339	83964
6	3	13875	41625	32808	74433
7	2	13875	27750	20351	48101
					443033

The minimum transportation cost to move the goods from FCI godowns to MLSP is Rs 4,43033 only.

The comparison of delivery time by using different number of trucks from each FCI godowns to MLSP's are shown in Figure 4.8

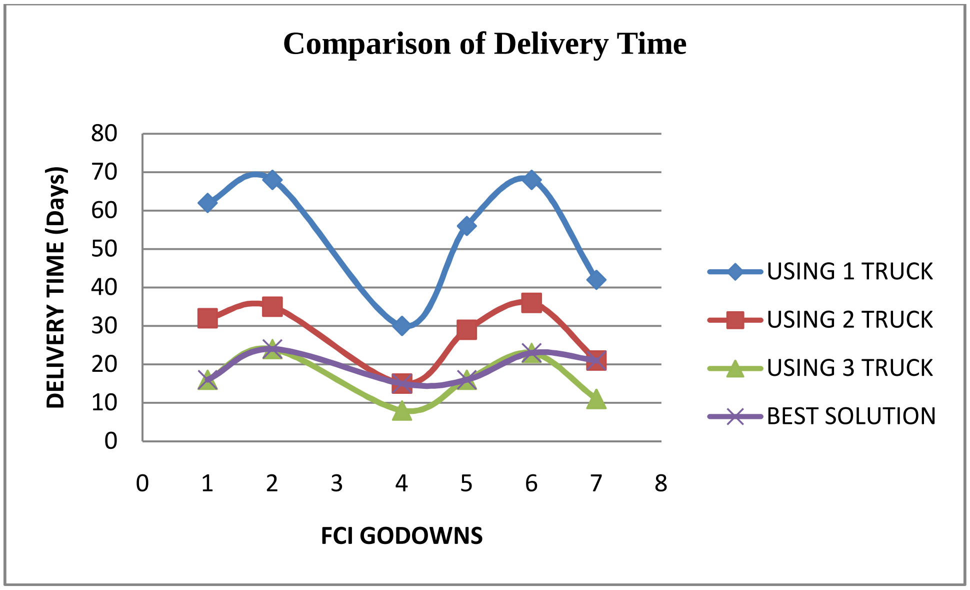


Figure 4.8 Comparison of Delivery Time Using CPLEX Solver

The comparison of transportation cost by using different number of trucks from each FCI godowns to MLSP's are shown in Figure 4.9

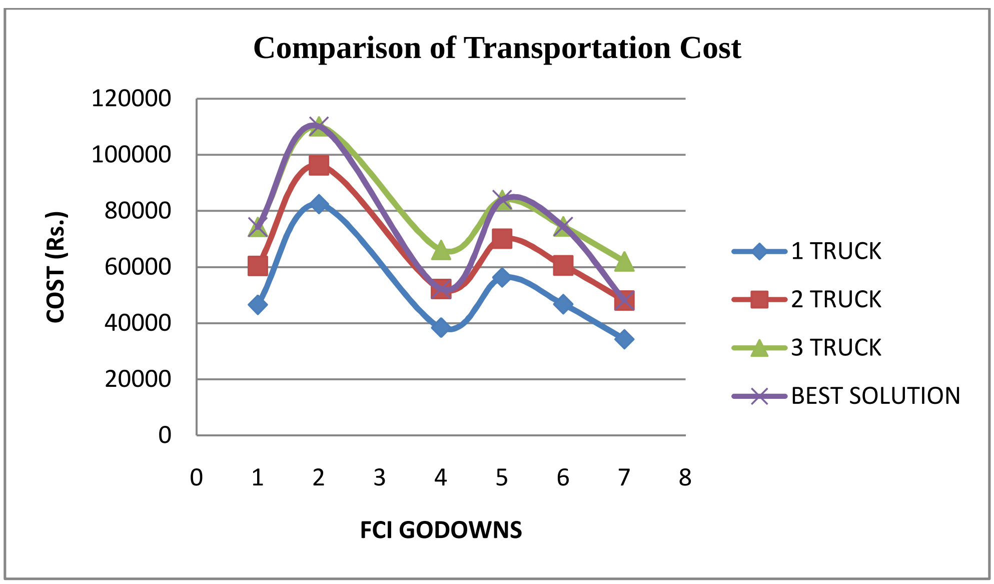


Figure 4.9 Comparison of Transportation Cost Using CPLEX Solver

4.6.1.3 Result generated by using minimum quoted tender values of Warangal District.

Table 4.13 Allocations of demands in Government provided Unit cost matrix.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	S (FCI) (Qtls)
1	129	129	141	165	198	239	256	279	209	275	239	209	175	222	320	199	184	224	883400
2	129	129	169	154	226	243	284	262	199	266	228	199	182	211	311	213	167	207	85000
3	129	129	169	154	226	243	284	262	199	266	228	199	182	211	311	213	167	207	100000
4	133	129	177	162	233	250	292	243	207	273	235	207	190	218	319	220	148	188	200000
5	196	207	141	186	129	203	175	360	235	301	301	292	256	305	404	264	267	307	300000
6	277	266	328	275	366	277	419	129	188	165	145	267	294	341	383	318	199	198	100000
7	129	129	163	148	220	237	277	256	194	260	222	194	177	205	305	207	162	201	25000
D (Qtls)	16222	14334	5807	11964	7312	6423	8460	8902	3058	6105	7154	9000	7500	3000	5000	950	10972	3054	

The transportation cost to move the goods from FCI godowns to MLSP is Rs.2164311 by taking consideration of rates paid by State government.

Rates fixed by State Government up to 16 km Rs129 per MT beyond 16 km Rs1.89 per MT per km.

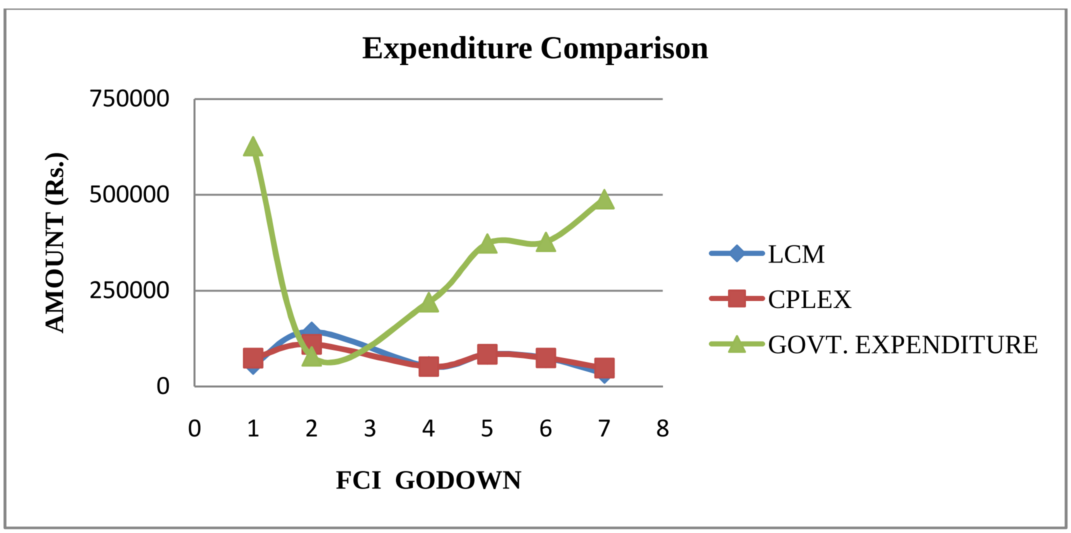


Figure 4.10 Cost Comparison by different Methods

Estimates transportation cost using Least Cost Method: Rs 443684

Estimates transportation cost using CPLEX12.4 solver: Rs 443033

Actual amount spent by Government for same quantity: Rs 2164311

4.6.2 Stage 2 Solution

Step1: The "cluster first route second" method is used to calculate all distances from depots to Distribution Center. By doing allocation of the different Mandals of Warangal District to various MLSP, the Multi-Depot Vehicle Routing Problem is converted into collection of separate and independent Single Depot Vehicle Routing Problem.

4.6.2.1 Allocation for Warangal Division

Table 4.14 Allocation results of Warangal Division

	1	2	3	4	5	6	7	8	9	10	11	12	Supply (Qtls)
1	24	16	18	28	0	8	42	40	36	5	31	42	22000
2	21	20	14	32	5	11	39	36	33	0	27	47	10000
3	50	29	45	0	28	34	48	46	64	32	28	15	10000
4	47	21	12	28	42	15	36	33	30	47	0	38	7500
D (Qtls)	2652	3040	2626	3846	10126	3056	1798	2187	2341	11683	3015	1961	

*D: Demand

This means which mandal is to be served by which mandal level service point. The result shows the assignment of MLSP's 1 to 4 to fulfill the demands of mandals is given bellow

MLSP1 is assigned to fulfill the demand of Mandal 1,2,5,6,10

MLSP2 is assigned to fulfill the demand of Mandal 10

MLSP3 is assigned to fulfill the demand of Mandal 7,8,12

Similarly we can conclude all the results of allocation for different Divisions.

4.6.2.2 Allocation for Jangaon Division

Table 4.15 Allocation results of Jangaon Division

	13	14	15	16	17	18	19	20	21	22	Supply (Qtls)
5	19	37	35	0	58	12	55	32	36	12	15000
6	71	89	27	58	0	49	106	76	20	67	6000
7	18	0	67	37	89	43	19	27	68	45	7500
D (Qtls)	1917	2906	1820	3360	2092	1708	1740	1897	2512	2245	

4.6.2.3 Allocation for Mahabubabad Division

Table 4.16 Allocation results of Mahabubabad Division

	23	24	25	26	27	28	29	30	31	Supply (Qtls)
8	30	25	12	0	34	51	49	22	44	10000
9	73	39	56	40	36	25	41	32	0	5000
10	61	58	24	34	0	21	64	51	35	6000
11	58	0	36	25	59	49	20	8	40	5000
D (Qtls)	2172	2645	2798	3934	3472	2634	1995	2516	3058	

4.6.2.4 Allocation for Mulugu Division

Table 4.17 Allocation results of Mulugu Division

	32	33	34	35	36	37	38	39	40	41	42	43	44	Supply (Qtls)
12	42	63	60	78	21	72	48	0	47	23	33	43	78	70000
13	35	27	106	62	68	118	33	46	0	11	12	89	124	80000
14	31	0	103	86	65	116	58	63	27	18	36	87	121	25000
15	92	103	0	137	39	18	107	60	106	82	92	18	19	50000
16	53	26	125	82	86	137	60	107	39	42	50	108	142	10000
D (Qtls)	2395	2502	1582	1461	1368	1698	1764	2354	3215	2639	1869	912	1679	

4.6.2.5 Allocation for Narsampet division

Table 4.18 Allocation results of Narsampet Division

	45	46	47	48	49	50	51	Supply (Qtls)
17	7	15	21	6	20	15	0	10000
18	27	35	15	26	0	35	20	5000
D (Qtls)	2311	1916	2411	1415	1640	1693	2643	

Narsampet is the MLSP number 17 as shown in the above table, the data for MLSP 17 i.e. detail of all FPS, name of villages, distance from MLSP and there intermediate distances is collected. MLSP 17 will serve all FSP's in Mandals 45,46,48,50,51.

Demand at Narsampet MLSP is the summation of demands of mandals 45,46,48,50,51.

4.19 Particulars of Mandals under Narsampet MLSP

M.No	Name of the Mandal	Total BPL Cards	Annapurna (AAP)		Anthyodaya (YAP)		White Cards (WAP)							Total (In Qtls)
			Cards	Rice Quota (In Qtls)	Cards	Rice Quota (In Qtls)	1M	2M	3M	4M	5M and more	Total White Cards	Rice Quota (In Qtls)	
45	Chennaraopet	15559	50	5.00	1194	417.90	1184	2975	2976	4723	2457	14315	1888	2310.46
46	Duggondi	12869	38	3.80	990	346.90	941	2456	2482	3925	2037	11841	1565	1915.66
48	Khanapur	9263	37	3.70	854	298.90	679	1644	1853	2667	1529	8372	1112	1414.16
50	Nallabelly	11395	33	3.30	921	322.35	992	2134	2106	3402	1807	10441	1367	1692.49
51	Narsampet	17020	39	3.90	1349	472.15	1077	2647	3099	5559	3250	15632	2166	2642.21
	Total	66106	197	20	5308	1858	4873	11856	12516	20276	11080	60601	8097	9975

Step2: the algorithm generated following final results by taking the parameters as given bellow for Narsampet MLSP

- Truck Average Speed = 200 m/s
- the truck loading time = 60 minutes
- truck unloading time (0-25) = 20 minutes
- truck unloading time (0-50) = 30 minutes
- truck unloading time (0-75) = 40 minutes
- truck unloading time (0-100) = 60 minutes
- Total capacity of truck = 20 (in tons)

Final Results

Least_distance_travelled = 1690 km

Total time taken = 11065 Minutes

Total time taken = 184 Hours

Thus the algorithm results the Transportation Cost for different capacity of trucks. The comparison of results are as follows. Comparison of Delivery time for different truck capacity are shown in Figure 4.11

4.6.2.5.1 Comparison of Delivery Time, Transportation Cost by Using Different Capacity of Trucks and its Numbers

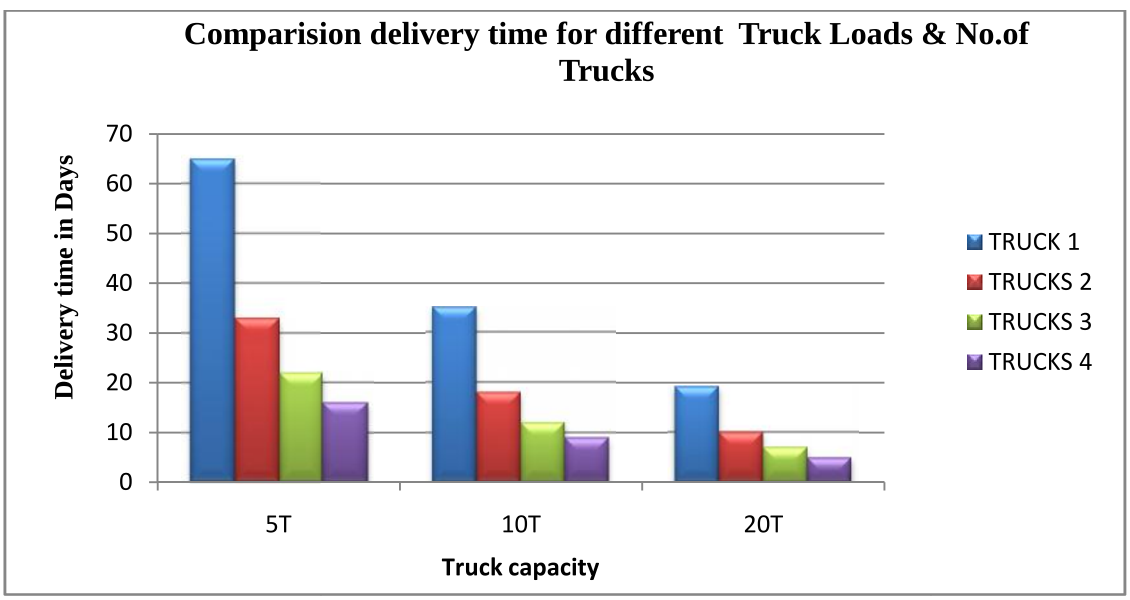


Figure 4.11 Comparison of Delivery time for different truck load.

Comparison of Transportation Cost using Different type of trucks are shown in Figure 4.12

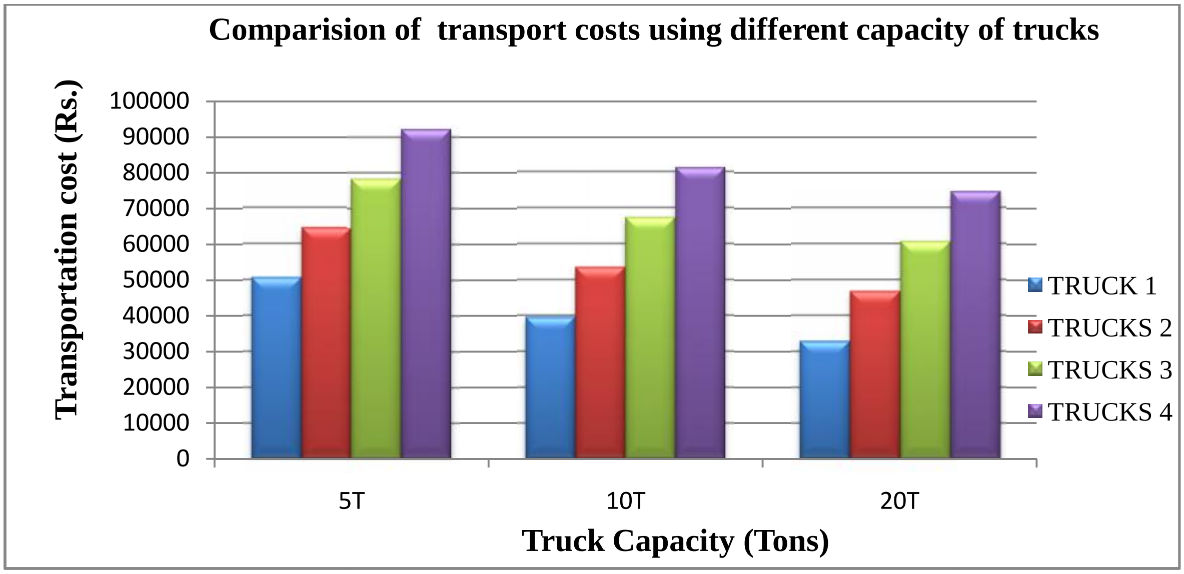


Figure 4.12 Comparison of Transportation Cost using Different type of trucks

Statement of Different costs for different number of trucks with different truck capacities are shown in Table 4.20

Table 4.20 Statement of Different cost (in Rs.) for different no. of trucks

Truck Capacity	Truck 1	Trucks 2	Trucks 3	Trucks 4
5T	50503	64378	78253	92128
10T	39530	53405	67280	81155
20T	32825	46700	60575	74450

As per the data the amount paid by Government is @ Rs. 6.5 per Quintal. Quantity of Material moved is 9978 qtls. Hence the expenditure will be Rs. 64857.

So, if we use 20 ton truck then the Minimum no. of trucks required to ship the goods in given time window = 2, then the cost will be Rs. 46700

4.6.3 Comparison of Transportation Cost under Stage 1, by the Developed Algorithm with the Government Expenditure

As per the results under Stage I transportation the cost comparision is shown in Figure 4.13

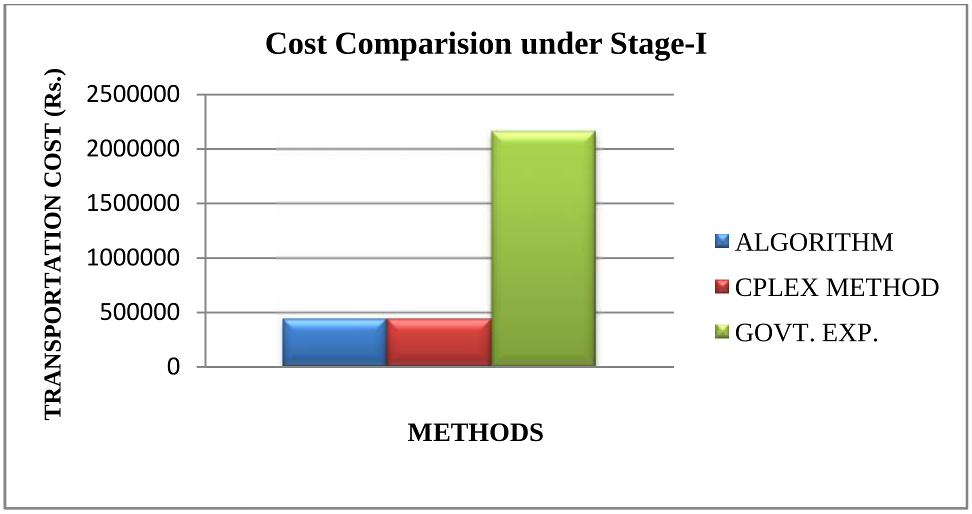


Figure 4.13 Cost Comparison under Stage I.

4.6.4 Comparison of Transportation Cost under Stage 2, by the Developed Algorithm with the Government Expenditure

As per the results under Stage II transportation the cost comparision is shown in Figure 4.14

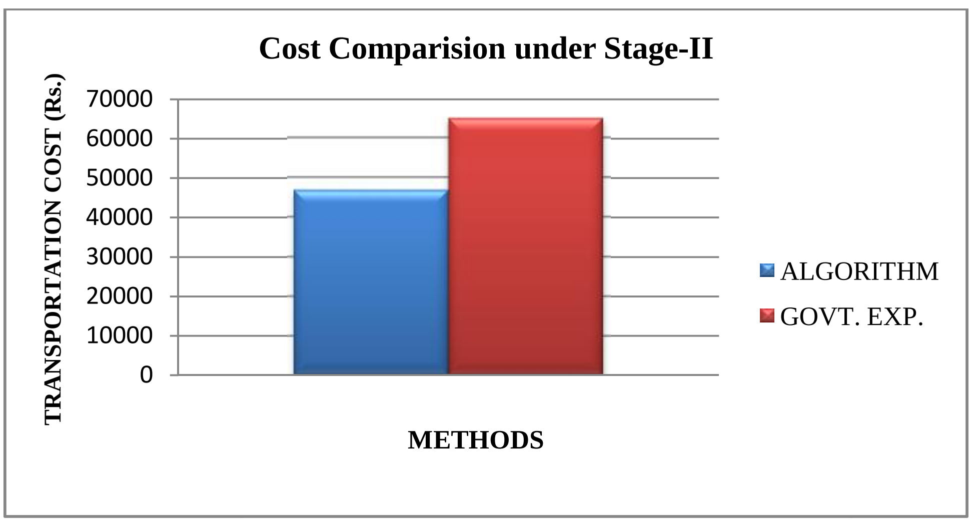


Figure 4.14 Cost Comparison under Stage II

From the Figure 4.13, it is known that Government expenditure for delivery of quantities per month under Stage–I is much more when compare to cost estimations by Algorithms developed, nearly 78% of expenditure can be saved by engaging Old Trucks instead of New Trucks as estimated by Algorithm. And Figure 4.14 shows the monthly cost estimation for transportation of quantities from one MLSP to retailers under that MLSP, the Government expenditure in Stage- II also more, at an average 28% reduction of expenditure can be ensured at each MLSP by using Algorithm under stage II. Hence the expenditure can be minimized by applying the techniques in the distribution of PDS.

4.7 Summary

A transportation model has been developed with multi depot vehicle routing planning that help managers to solve the daily vehicle routing problems for operation of PDS. The salient features of developed model are,

1) The number of vehicles used in daily delivery tasks can be effectively estimated and optimally arranged, as a result the overall cost is reduced.

2) From the developed model for PDS Warangal it is observed that in Stage I Transportation, the algorithm applied for solving the problem generated the optimum number of vehicles to be engaged from each FCI to deliver the goods to respective MLSP's in given time window. The month wise cost reduction estimated is very high compared to expenditure incurred by the Government. It is observed that 78% of earlier expenditure can be reduced under Stage I transportation.

3) From the developed model for PDS Warangal it is observed that in Stage II Transportation also the algorithm applied for solving the problem generated the optimum number of vehicles to be engaged from MLSP to deliver the goods to respective FPS'S in given time window in order to minimize the transportation cost. The month wise cost reduction is significantly high i.e. 28% can be reduced at each MLSP when compared to what is being spent now.

4) By the research study it is observed that huge amounts spent on transportation of PDS can be minimized and significant savings can be achieved by adoption of these supply chain techniques in real life problems.

Development of Cloud based PDS Model with Smart Ration Card Authentication for Accountability and Transparency

5.1 Introduction

A significant part of the challenges in the PDS system emanates from Bogus (ration cards belonging to fictitious families) and Shadow (genuine ration cards used by someone else) ration cards in the system. If the bogus cards can be substantially weeded out and a mechanism put in place to positively confirm and track the individual beneficiary off take on a monthly basis, the problems relating to PDS leakages, Transparency and Transportation would get resolved, as leakage would become more difficult to hide.

A solution that improves the quality of the beneficiary database and can track Individual Beneficiary off take coupled with a computerized Management Information System (MIS) system can effectively improve the PDS system. By leveraging some of the large e-governance initiatives that are being rolled out, the solution can be implemented swiftly and cost effectively. This chapter deals with this aspect of PDS.

5.2 Cloud computing

A strategy that has been recently designed for tracking and maintaining the information regarding the distribution system of fair price shop (FPS) through web is called 'Cloud Computing'. Cloud computing refers to the delivery of computing resources over the Internet. Instead of keeping data on our own hard drive or updating applications for our needs, we use a service over the Internet, at another location, to store our information or use its applications [56]. Once a cloud is established, how the cloud computing services are deployed in terms of business models can differ depending on the requirements. The primary service models being deployed are commonly known as:

• Software as a Service (SaaS) — Consumers purchase the ability to access and use an application or service that is hosted in the cloud. A benchmark example of this is Salesforce.com, where necessary information for the interaction between the consumer and the service is hosted as part of the service in the cloud. Office Web Apps are available to Office volume licensing customers and Office Web App subscriptions through its cloud-based Online Services.

• Platform as a Service (PaaS) — Consumers purchase access to the platforms, enabling them to deploy their own software and applications in the cloud. The operating systems and network access are not managed by the consumer, and there might be constraints as to which applications can be deployed.

• Infrastructure as a Service (IaaS) — Consumers control and manage the systems in terms of the operating systems, applications, storage, and network connectivity, but do not themselves control the cloud infrastructure [56].

Cloud manufacturing (CMfg) is a computing and service oriented manufacturing model developed from existing advanced manufacturing models (e.g. ASP, MGrid) and enterprise information technologies under the support of cloud computing, Internet of things, virtualization and service-oriented technologies, and advanced computing technologies. It aims to realize the full sharing and circulation, high utilization, and on-demand use of various manufacturing resources and capabilities by providing safe and reliable, high quality, cheap and on-demand used manufacturing services for the whole lifecycle of manufacturing. The abstract running principle for CMfg is shown in Figure. 5.1.

In a CMfg system, various manufacturing resources and abilities can be intelligently sensed and connected into the wider internet, and automatically managed and controlled using Internet of Things (IoT) technologies (e.g. radio frequency identification (RFID), wired and wireless sensor network, embedded system). Then the manufacturing resources and abilities are virtualized and encapsulated into different manufacturing cloud services (MCSs) that can be accessed, invoked, deployed, and on-demand used based on knowledge by using virtualization technologies, service-oriented technologies, and cloud computing technologies. The MCSs are classified and aggregated according to specific rules and algorithms, and different kinds of manufacturing clouds are constructed. Different users can search and invoke the qualified MCSs from a related manufacturing cloud according to their needs, and assemble them to be a virtual manufacturing environment or solution to complete their manufacturing task involved in the whole life cycle of manufacturing processes under the support of cloud computing, service-oriented technologies, and advanced computing technologies [42].

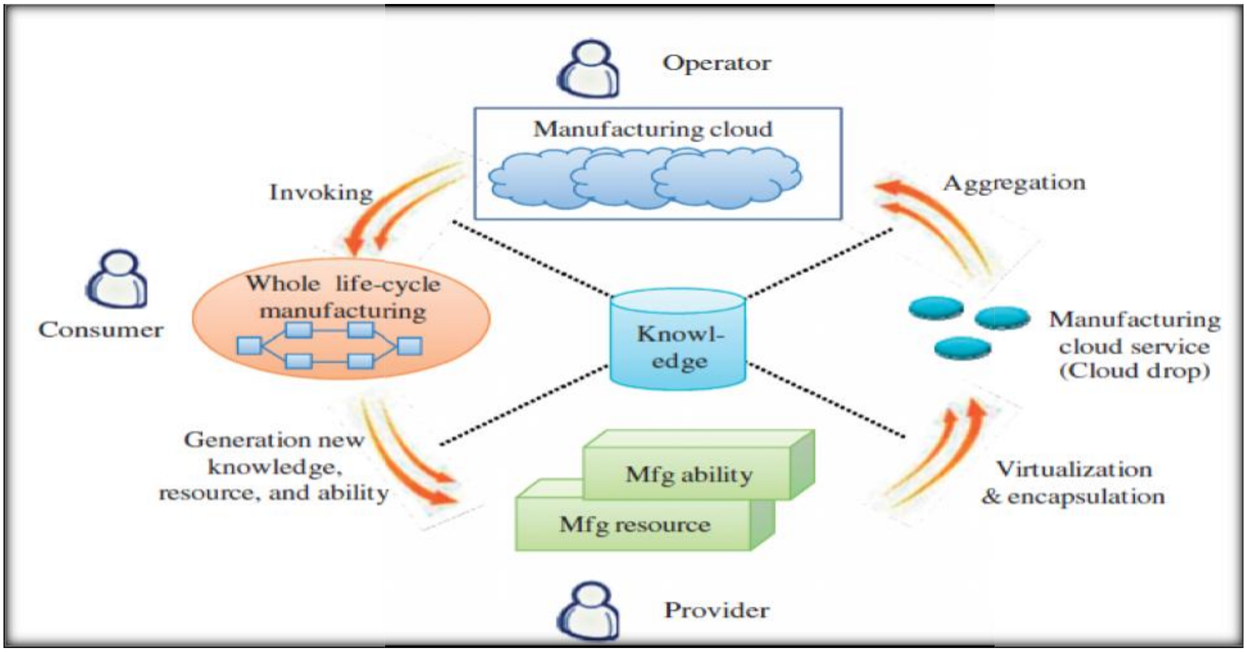


Figure 5.1: Cloud Manufacturing Structure

In October 2007, cloud computing was first introduced to the public through a cooperation between two computing companies, IBM and Google. Cloud computing as a model that allows the sharing of many computing resources as services to various clients. In this model, clients can easily change or adjust their service requirements at a very low cost. The Clouds in cloud computing include both software and hardware in data center that are usable and accessible virtualized resources. The components of cloud computing include data, information, application semantics, metadata, schema, data dictionary, data catalog, and information model. Li Bo hu [39] systematically explained the cloud manufacturing in Clouds manufacturing mixes network-based manufacturing and service technology with cloud computing, cloud security, high performance computing, Internet of Things (IoT) and other advanced technology to achieve all kinds of manufacturing resources (manufacturing hardware devices, computing systems, software, models, data, knowledge, etc.) centralized management, intelligent business, provides readily available, demand-oriented, safe, reliable, high-quality, low-cost services to various manufacturing activities for manufacturing life cycle process in context of manufacturing operations. This approach has been adopted in context of Public Distribution System (PDS).

Following the paradigm of cloud computing, we can distinguish three types of clouds agile manufacturing: public, private and hybrid. Public clouds are handled by third parties, and the work of many different clients may be mixed in the factories (virtual), servers, storage systems and other infrastructure in the cloud. End users do not know what other clients works may be carried out in the same factories, even on the same machines. In this type of cloud, the end user basically deals only edit their processes and track them.

Private clouds are a good choice for companies that need high data protection and editing at lower levels (the process) of the services offered by cloud: definition of its own services, computational resources and production, machine or, even, factories. Private clouds are in demand infrastructure managed by a single customer who controls what and where you run a process. They are owners of the factory, of IT and can decide which users are allowed to use the infrastructure [42].

Hybrid clouds combine the models of public and private clouds. Every customer is a part owner and shares another, albeit in a controlled manner. Hybrid clouds may be the key to achieving an external supply in scale form and under demand, but these clouds add the complexity of determining how to allocate tasks and processes across these different environments. Companies may feel some attraction to the promise of a hybrid cloud, but this option, at least initially, will probably be reserved for simple applications without conditions, which do not require any synchronization or not require highly specialized or expensive equipment.

The advantages of cloud computing are described below:

- Achieve economies of scale – increase volume output or productivity with fewer people. The cost per unit, project or product plummets.

- Reduce spending on technology infrastructure. Maintain easy access to the information with minimal upfront spending. Pay as (weekly, quarterly or yearly), based on demand.
- Globalize our workforce on the chip. People worldwide can access the cloud, provided they have an Internet connection.
- Streamline processes. Get more work done in less time with less people.
- Reduce capital costs. There's no need to spend big money on hardware, software or licensing fees.
- Improve accessibility. One can have access anytime, anywhere, making life so much easier!
- Monitor projects more effectively. Stay within budget and ahead of completion cycle times.
- Less personnel training is needed. It takes fewer people to do more work on a cloud, with a minimal learning curve on hardware and software issues.

5.3 Radio Frequency Identification (RFID)

RFID (radio frequency identification) is a technology that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to uniquely identify an object, animal, or person. An RFID system consists of three components: an antenna and transceiver (often combined into one reader) and a transponder (the tag) as shown in Figure 5.2. The antenna uses radio frequency waves to transmit a signal that activates the transponder. When activated, the tag transmits data back to the antenna [45]. The data is used to notify a programmable logic controller that an action should occur. The action could be as simple as raising an access gate or as complicated as interfacing with a database to carry out a monetary transaction.

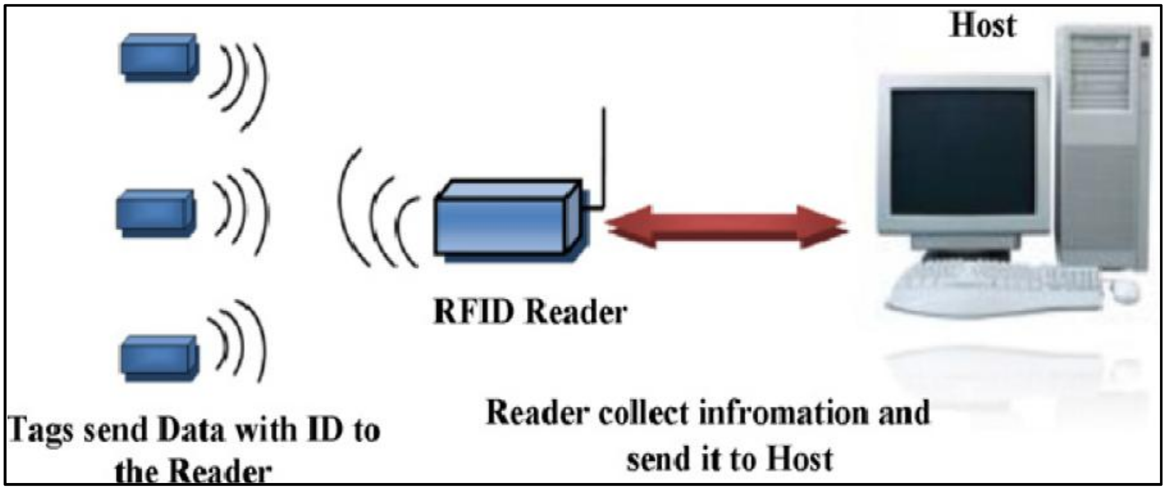


Figure. 5.2: RFID System Components

Many types of RFID exist, but at the highest level, we can divide RFID devices into two classes: active and passive. Active tags require a power source—they are either connected to a powered infrastructure or use energy stored in an integrated battery. In the latter case, a tag's lifetime is limited by the stored energy, balanced against the number of read operations the device must undergo. One example of an active tag is the transponder attached to an aircraft that identifies its national origin. Another example is a LoJack device attached to a car, which incorporates cellular technology and a GPS to locate the car if stolen. However, batteries make the cost, size, and lifetime of active tags impractical for the retail trade. Passive RFID is of interest because the tags don't require batteries or maintenance. The tags also have an indefinite operational life and are small enough to fit into a practical adhesive label.

5.3.1 Working principle of RFID

Faraday's principle of magnetic induction is the basis of near-field coupling between a reader and tag. A reader passes a large alternating current through a reading coil, resulting in an alternating magnetic field in its locality. If a tag is placed that incorporates a smaller coil in this field, an alternating voltage will appear across it. If this voltage is rectified and coupled to a capacitor, a reservoir of charge accumulates, which one can then use to power the tag chip. Tags that use near-field coupling send data back to the reader using load modulation.

Because any current drawn from the tag coil will give rise to its own small magnetic field—which will oppose the reader's field—the reader coil can detect his as a small increase in current flowing through it. This current is proportional to the load applied to the tag's coil (hence load modulation). This is the same principle used in power transformers found in most homes today although usually a transformer's primary and secondary coil are wound closely together to ensure efficient power transfer. However, as the magnetic field extends beyond the primary coil, a secondary coil can still acquire some of the energy at a distance, similar to a reader and a tag. Thus, if the tag's electronics applies a load to its own antenna coil and varies it over time, a signal can be encoded as tiny variations in the magnetic field strength representing the tag's ID. The reader can then recover this signal by monitoring the change in current through the reader coil. A variety of modulation encodings are possible depending on the number of ID bits required, the data transfer rate, and additional redundancy bits placed in the code to remove errors resulting from noise in the communication channel.

Near-field coupling is the most straightforward approach for implementing a passive RFID system. This is why it was the first approach taken and has resulted in many subsequent standards, such as ISO 15693 and 14443 and a variety of proprietary solutions. The range for which we can use magnetic induction approximates to $c/2\pi f$, where c is a constant (the speed of light) and f is the frequency. Thus, as the frequency of operation increases, the distance over which near-field coupling can operate decreases. A limitation is the energy available for induction as a function of distance from the reader coil. The magnetic field drops off at a factor of $1/r3$, where r is the separation of the tag and reader, along a centerline perpendicular to the coil's plane [45]. A schematic diagram of Near Field RFID communication is shown in Figure 5.3.

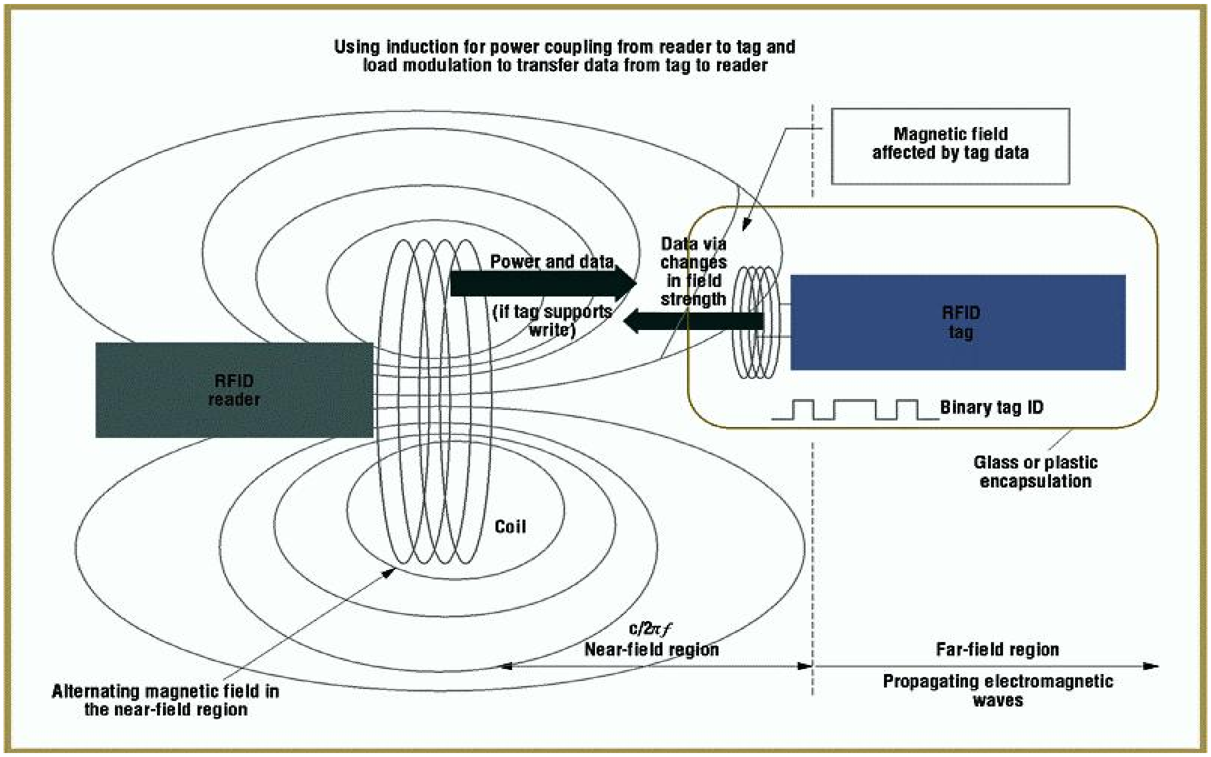


Figure.5.3: Near-field communication (NFC) mechanism for RFID tags.

5.3.1.1 Advantages of NFC

- Near Field Communication provides secure communication to all users. It promotes the transfer of data through safe channels as well as the encryption of sensitive information. Although some risk still exists, these measures significantly reduce the threat of hackers and stolen information.

- The close proximity needed for NFC to function is not just a technical advantage; it proves to be very useful when in crowded locations. The two inch range allows for less interference which in turn provides a smooth data sharing feed between devices.

- NFC provides the technology that permits users to transfer files and perform transactions with ease. It allows individuals to share data cost efficiently as it has the ability to transfer files like pictures or music without carrier charges. NFC also lets users purchase items wirelessly. The introduction of Passbook on the iPhone and Google Wallet allows individuals to store all their credit card, coupon, and ticket information on their smart phone device for use at any given time.

- NFC has a competitive advantage over its rival, Bluetooth. It consumes less power and does not require the setup and connection establishment with another device like Bluetooth does.NFC allows users to connect to other devices in less than one second, whereas, Bluetooth connections take significantly longer time.

- As a business user, NFC provides many advantages for improving workplace efficiency and customer service. It allows managers to maintain knowledge as to where their employees are if one were to use location services. In regards to improving customer service, the implementation of NFC transactional services such as, Pay Pass or Passbook, enables a fast and efficient experience for consumers [45].

5.3.1.2 Disadvantages of NFC

- Since Near Field Communication is a relatively new technology, it may not be compatible with other devices. This is the main challenge that NFC technology is facing because device compatibility is a key aspect to expanding its consumer base.

- Many companies do not have the motive to implement NFC technology into the workplace as the technology they currently use may be all they need to perform efficiently. Transferring employees over to NFC compatible devices is costly and may not align with the goals of the organization.

5.4 Smart Card Authentication

For security professionals one of the major objectives is to ensure that a person accessing a resource has the authority to do so. In order for users to access a resource it must be determined whether this individual is whom they claim, whether they have the necessary credentials, and whether they have been given the necessary rights and privileges to perform the actions requested for. Most organizations user authentication is accomplished through a combination of username and password. Passwords are the foundation on which much of information security is built and an enterprise's first line of defense against unauthorized access. Smart cards can provide added security to help bolster that defense.

Identification is one of the important uses of the smart card technology. It is the motivation behind its development. Identifying a user can be accomplished in three ways; "something you know", "something you possess", or "something you are". Combining at least two of these methods is considered to be strong authentication. The use of smart cards can offer an added layer of security by combining these methods to provide multi-factor authentication.
The term "smart card" has been used to describe a class of credit card sized devices with varying capabilities: contact cards, proximity cards, stored value cards, and Integrated Circuit Cards (ICC) [63].

5.5 Smart Card

Plastic ID cards are used extensively for identification and authentication purposes in various applications such as driving licenses, Bank ATM card, Credit card, Club membership card, and in various Academic and commercial organizations as well. Some of these cards contain a magnetic-stripe to make it machine readable. However these cards are not secure enough and given the right kind of equipment, the information on these cards can be modified easily. Smart card is the youngest and cleverest one in the family of identification cards. Smart card is one of the latest additions to the world of information technology (IT). The size is that of a credit card; it has an embedded silicon chip that enables it to store data and communicate via a reader with a workstation or network. The chip also contains advanced security features that protect the card's data. With an embedded microcontroller, smart cards have the unique ability to secure the large amount of data, carry out their own on-card function and interact intelligently with a smart card reader.

5.5.1 Types of Smart Card

- **Contact**: A contact card has an embedded integrated circuit and an electronic "contact" module. This module makes a physical connection to a smart card reader in order for a system to receive power and transfer information. Most commonly these types of cards follow the ISO 7816 standard for communication between the card and it's reader. Smart card readers are available in a variety of form-factors and can be connected to a computer using an RS-232, PCMCIA or USB interface [63].

- **Proximity (contactless):** A proximity smart card receives its power from a radio frequency transmitter. It has an antenna coil embedded inside that communicates with an external receiving antenna. These cards conform to the ISO 14443 communication standard. They are known as "contactless" cards because the reader and card do not need to make direct contact but must be in the same proximity to work, generally about 10cm.
- **Stored Value:** A stored value card has an EEPROM (Electrically Erasable Programmable Read-Only Memory) chip for storage. These cards tend to be the least expensive and are generally used when the data stored rarely changes.
- **Integrated Circuit:** Integrated Circuit Cards (ICC) have an embedded microchip that is a combination of a microprocessor and an EEPROM memory chip. These cards also tend to be contact type cards due to the power requirements of the processor.

All of these cards differ in functionality from each other and from the more familiar magnetic stripe cards used by standard credit, debit, and ATM cards. Smart cards can store several hundred times more data than the conventional magnetic stripe card.

5.6 Problem Statement

In this research it is proposed to develop and implement a cloud based supply chain for Public Distribution System for Warangal district of Telangana state to ensure transparency, minimize leakages and prevent the diversion of commodities in distribution. Further feasibility of web based supply chain for variety of input data can be checked. It is also proposed to develop methodology for application of smart card technology using RFID for authentication of beneficiaries so as to eliminate the bogus ration cards.

5.7 Objectives

The main objective of this research work is to create transparency in operations so that every citizen can very easily know what is happening and what is supposed to happen. Transparency is the basic requirement to check corruption. Without providing adequate transparency no controls or inspections can reduce corruption. Transparency will be created by computerizing all operations and providing all information on the web.

The objectives are;

1. Design and develop a web portal for Warangal PDS supply chain by using PHP as front end and MySQL as back end.
2. Development of Smart Ration Card with RFID technology for authentication of beneficiary by using MYSQL and Java.
3. Development of Fair Price Shop automation with RFID technology by using MYSQL and Java programming.

5.8 Methodology

5.8.1: Different modules of cloud based supply chain

The step by step processes of making cloud based PDS can be seen in the Flowchart given in Figure 5 .4 Steps are as follows:

- Preparation of master data of District
- Creation of a Beneficiary Database
- Public District Portal
- Ration card digitization
- Smart ration card
- Fair price shop automation
- Integration of POS device with district zonal office.
- Allocation details of food grains

- Security and privacy issues of the portal
- Grievance redressal mechanism

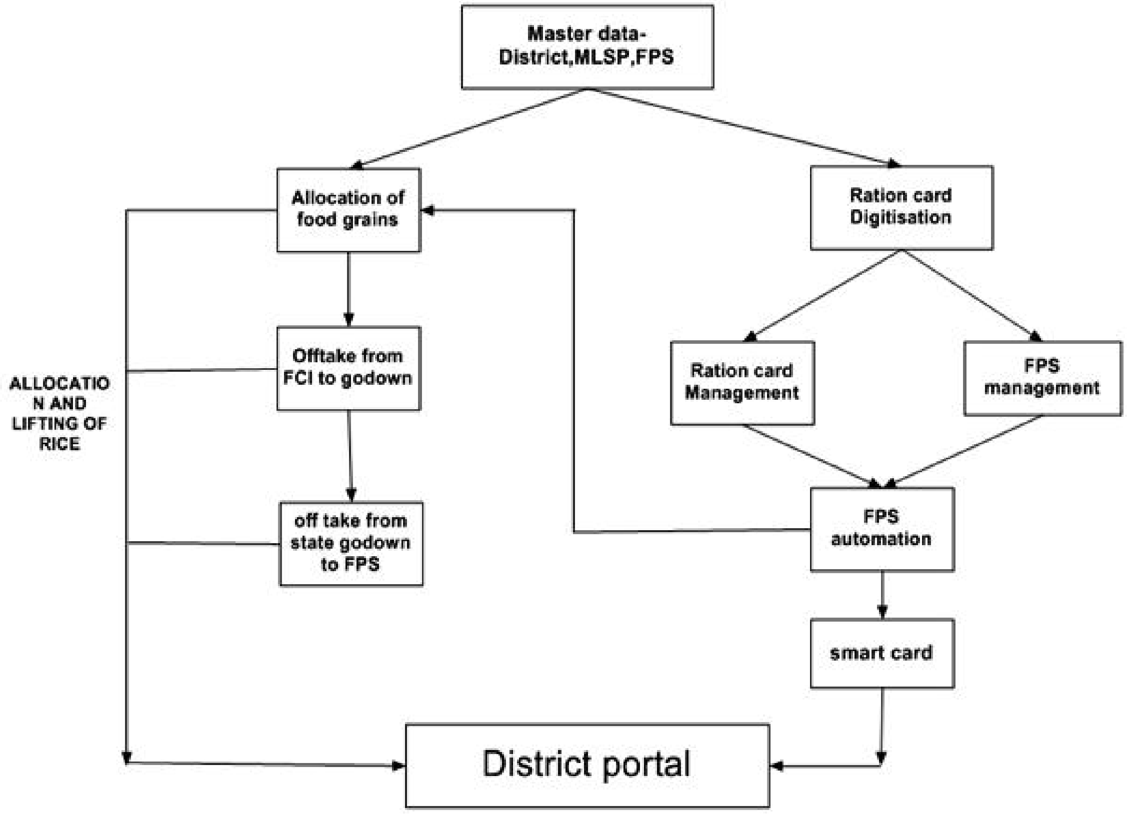


Figure 5.4 Different modules of cloud based supply chain

The explanation of the each step as given in the Flowchart is furnished below. These details will help in making the public distribution system in Warangal corruption free to some extent.

5.8.2. Creation of a Beneficiary Database

The beneficiary database is digitized and any offline data on register or manual file is fed into excel file which further is fed into central district ration card database. As of now, the beneficiary database is manually stored and ration records are kept manually. So, the digitization of database helps in eliminating the bogus ration cards. So the MS excel file of the ration card if available is fed into the structured query language database.

Table 5.1 Ration card details of Fair price shop in Atmakur mandal

S. No	Card No.	Name of the CardHolder	Family size	Shop No.	village
1	WAP213700100003	Dameruppala Jayamma	5	ATM01	Atmakur
2	WAP213700100004	Thati Konda Batukamma	1	ATM01	Atmakur
3	WAP213700100006	Devaruppula Veeraswamy	6	ATM01	Atmakur
-	- - - - - - - - - - - - - -	- - - - - - - - - - - - - - - -	- -	- -	- - - - - -
_	- - - - - - - - - - - - - -	- - - - - - - - - - - - - - - -	- -	- -	- - - - - -
6	WAP213700100014	Sadiram Ravinder	2	ATM01	Atmakur

Such data is displayed on public portal where user can verify the details about him by searching his or her name or card number if he knows it. The data can be seen in the Table 5.1.

5.8.3. Preparation of master data of District

First of all the data regarding the stake holders, Mandal level service points, Ration card, Wholesalers, FPS dealer is collected. Several master files are created. This will help in having all the data in structured manner and can be accessed (privately and publicly) anytime. Figure 5.5 shows a sample structure of district level master data. Further it will help the district to maintain central repository of all PDS stakeholders which can further be used by other applications.

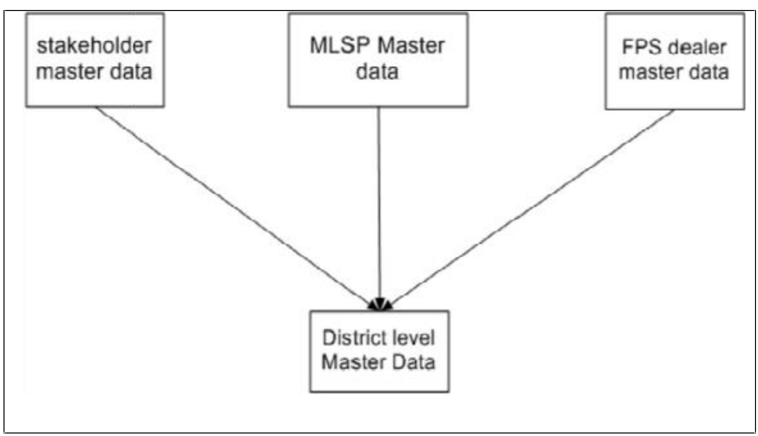


Figure 5.5 Integration of various data into single master data

Table 5.2 Allocation details of MLSP

Sl. No.	MLSP Name	Corresponding FCI warehouse	Capacity (Qtls)	Monthly allocation (Qtls)
1	CSC Hanamkonda	CWC Warangal, FCI Kazipet	22000	16222
2	DCMS Warangal	CWC Warangal	20000	14334
- -	- - - - - - - - - -	- - - - - - - - - - - - - -	- -	- -
- -	- - - - - - - - - -	- - - - - - - - - - - - - -	- -	- -
18	Kesamudram	SWC Dharmaram	5000	3054

Table 5.3 FCI Warehouse data

S. No.	FCI Warehouse Name	Capacity (ton)
1	FCI Kazipet	88340
2	CWC Ennumala	8500
-	-	-
7	CWC Warangal	2500

Table 5.4 Mandal wise allocation data

S.No	Mandal Name	MLSP name	allotted Qty. (Qtls)
1	Atmakur	CSC Hanamkonda	2652
2	Geesugonda	Ghanpur station	2626
-	-	-	-
-	-	-	-
18	Lingala ghanpur	Kodakanndla	1708
19	Maddur	Cherial	1740

Table 5.5 Fair Price Shop data

S. No.	Shop No	Mandal Name	Annapurna (AAP)	Athyodaya (AYP)	White (WAP) Cards	TotalBPL Cards	Allotted Rice (Kg)
1	ATM001	Atmakur	0	63	544	607	8961
2	ATM002	Atmakur	3	55	534	592	9083
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
14	ATM014	Atmakur	3	50	464	517	8268
15	ATM015	Atmakur	0	39	489	528	7961

For preparing the district level master data it is required to gather data from all the sources of the supply chain of PDS. Table 5.2, 5.3, 5.4 and 5.5 shows the various data collected which gives the details of MLSP, FCI, mandals and FPS respectively. These all are clubbed into one master file with proper sequencing and keys so that it can be accessed with ease by the administrator.

5.9 Public District Portal

There is a need for a single unified information system i.e. District PDS portal for achieving total transparency in Public Distribution System (PDS) by ensuring all information pertaining to the PDS is made available in the public domain. The portal shall be used to display information related to FPS wise digitized database of ration cards, entitlement of beneficiaries, stock position at go-downs, lifting of food grains, stock availability at FPS, movement and date of stock/ quantity supplied to FPS every month for all the shops, etc. The portal also enables a beneficiary or citizen to log his/her complaints, contact details of Food and Civil Supplies officers in the vicinity, etc. Under the portal certain information will be static in nature (circulars, document, etc.) that is displayed as Static page. The home page of the portal is shown in Figure 5.6

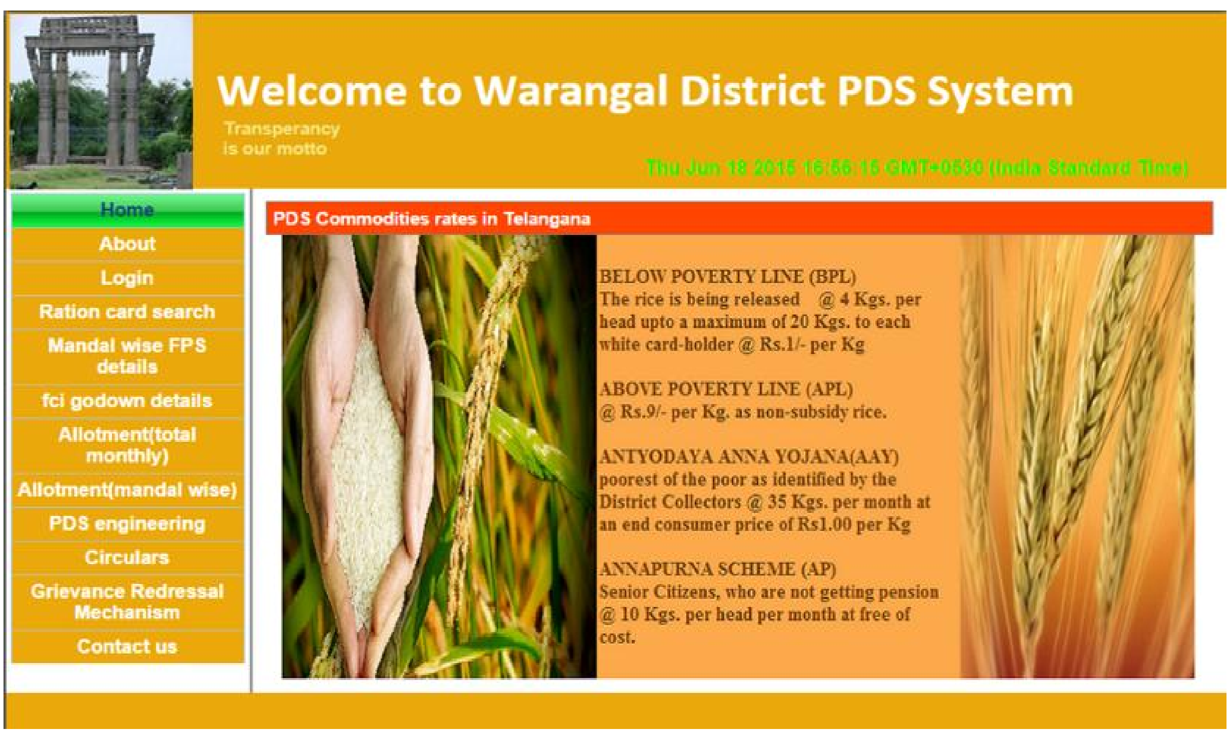


Figure 5.6 District Public Portal (Screen shot)

The details of module developed for Warangal district PDS portal is furnished in Flowchart as shown in Figure 5.7

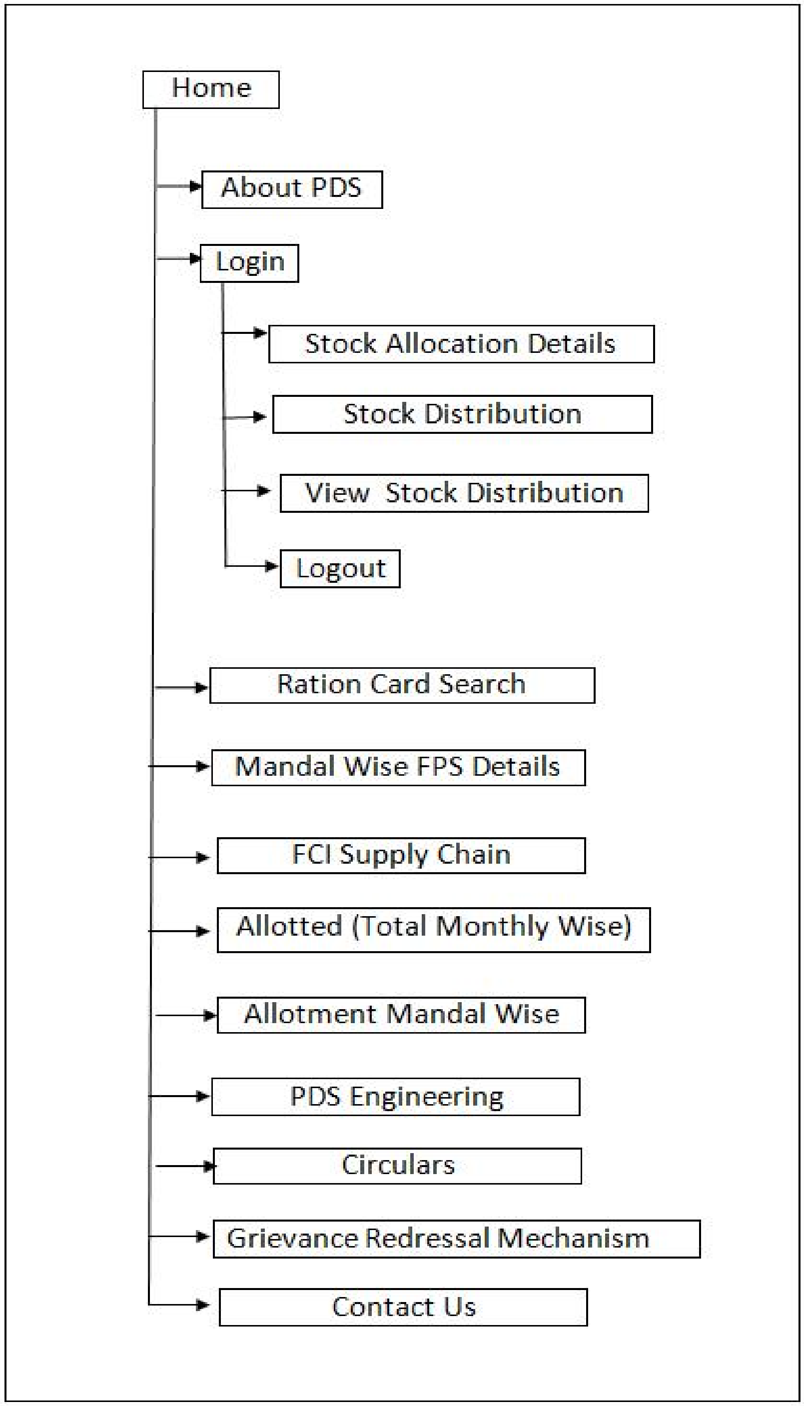


Figure 5.7 Flowchart of Modules Developed for Web based PDS

For sake of Administrators a module Login is created, through which an Administrator can allot quantities to FPSs wise versa to MLSP. The Flowchart for Stock Allocation Module is furnished in Figure 5.8

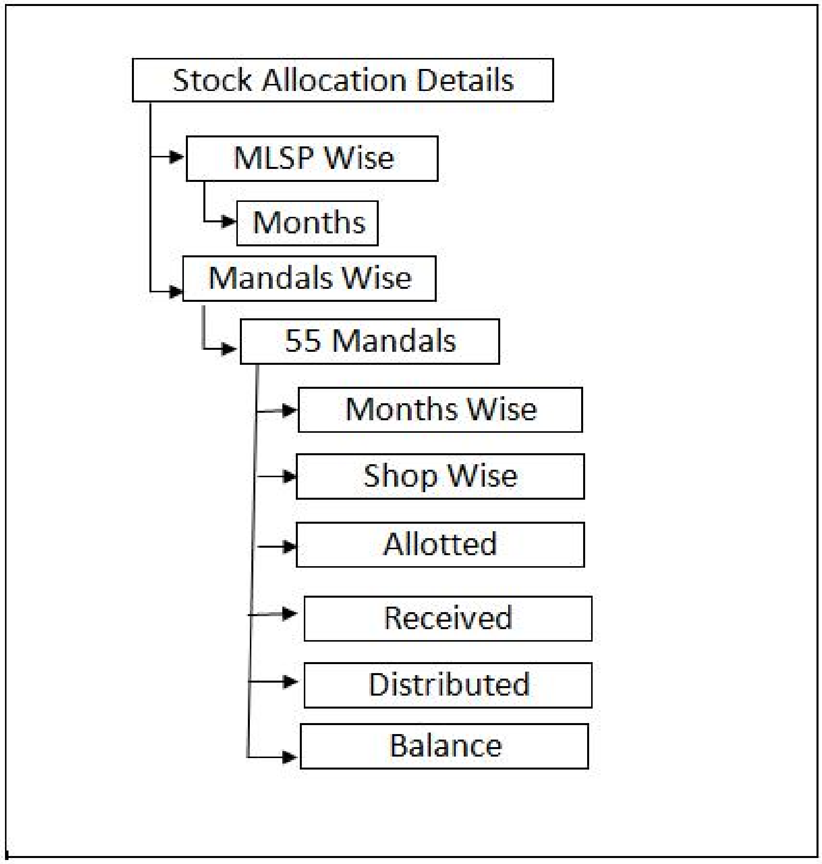


Figure 5.8 Flowchart of Stock Allocation Module

The Administrator can also mention quantities to be distributed as per the demands and previous stock positions of Fair Price Shops by login to the web portal. The module developed for this activity is shown in Figure 5.9

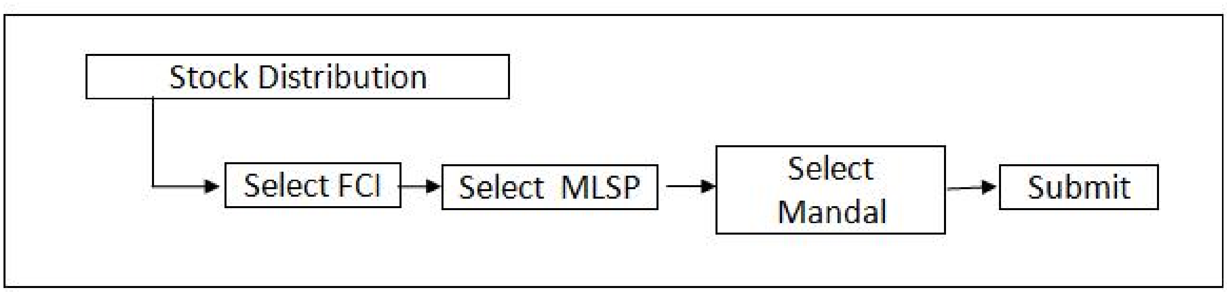


Figure 5.9 Flowchart of Stock Distribution Module

Administrator can also view the status of stock distributions MLSP wise and Mandal Wise as on date of current month by login into web portal. The module is created as shown in Figure 5.10

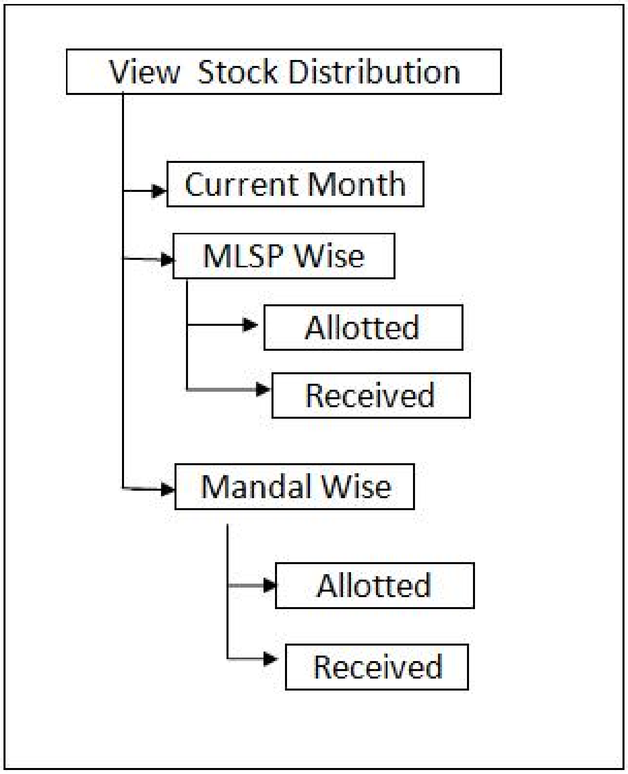


Figure 5.10 Flowchart of View Stock Distribution Module

List of the information which is provided in this portal are as follows:

- Hierarchy of departments/offices, Officer's name, designation, contact number and their roles & responsibility
- List of beneficiaries, FPS, godowns, etc.
- Details of monthly allocation, lifting and distribution under TPDS schemes.
- Gazette notifications, circulars and proceedings Information regarding Public Awareness including ration card application forms, etc.
- Acts & Rules (Consumer Protection Act, Essential Commodities Act, etc.)
- SMS alerts Registration facility for beneficiaries, individuals, etc.
- Details of Officer in-charge of Grievance Cell along with contact and email details.
- Ration Card related information.

- Details of State schemes & Allocation Policy.
- Rate and eligible quantity of commodity distributed under various schemes.
- Information related to FPS allotment, inspection, cancellation, suspension, revocation, tc. etc.
- Retailing dates and rules of essential commodity at FPS.
- Dates of Allocation, Lifting and Distribution.
- MIS reports.
- Details of District Food Supply Officer (DFSO).
- Summary Report of Godowns/Warehouses.
- Summary Report of Fair Price Shop.
- Ration Card Report.
- District-wise Ration Card Count– BPL, AAY & APL.
- Mandal wise Ration Card Count – BPL, AAY & APL.
- FPS-wise Ration Card Count – BPL, AAY & APL.
- Details of Ration Card – BPL, AAY & APL.
- Allocation Details.
- Capacity and stock position of Godowns.
- From FCI Godowns to State Godowns – quantity, release order, etc.
- District-wise issuance of food grains (BPL, AAY & APL) – monthly
- Monthly report Issuance of food grains (BPL, AAY & APL) – monthly
- Statistical Reports.

We can see all the details individually in detail and also tries to understand how it will help in streamlining the supply chain of PDS in Warangal district.

5.10 Ration Card Digitization

Ration card data is fed into the central district database. The database is included with all the details of individual beneficiary. The various information stored in the database are like- name of the beneficiary, Adhaar card number, family size, shop number, village, mandal, card type, district etc.. The steps to find beneficiary details is shown in Figure 5.11

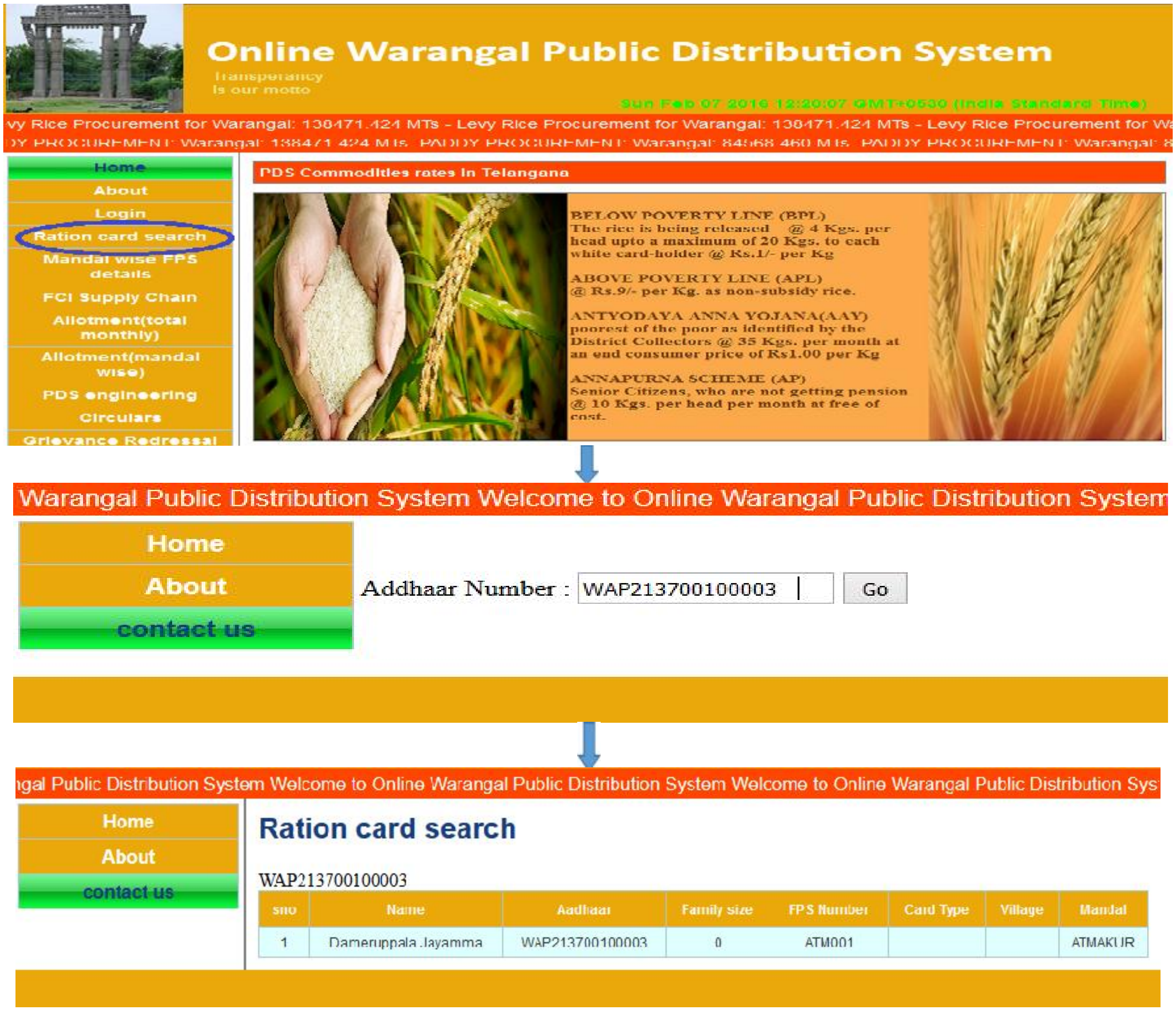


Figure 5.11 Steps for Ration card search (Screen Shot)

5.11 Smart Ration Card

Smart Cards are secure electronic devices which are used for storing date pertaining to the beneficiary, in a secure form. It is pertinent to note the only authorized persons can view the date stored on the card and/or write information thereon.

The smart cards are compliant with the unique ID (UID) project called Aadhaar. When a smart card is used In PDS, the following data can be stored on the card:

1. The name of the Beneficiary, family members.
2. The address of the beneficiary.
3. Unique Aadhar number.
4. The category in which the beneficiary falls (i.e. APL, BPL, Antodaya) and the monthly entitlement.

A smart card resembles a debit card in size and shape. Integrated circuits/microprocessor are embedded in these cards to enable them to process data. These cards can receive inputs, which are processed — by way of the Integrated Circuit Card applications — and deliver an output. The card can be embedded with a hologram to avoid counterfeiting. The microchip will store all information and help government track utilization. Card-holder can buy from an approved private grocer through the smart card transaction. The application of Smart ration Card will eliminate intermediaries, lower pilferage, thus help reduce food subsidy. At all Fair Price Shops, a Smart Transaction Terminal (STT) will be used to access the smart for consumer authentication and transaction. Every beneficiary will have smart- Aadhaar enabled ration card as shown in Figure 5.12.

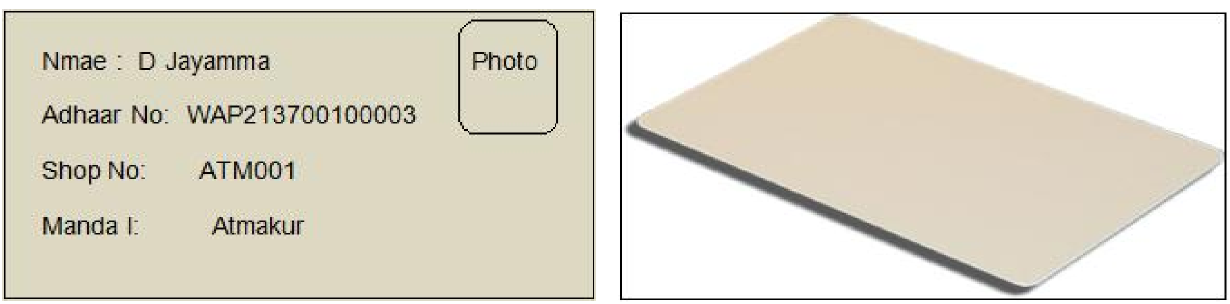


Figure 5.12 Smart ration card

5.12 Registration of Ration Card

For registering the Smart Ration Card, the beneficiaries are required to go to the concerned office with the old ration card, AADHAR card, and all other required documents, where the concerned authority will register the card by entering the details. The step by step procedure is described as follows:

1. When the module will start a home page will appear as shown in Figure 5.13. In the home page there will be buttons like check key, change key, issue card, Read details, Edit details, distribution etc.

Figure 5.13 Home Screen for Smart Card registration (Snap shot)

2. Click on ‘ Issue Card ’ button it displays the Registration format as shown in Figure 5.14 The registration involves entering the detailed information of the beneficiary in different fields.

Figure 5.14 Registration Form

3. After entering the particulars of beneficiary in different fields of registration form, it can be saved in smartcard by clicking the submit button. Thus Registration of Ration Card will be completed.
4. Each card will have a default password which has to be accessed by respective Fair Price Shops. The 'Check key' button will accepts if the beneficiary belongs to the respective Fair Price Shop.
5. The 'Change Key' button is used to change the password of a smart card.

5.12.1 Verification of Smart Ration Card

The smart card and the reader looks like as shown in Figure 5.15. The next step is to put the smart card on the reader. For checking the key it is required to click on the check key button and have to wait for some time until a small window is appeared. Pressing OK button after giving a twelve digit password in the field provided will result in a message window showing key success as shown in the Figure 5.16 if Smart Ration Card is allotted to respective Fair Price Shop.

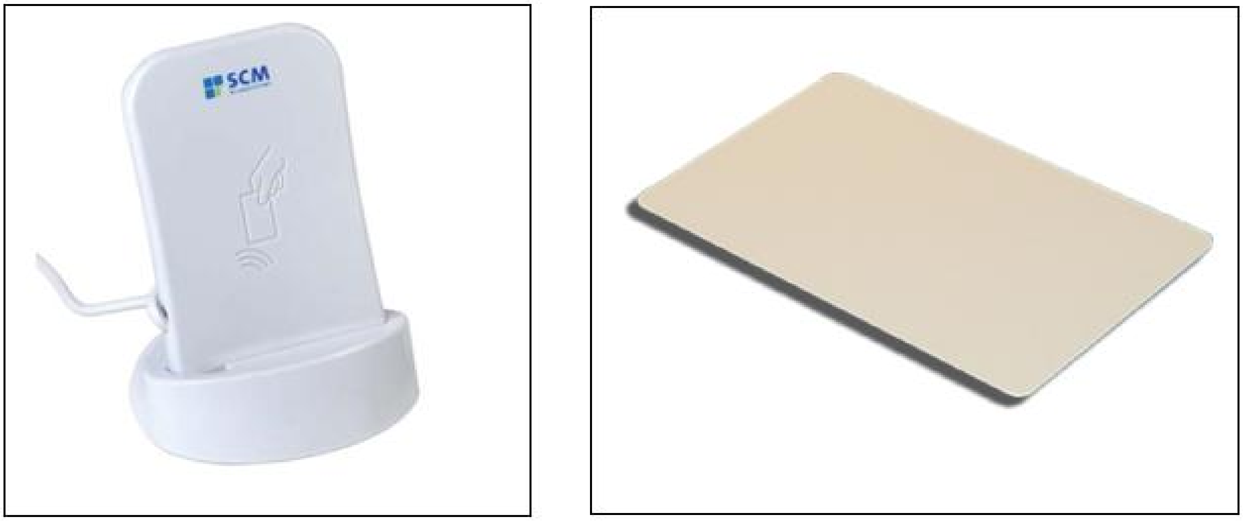


Figure 5.15 Smart Card and Reader

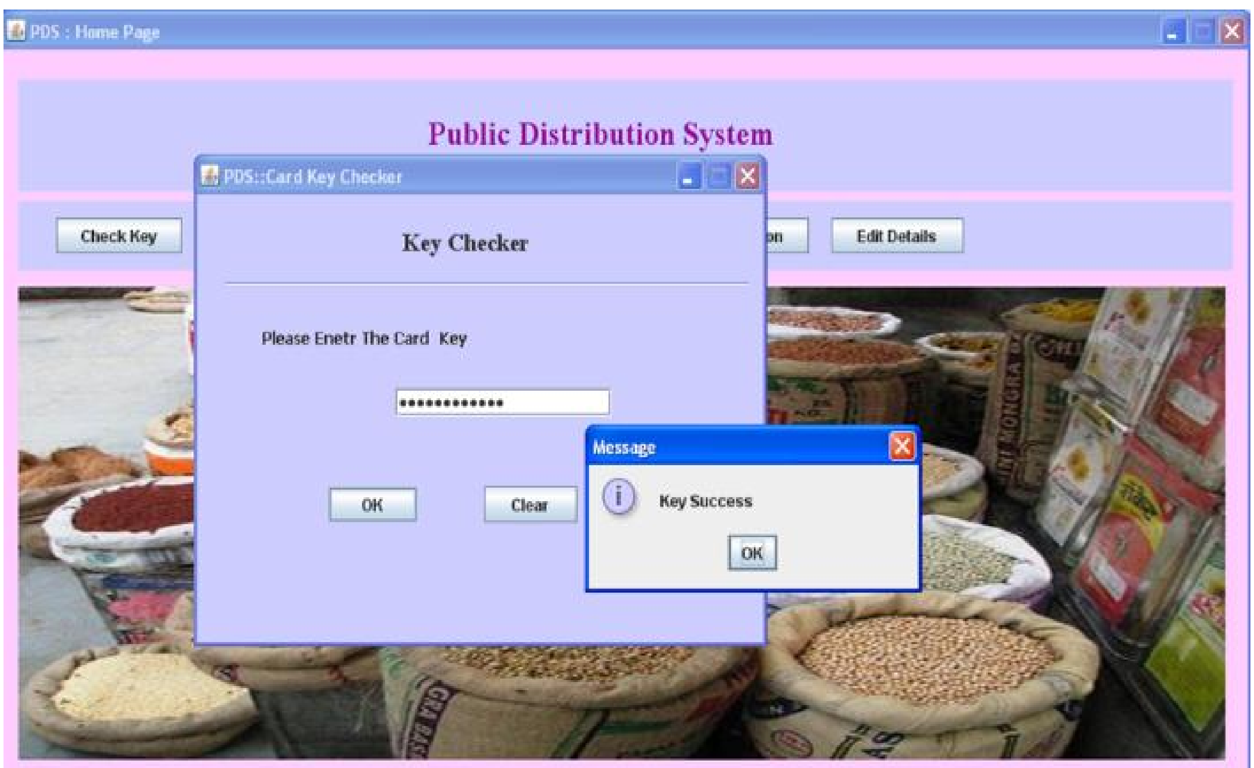


Figure 5.16 Smart Card Key check

The pass key can be changed by just clicking on the change key option and then filling the required field. On pressing ok button the new key will be saved.

5.13 Fair Price Shop Automation

Till now in most of the places the fair price shop are working on register based entry basis. Such practices only increase the leakages in the PDS system. To reduce this, automated retail software-cum hardware is proposed keeping in mind the constraint of PDS system. Such devices are called Point of sale device. The Point of Sale device is run through Java programming. The sequence of programming for use of Admin and for FPS is furnished in flowchart as detailed in Figure 5.17

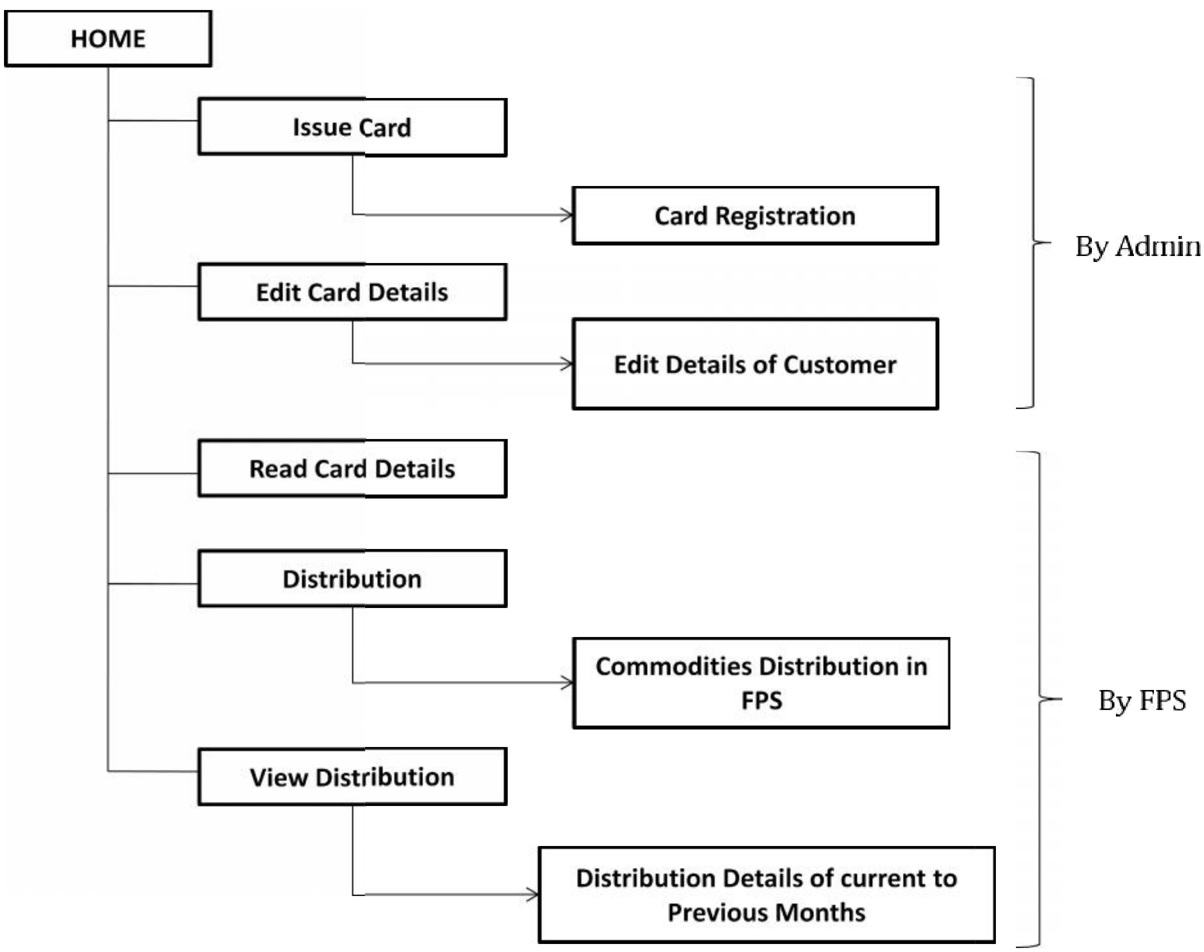


Figure 5.17 Flowchart of activities for FPS automation

5.13.1. Point of Sale Device (PoS)

A POS device is a integrated machine having memory to store transaction data over a period of time. There are mainly two objectives of using this device, the first one is to identify the beneficiary of the corresponding shop and the other one is to track off-take of commodities by beneficiaries with precision and to thereby eliminate avenues for diversion of stock. The activities to be performed in FPS are as shown in the following flow chart Figure 5.18.

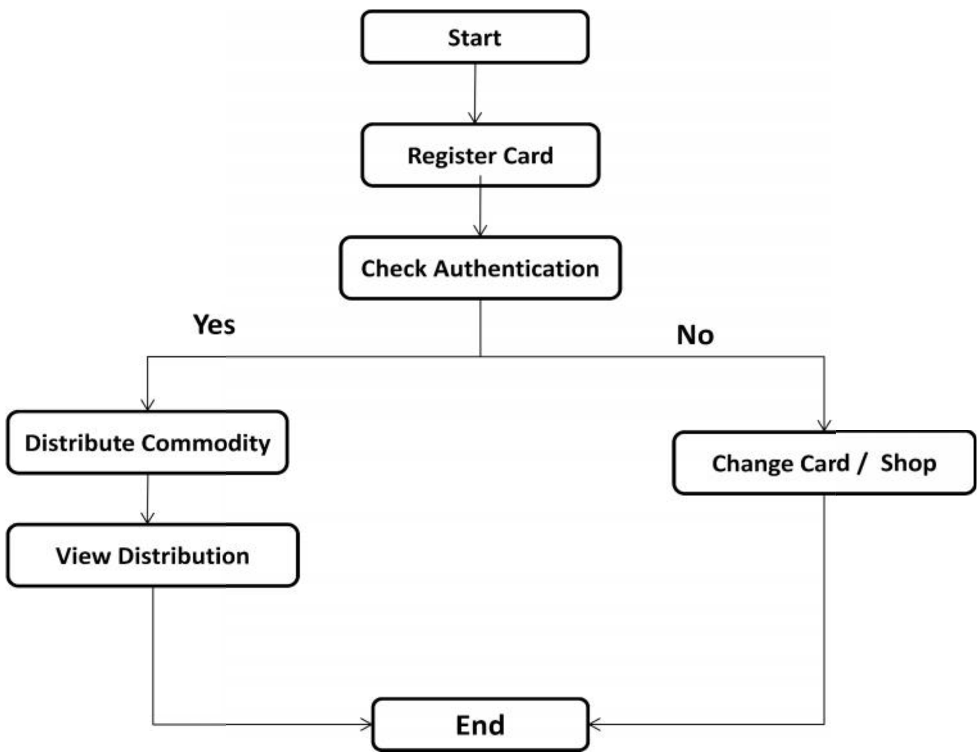


Figure 5.18 Flowchart of activities at Fair Price Shop

The device has the capability of carrying out sales and billing transactions, and to print the receipt of a completed transaction. One of the examples can be seen in Figure 5.19.

The other main features of a POS device are:

- Card programming
- It is a tamper proof device to protect data.

- Cloud based applications
- Standards and Protocols: ISO 14443 A/B with up to 848 kbps transmission rate
- Cards: HID iCLASS®; MIFARE™ Classic/Ultralight/ Plus/DESFire
- Operating Temperature: 0° 55°C (32°-131°F)
- Stores data of transactions carried out in the month.

And it can function off-line and the stored data can be transferred subsequently as and when connectivity becomes available.

Figure 5.19 Point of sale device

5.13.2 Issuing of Commodity at FPS

The Fair Price Shop owner can issue a particular commodity to a beneficiary after prior authentication. To withdraw a commodity a beneficiary has to carry the registered smart ration card to the FPS. The shop owner has to place the card over the POS device, for accessing the card a pass key will be required to enter. After successful entry of pass key, it will be required to click on read button, which will display the details of the beneficiary. The next step will be to distribute the required commodity. The step by step method is shown in Figure.5.20.

Figure 5.20 Checking key before reading card

After successful submission of key one can read the details of the beneficiary. Figure.5.21 shows how the reading form looks like.

Figure 5.21 Details shown after reading the card

For distributing the commodities it is required to click on distribution button available on the home page. A window containing the names of commodities will appear after clicking the distribution button. After entering the allotted quantity it will require to click on submit button and the transaction completes there. The steps are shown in Figure 5.22.

Figure5.22 Distribution of commodities at FPS.

The programming is done in such a way that as and when the transactions occurs it will automatically updated the stock details of corresponding Fair Price Shop in the web site of Warangal Public Distributed System. The Figure 5.23 shows the stock details of ATM001 shop before distribution.

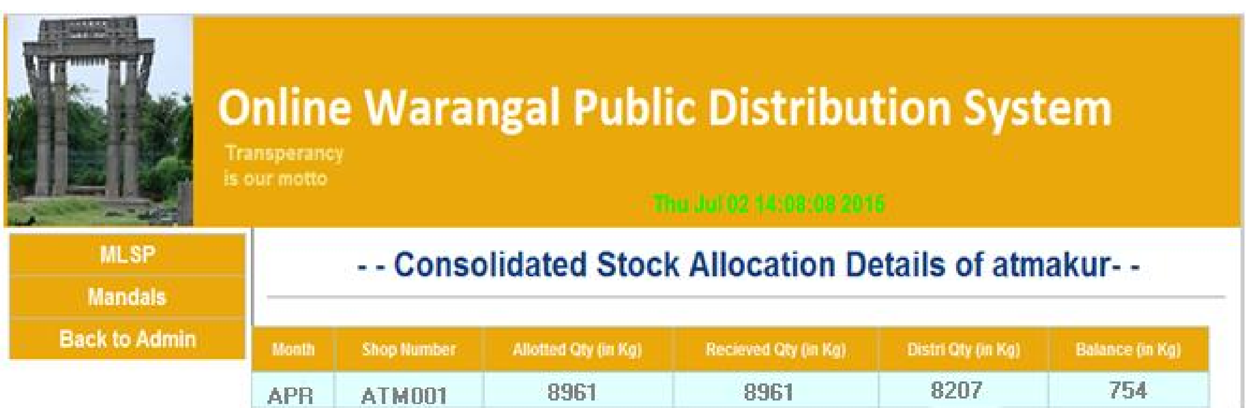


Figure 5.23 Stock details of ATM001 shop before distribution.

After distribution the stock details will update automatically in the web site as shown in Figure 5.24.

Figure 5.24 Stock details of ATM001 shop after distribution.

The programming is also done to view the stock distribution to particular card by the Administrator, Fair Price Shop owner and Card holder and also can know the stock distributions for current month and previous months. The Figure 5.25 shows the stock distributions of a beneficiary.

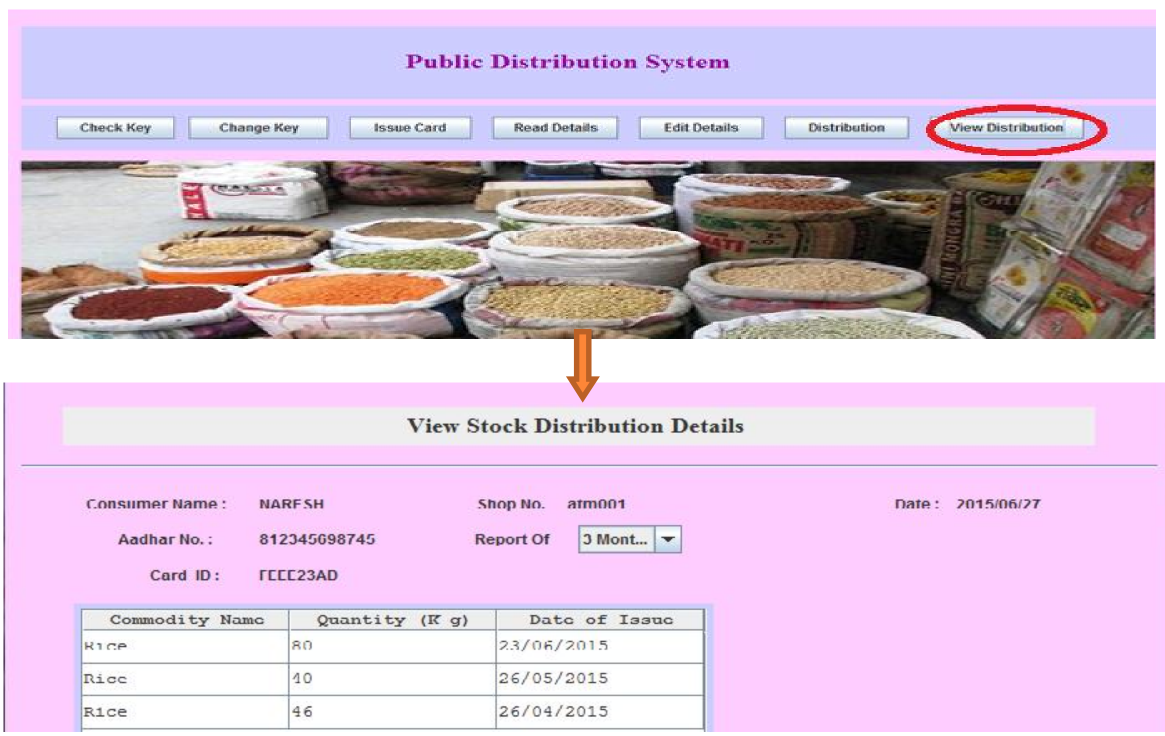


Figure 5.25 Distribution details of a beneficiary.

5.14 Integration of POS device with district zonal office.

The PDS model has been developed in such a way that the data can be updated in real time. For those places where internet connectivity is available any transaction at any FPS will update the data instantaneously. But in reality many villages are not accessible to the internet facility. For those places, the transaction data will be stored in the POS device and has to be send to the zonal office where the information can be updated on the central district database. In zonal office, concerned administrator will copy the information from the POS to database and that data will be uploaded on the portal.

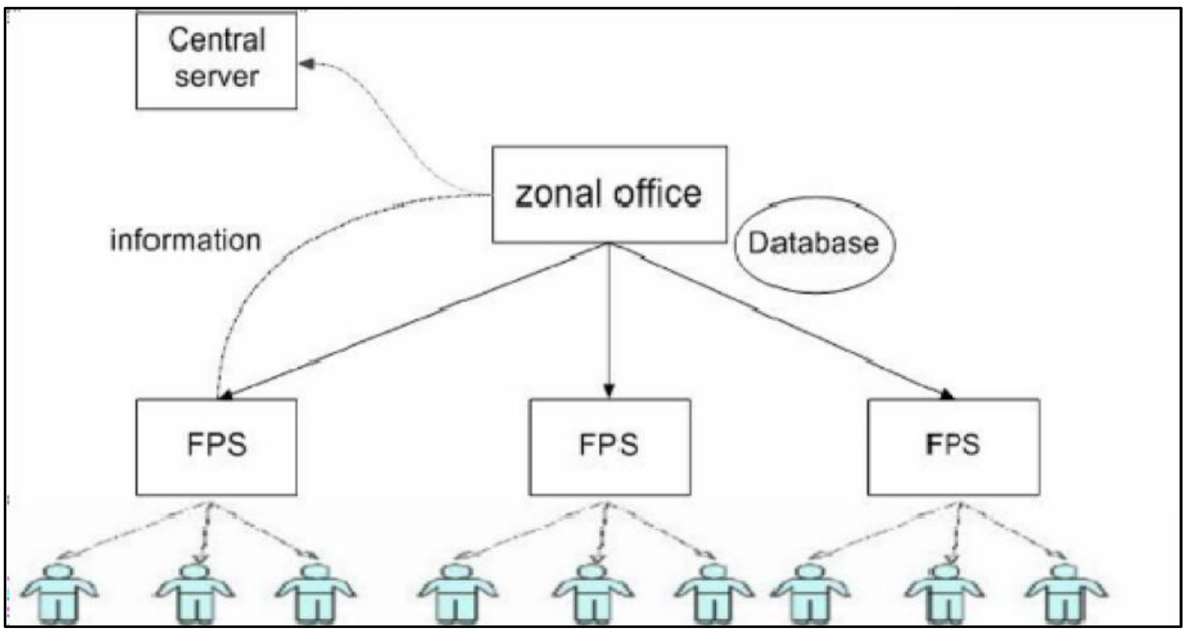


Figure 5.26 Integration of POS device with public district portal

So for this purpose, the coding is written in PHP (Pre Hypertext Processor) language, by which data can be uploaded in the CSV (Comma Separated Values) format. This format will then show on the district portal. After that zonal administrator will refresh the data and POS device will be ready for next set of transactions. It is important to note that, such data changes can only be made by only the required concerned authority. The Flowchart for the information flow can be seen in Figure 5.26.

5.15 Allocation details of food grains

In this part it is shown how much food grain is allotted to different Mandals by the state government. Allocation details of inventory can also be seen by clicking on corresponding mandals. This data is collected from district collectorate office to test our system. The files are imported into the central district database. The Shop numbers are assigned on the smart card of the user. The details of the corresponding mandals can be seen in Figure 5.27, 5.28 and 5.29. This will generate the allocation details for different mandals of the district. The distribution is done on the basis of different BPL cards like, Annapurna , Anthyodaya, White cards.

Mandal list :

Select ▼ Go

Allocation details in Atmakur mandal

S.No.	FPShop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)				
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	Rice Quota (In Kgs.)
1	1	607	0	0	0	63	197	2,205	76	123	107	144	6,756
2	2	592	3	5	30	55	172	1,925	51	107	106	161	7,088
3	3	429	2	2	20	31	113	1,085	25	53	81	135	5,696
4	4	683	3	5	30	39	79	1,365	53	105	119	207	8,932
5	5	419	0	0	0	30	111	1,050	30	78	85	114	5,228
6	6	505	5	5	50	39	129	1,365	32	82	101	149	6,320
7	7	508	1	1	10	31	79	1,085	28	72	110	154	6,712
8	8	641	1	1	10	56	192	1,960	35	103	127	191	8,104
9	9	745	4	5	40	66	226	2,310	43	158	145	209	8,920
10	10	654	7	7	70	44	108	1,540	44	125	123	189	8,116
11	11	260	0	0	0	18	65	630	11	35	43	94	3,524

Figure 5.27 Allocation details of Atmakur mandal

Allocation details in warangal urban mandal

S.No.	FPShop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)				
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	Rice Quota (In Kgs.)
1	001	483	0	0	0	26	90	910	31	85	109	144	6,176
2	002	464	0	0	0	7	31	245	24	48	95	150	6,820
3	003	716	0	0	0	2	5	70	22	121	180	244	10,060
4	004	706	1	1	10	17	77	595	32	119	151	230	9,692
5	005	783	0	0	0	3	6	105	27	108	191	282	11,216
6	006	1,005	2	2	20	67	236	2,345	46	130	191	309	13,660
7	007	406	0	0	0	7	29	245	12	45	99	145	5,876
8	008	579	2	2	20	47	185	1,645	35	91	104	161	7,472
9	009	560	1	1	10	19	52	665	20	96	122	178	7,640
10	010	663	3	3	30	51	171	1,785	39	102	90	200	8,812
11	011	364	1	1	10	24	87	840	12	60	62	111	4,928
12	012	538	4	5	40	41	158	1,435	27	85	107	165	6,892
13	013	626	1	3	10	16	60	560	32	102	128	198	8,628
14	014	401	1	2	10	14	51	490	18	69	91	125	5,376

Figure 5.28 Allocation details of Warangal urban district

Allocation details in Hanamkonda mandal

S.No.	FPShop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)				
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (In Kgs.)	1M	2M	3M	4M	Rice Quota (In Kgs.)
1	060	419	1	1	10	46	148	1,610	27	56	51	101	5,524
2	061	430	3	3	30	42	131	1,470	30	54	80	113	5,480
3	062	246	0	0	0	16	52	560	19	37	37	74	3,260
4	063	495	0	0	0	20	74	700	31	92	101	170	6,412
5	064	339	0	0	0	19	70	665	11	47	43	97	4,928
6	065	350	1	1	10	25	81	875	19	47	72	112	4,588
7	066	492	1	2	10	43	106	1,505	38	89	93	151	5,936
8	067	398	0	0	0	34	130	1,190	26	77	94	111	4,744
9	068	360	0	0	0	29	94	1,015	23	83	89	85	4,204
10	069	406	1	1	10	37	123	1,295	23	57	65	124	5,292
11	070	431	1	1	10	30	91	1,050	23	69	67	108	5,836

Figure 5.29 Allocation details of Hanamkonda Mandal

Mandal wise allocation of rice to Fair Price Shop and their entailments obtained from the district office is furnished in website. Allocation detail comprises total cards available in each Fair Price Shop category wise, and quota allotted. Apart from this the information pertains to different FCI stock points, MLSP's and their maximum holding capacity of grains also provided in the web site. The supply chain from FCI godown to MLSP and from MLSP to FPS are published so that public can know where the stock points are situated. Such details are accessible on the main webpage of the district portal under the tab 'FCI Supply Chain' details. The Figure 5.30 shows the MLSP godown details in Warangal. Accessibility to such information will help in giving the much needed transparency that is required.

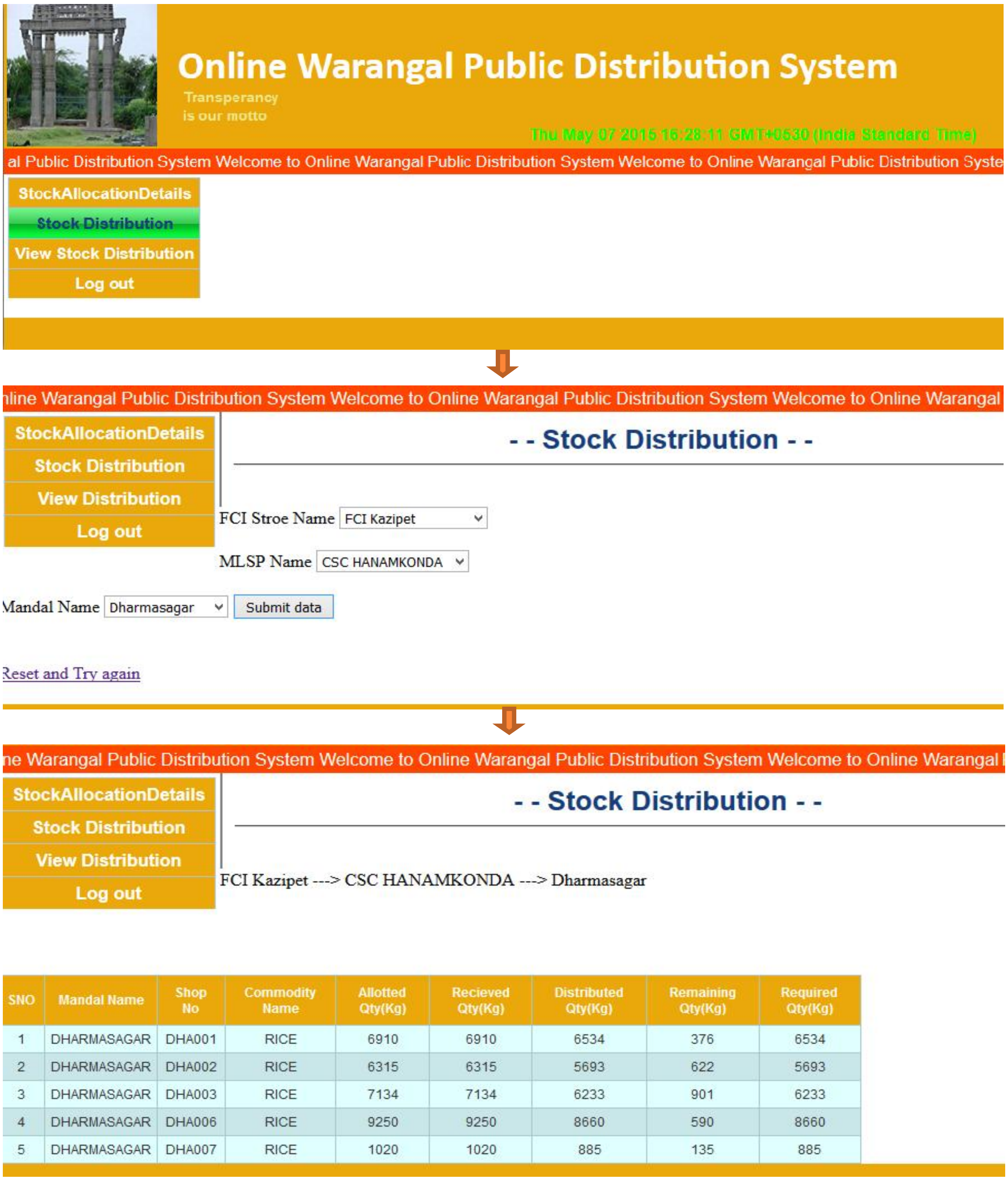
SNO	depotname	district	covered capacity(MT)	type
2809001	HANAMKONDA	Warangal	2000	Owned by csc
2809002	WARANGAL RURAL	Warangal	350	Hired - by csc
2809003	GHANPUR STN	Warangal	1000	Hired - by csc
2809004	WARDHANNAPET	Warangal	500	Owned by csc
2809005	KODAKANDLA	Warangal	500	Owned by csc
2809006	JANGOAN	Warangal	1000	Hired - by csc
2809007	MAHABUBABA	Warangal	500	Owned by csc
2809008	CHERIAL	Warangal	1000	Hired - by csc
2809009	THORRUR	Warangal	1000	Hired - by csc
2809010	MARIPEDA	Warangal	1000	Owned by csc
2809011	KOTHAGUDA	Warangal	400	Hired - by csc
2809012	NARSAMPET	Warangal	1000	Hired - by csc
2809013	PARKAL	Warangal	1000	Owned by csc
2809014	CHITYAL	Warangal	250	Owned by csc

Figure 5.30 MLSP godowns details in Warangal.

Post automation of allocation order, the process of release of commodity for FCI/MLSP shall be automated. By implementing this module, State will be able to consolidate and track the delivery of various commodities against allocation order/release order. Information related to commodity off-take is made available to State agencies through website/ online application.

The FCI Supply Chain module will help the District Administration to ensure the availability of stock position information at all levels right from FCI to Fair Price Shops. This is shown in

Figure 5.31.This will help the officers for tracking of food grain movement and reduce the time and effort for data consolidation & sharing.



SNO	Mandal Name	Shop No	Commodity Name	Allotted Qty(Kg)	Recieved Qty(Kg)	Distributed Qty(Kg)	Remaining Qty(Kg)	Required Qty(Kg)
1	DHARMASAGAR	DHA001	RICE	6910	6910	6534	376	6534
2	DHARMASAGAR	DHA002	RICE	6315	6315	5693	622	5693
3	DHARMASAGAR	DHA003	RICE	7134	7134	6233	901	6233
4	DHARMASAGAR	DHA006	RICE	9250	9250	8660	590	8660
5	DHARMASAGAR	DHA007	RICE	1020	1020	885	135	885

Figure 5.31 View of Stock Distribution chain from FCI to FPS

The total data is kept month wise as well for better understanding and transparency. For this user has to select the month and the total summary details can be seen month wise for different Mandals. This data can be verified with total Mandal wise data for any discrepancies. Such incidents can be reported if any, through proper grievance redressal mechanism.

Allocation details in Warangal district

S.No.	NAME OF THE MANDAL	TOTAL BPL CARDS	Annapurna (AAP)		Anthyodaya (YAP)	white cards		Crippled Weavers		Allotment of Sugar in Qtls	Allotment of Redgram Dall in Q	Allotment of P.Oil in Liters	Allotment of Wheat in Qtls
			Cards	Rice Quota (In Qtls.)	Cards	Total White Cards	Rice Quota (In Qtls)	No. of Crippled Weavers	Net Allotment in Qtls				
1	2	3	4	5	6	13	14	15	16	17	18	19	20
	WARANGAL DIVISION												
1	Atmakur	17,295	54	5.4	1,361	15,880	2,170	10	2.5	86.48	86.48	17,295	0
2	Dharmasagar	19,579	66	6.6	1,677	17,836	2,446	0	0	97.9	97.9	19,579	0
3	Geesugonda	17,285	35	3.5	1,142	16,108	2,222	0	0	86.43	86.43	17,285	0
4	Ghanpur(Stn)	24,704	40	4	1,992	22,672	3,144	11	2.75	123.52	123.52	24,704	0
5	Hanamkonda	66,125	111	11.1	3,700	62,314	8,820	2	0.5	330.63	330.63	66,125	200
6	Hasanparthy	20,193	42	4.2	1,531	18,620	2,516	1	0.25	100.97	100.97	20,193	0
7	Parvathagiri	11,410	25	2.5	870	10,515	1,491	14	3.5	57.05	57.05	11,410	0
8	Raiparthy	14,307	42	4.2	1,048	13,217	1,815	5	1.25	71.54	71.54	14,307	0
9	Sangem	16,137	36	3.6	1,229	14,872	1,906	0	0	80.69	80.69	16,137	0
10	Warangal	73,466	159	15.9	5,240	68,067	9,832	36	9	367.33	367.33	73,466	300
11	Wardhannapet	18,592	77	7.7	1,570	16,945	2,457	17	4.25	92.96	92.96	18,592	0

Figure 5.32 Summary details of Warangal district (snapshot)

In the summary details, all the mandals information is clubbed to generate the cumulative information about the district. Such information then can be sent to the state and central government as there in the procedure. This information can be procured monthly wise in excel format as well. Figure 5.32 shows the details for particular month for Warangal district.

5.16 Security and privacy issues of the portal

There may be some information that we want it to be not accessible to public but it can be shared between the privileged users. For such purposes, there are some modules or web pages that are only accessible to the few persons. For such persons username and password are to be generated which they have to use to enter those pages. The administrator has the authority to change or remove such users depending on the situation. The Login menu is shown in Figure 5.33.

Figure 5.33 Login page

As far as security issues about the portal, only the administrator can make the changes that are required. The page after the login will consists of various details regarding the PDS system that administration think are necessary to keep out of the public. Such details can be kept in these portions.

5.17 Grievance Redressal Mechanism

Grievance Redressal process takes care of the grievances filed by the PDS beneficiaries and various private dealers / agents involved in the PDS process. Once data of beneficiary and PDS stakeholders (like Offices, FPS, Depot, Card Type, etc.) gets digitized, States will be able to automate grievance redressal process. These complaints shall get auto forwarded to the concerned officials responsible for their redressal. For getting the details the person has to enter its information, by which he will get the complaint-id. That id will generate flag into the system for concerned authority. So, that there will be accountability of the complaint redressing officer. Figure 5.34 shows such representation.

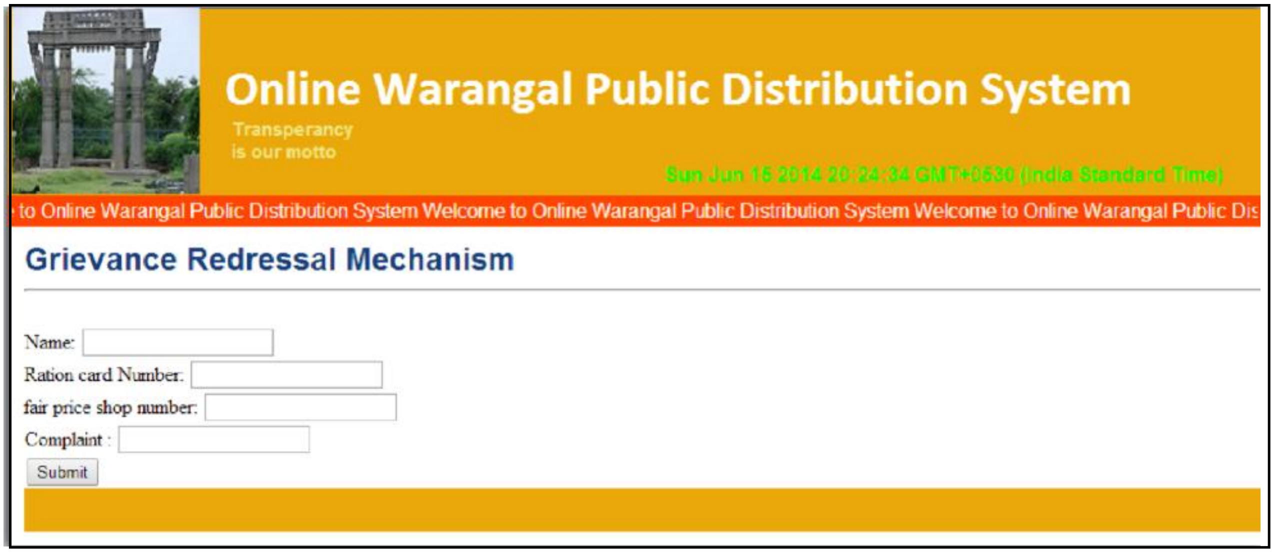


Figure 5.34 Grievance Redressal Mechanism

5.18 Software Development

For designing of WebPages Hypertext Pre Processor (**PHP)** language is used and **MYSQL** is used for Relational Database Management System **(RDBMS)** . Open source cross-platform web Server **Xampp** is used**.**

5.18.1 PHP

PHP is a server-side scripting language designed for web development but also used as a general-purpose programming language. PHP is now installed on more than 244 million websites and 2.1 million web servers. Originally created by Rasmus Lerdorf in 1995, the reference implementation of PHP is now produced by The PHP Group. While PHP originally stood for Personal Home Page, it now stands for PHP: Hypertext Pre-processor, a recursive acronym.

PHP code is interpreted by a web server with a PHP processor module, which generates the resulting web page: PHP commands can be embedded directly into an HTML source document rather than calling an external file to process data. It has also evolved to include a command-line interface capability and can be used in standalone graphical applications. The PHP language was originally implemented as an interpreter, and this is still the most popular implementation

PHP is a general-purpose scripting language that is especially suited to server-side web development where PHP generally runs on a web server. PHP can be deployed on most web servers, many operating systems and platforms, and can be used with many relational database management systems (RDBMS). Most web hosting providers support PHP for use by their clients. It is available free of charge, and the PHP Group provides the complete source code for users to build, customize and extend for their own use.

Sample Coding used for connecting database:

```
<?php

// 1. Create a database connection

$conn= mysql_connect("localhost","root","kiet");

if (!$conn) {

        die("Database connection failed: " . mysql_error());

}

// 2. Select a database to use

$db_select = mysql_select_db("supply_inventory",$conn);

if (!$db_select) {

        die("Database selection failed: " . mysql_error());

}

?>
```

This particular code connect database to the web server. Similarly other codes are made to make district portal.

5.18.2 XAMPP

It is a free and open source cross-platform web server solution stack package, consisting mainly of the Apache HTTP Server, MySQL database, and interpreters for scripts written in php and Perl programming languages. With the help of the Xampp we can easily integrate the database with web based programming languages. Home page can be seen in Figure 5.35.

In Xampp there is sub application called as PhpMyAdmin that contains the database as can be seen in Figure 5.36 where tables in particular databases can be seen that are displayed with the help of the php language.

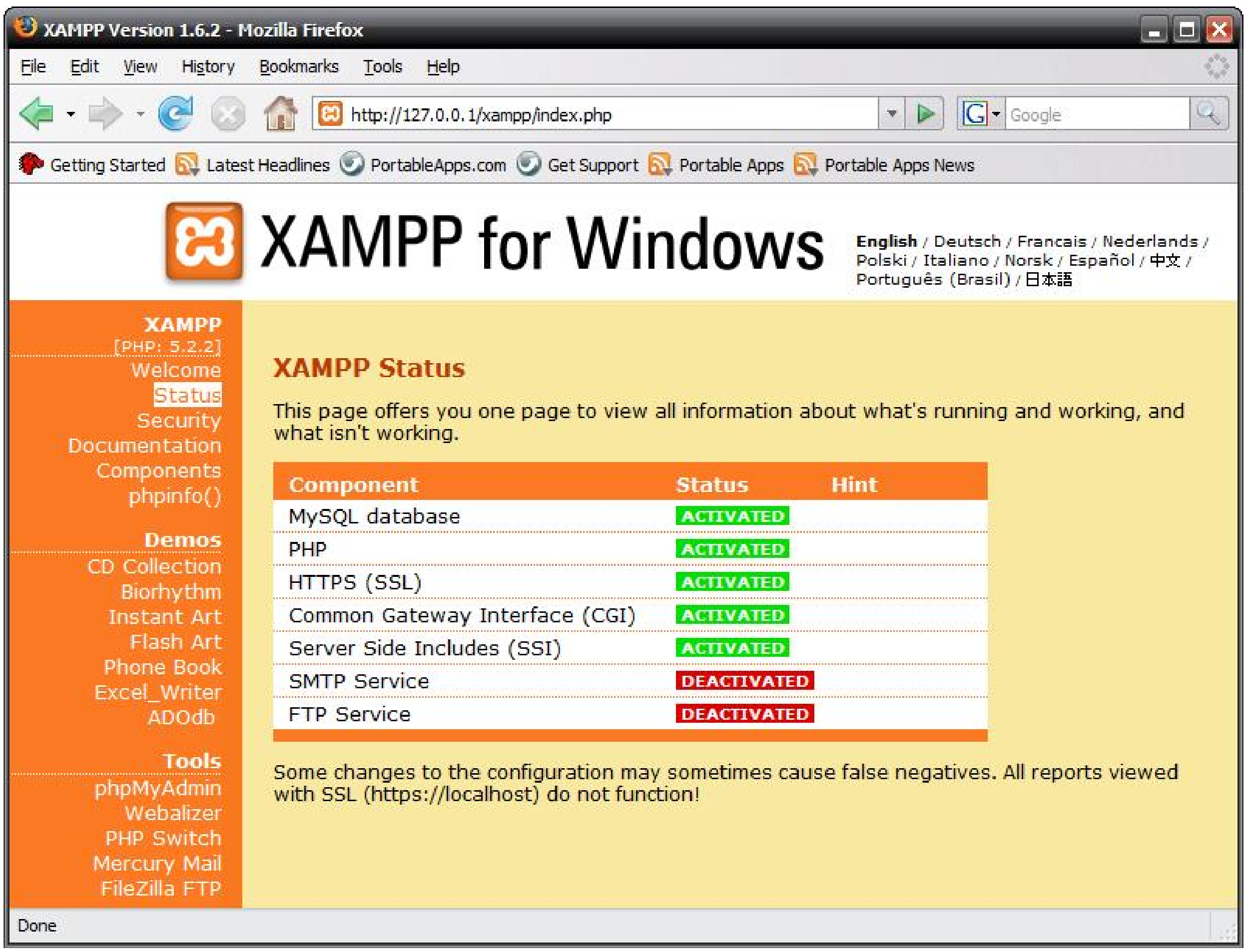


Figure 5.35 Xampp main page

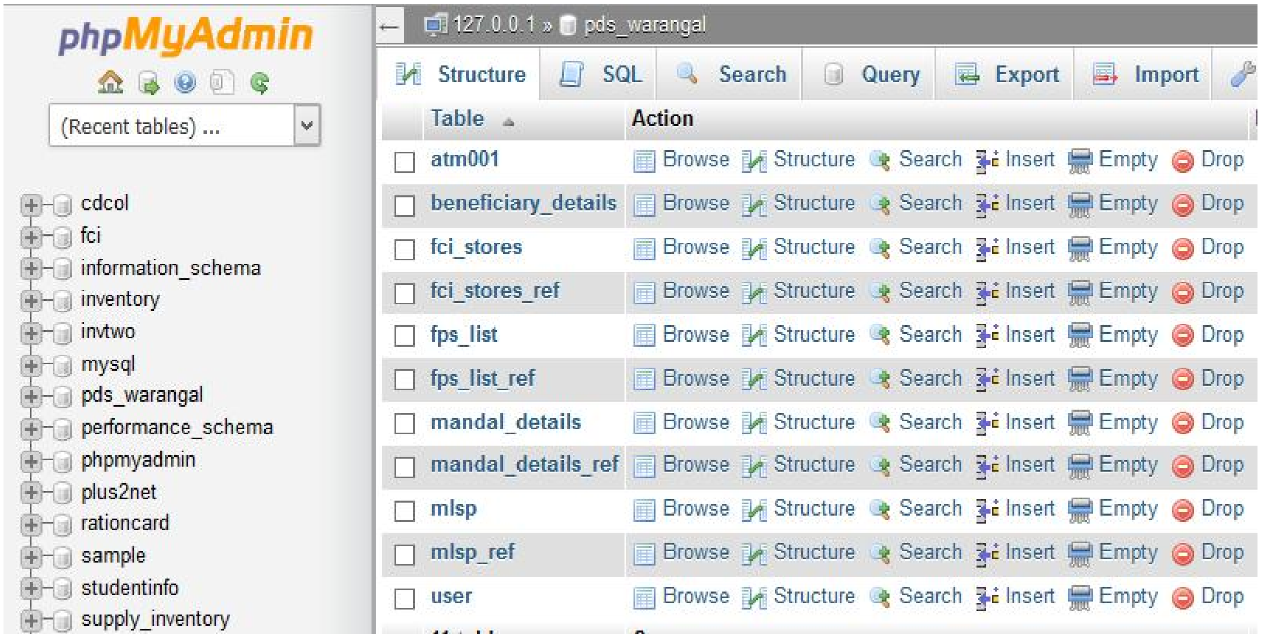


Figure 5.36 PhpMyAdmin showing different databases used

5.18.3. MySQL

It is officially the world's second most widely used open-source relational database management system **(RDBMS)** . It is named after co-founder Michael Widenius's daughter. The SQL phrase stands for Structured Query Language.

MySQL is a popular choice of database for use in web applications, and is a central component of the widely used Free-software-open source projects that require a full-featured database management system often use MySQL.

SQL Commands:

The standard SQL commands to interact with relational databases are CREATE, SELECT, INSERT, UPDATE, DELETE and DROP. These commands can be classified into groups based on their nature:

DDL - Data Definition Language:

Command	Description
CREATE	Create a new table
ALTER	Modifies an existing database object, such as a table
DROP	Deletes an entire table, a view of a table or other object in the database

.

DML - Data Manipulation Language:

Command	Description
INSERT	Creates a record in the database
UPDATE	Modifies records in the database
DELETE	Deletes records in the database.

DQL - Data Query Language:

Command	Description
SELECT	Retrieves certain records from one or more tables

The CREATE TABLE command can either be entered at the mysql> prompt or can be written into a file and sent into MySQL later. The latter is preferable because one can retain a record of how the table is created. A table in the portal may be created as follows:

Create Table inv1 (

`COL 1` varchar(5) DEFAULT NULL, `COL 2` varchar(10) DEFAULT NULL, `COL 3` varchar(15) DEFAULT NULL, `COL 4` varchar(15) DEFAULT NULL,

`COL 5` varchar(5) DEFAULT NULL, `COL 6` varchar(20) DEFAULT NULL,

`COL 7` varchar(16) DEFAULT NULL, `COL 8` varchar(8) DEFAULT NULL,

`COL 9` varchar(20) DEFAULT NULL, `COL 10` varchar(17) DEFAULT NULL,

`COL 11` varchar(8) DEFAULT NULL, `COL 12` varchar(8) DEFAULT NULL,

`COL 13` varchar(8) DEFAULT NULL, `COL 14` varchar(11) DEFAULT NULL,

`COL 15` varchar(20) DEFAULT NULL, `COL 16` varchar(16) DEFAULT NULL,

`COL 17` varchar(7) DEFAULT NULL)

The values can be inserted into the >

INSERT into inv1 VALUES ('1','wap21056789','233.3','NULL');

Similarly for all 17 columns values can be inserted. The values then will be reflected on the database added in the table 'inv1'. Figure 5.37 shows a snap shot of table created through MYSQL.

COL 1	COL 2	COL 3	COL 4	COL 5	COL 6	COL 7	COL 8	COL 9	COL 10	COL 11	COL 12	COL 13	COL 14	COL 15	COL 16	COL 17
S.No.	FPShop No.	Total BPL Cards	Annapurna (AAP)			Anthyodaya (YAP)			White Cards (WAP)						Total Rice Quota	
			Cards	Units	Rice Quota (In Kgs.)	Cards	Units	Rice Quota (in Kgs.)	1M	2V	3M	4M	5M and more	Rice Quota (In Kgs.)	In Kgs.	In MTs.
1	1	607	0	0	0	63	197	2,205	76	123	107	144	94	6,756	8,961	8.961
2	2	592	3	5	30	55	172	1,925	51	107	106	161	109	7,088	9,043	9.043
3	3	429	2	2	20	31	113	1,085	25	53	81	135	102	5,696	6,801	6.801
4	4	683	3	5	30	39	79	1,365	53	105	119	207	157	8,932	10,327	10.327
5	5	419	0	0	0	30	111	1,050	30	78	85	114	82	5,228	6,278	6.278
6	6	505	5	5	50	39	129	1,365	32	82	101	149	97	6,320	7,735	7.735
7	7	508	1	1	10	31	79	1,085	28	72	110	154	112	6,712	7,807	7.807
8	8	641	1	1	10	56	192	1,960	35	103	127	191	128	8,104	10,074	10.074
9	9	745	4	5	40	66	226	2,310	43	158	145	209	120	8,920	11,270	11.27
10	10	654	7	7	70	44	108	1,540	44	125	123	189	122	8,116	9,726	9.726
11	11	260	0	0	0	18	65	630	11	35	43	94	59	3,524	4,154	4.154
12	12	216	1	1	10	17	39	595	15	37	44	69	33	2,648	3,253	3.253
13	13	533	0	0	0	37	135	1,295	43	79	86	175	113	6,896	8,191	8.191
14	14	517	3	3	30	50	153	1,750	34	74	99	142	115	6,488	8,268	8.268
15	15	528	0	0	0	39	129	1,365	46	81	96	177	89	6,596	7,961	7.961

Figure 5.37 is a snap shot of table created through MYSQL

The SELECT command is used to view all or some of the elements of a table or multiple tables. The basic format is SELECT column FROM table;

With the help of these basic commands we can use SQL query comfortably.

5.18.4. Project Analysis

We are making a shift from local decentralised system to the centralised inventory system. The system implements a centralized inventory system on a database that has inbuilt functions for cross referencing entries. This linking will ensure that a person identified uniquely. Dynamic database inventory of all transactions in the PDS provide a huge boost to the system's accountability and transparency that will certainly help in streamlining the system.

5.18.5. Market Analysis

The PDS system can be implemented in India across 5 lakh FPS shops. As every state today wants to curb the leakages in the PDS system. They are trying new techniques by which they can curb this menace. Such system can be used in other e-governance schemes as well.

5.18.6. Technical Analysis

The project requires certain Information Technology infrastructure:
At Fair price shops POS device is required for doing the operation. Also at each fair price shop , Point of sale device should be inputted with details of ration card owner. the details of the card holder will be reflected in the system through which the authentication can be made of the owner. At mandal level / zonal offices, desktops / laptops would be required for data entry, online management of ration card, generating online allocation of food-grains, utilization reporting and monitoring the operations of TPDS in respective District/UT.

At District level office, like Mandal office will require desktops, cloud enabled server or infrastructure, central database storage server, application software's. Bandwidth/ connectivity is required for interlinking the different server, software and application.

Finally it can be linked to the state database for overall allocation in the states.

5.18.7. Technical support

To achieve these computerisation of PDS, we require that the existing officials, staff and other stakeholders including FPS dealers are also equipped to handle and bring about this change. The States/UTs would assess the overall requirements in terms of training and capacity building for all stakeholders associated with the PDS operations. A technical team is required for the safety of the cloud based data from hackers.

5.19 Summary

This chapter gives the overall details how the work is completed in stepwise starting from the collection of relevant data, developing databases with the gathered data and finally merging all the data's into a master data . Based upon these data, a web portal is designed for Warangal district public distribution system. The module also developed for the administrator to allocate the requirements for each FPS based on the distribution database and also can view the stock allocation and distributions. A smart card based ration card is developed and then integrated with the web portal so that beneficiaries can able to see what is the stock level in each FPS and how much quantity is allocated and distributed in each fair price shop

Conclusions

The purpose of the thesis is to study the working of existing Public Distribution System in India in general and Warangal district in particular as the both the Central and State Governments are spending huge amount of funds for operation of the System. The author has got motivation to study the operation of system to suggest suitable mechanisms for improving the working of system more effectively by minimizing the operational costs with the applications of engineering techniques of operation research in this real life project. The author further motivated to solve the burning problem of bogus cards by ensuring transparency and accountability in implementation of Public distribution system to enable the effective use of the supply mechanism by deserving users.

A typical Public Distribution System (PDS) in Warangal District of Telangana State consisting of Food Corporation of India (FCI), Mandal Level Stock Points (MLSP) and Fair Price Shops (FPS) is considered for this research work. Many existing problems like in adequate supply of Commodities, Poor quality of under weighing of Commodities, Leakages at FPS, loss of commodities in transportation, Bogus ration cards, Timely non-availability of food grains in FPS and Non-availability of information on arrivals of stocks at FPS's shops to general public in addition to unscientific methodology for transportation and inventory control. This research work addressed the above problems and evolved a suitable methodology by developing the models which are summarized here under. In addition modern terminology relating to the problems considered is explained in detailed.

A) Inventory Model

An inventory model is developed for the problem involving total variable cost/ expenditure minimization of a PDS in the form of an optimization problem with certain constraints. The total expenditure has been minimized through determination of optimum holding inventory at FCI taking into account of inventory holding cost, setup costs. The developed model has determined at FCI, the optimum inventory at the end of each time period, total variable cost estimate for FCI by taking into account realistic available data by implementation of BPSO technique with using C++ coding.

a) BPSO technique have been successfully employed to model and simulate lot sizing problem such as single item single level, capacitated problems under consideration to minimize total cost.
b) The total cost obtained for the PDS problem under consideration by BPSO method it is observed that reduced cost is nearly thirty two cores and there is a reduction of 31.82 % compared to the total cost of existing system.

B) Transportation Model

A transportation model is developed with multi depot vehicle routing planning that help engineers to solve the daily vehicle routing problems for a fixed –route trucking carrier. The salient features of developed model are,

a).The multi-depot routing problem of the case company was formulated based on the company's current delivery network. A hybrid algorithm integrating the nearest-neighbor searching algorithm and best case search algorithm is proposed to solve the routing problem. The algorithm allows more precise estimation of loading capacity for each delivery route. Therefore, the number of vehicles used in daily delivery tasks can be effectively estimated and optimally arranged.

b) With the aid of computing technology, the time needed to generate a routing plan is significantly reduced in comparison with time needed in the manual planning. The developed system also helps to shorten the learning curve for new engineers in dealing with the routing process. As a result the overall cost is reduced and possible loss due to poor routing plans is avoided.

c) From the developed model for PDS Warangal it is observed that in Stage I Transportation, the algorithm applied for solving the problem generated the optimum number of vehicles to be engaged from each FCI to deliver the goods to respective MLSP's in given time window. The month wise cost reduction estimated is very high compared to expenditure incurred by the Government. It is observed that 78% of earlier expenditure can be reduced under Stage I transportation.

d) From the developed model for PDS Warangal it is observed that in Stage II Transportation also the algorithm applied for solving the problem generated the optimum no. of. vehicles to be engaged from MLSP to deliver the goods to respective FPS'S in given time window in order to minimize the transportation cost. The month wise cost reduction is significantly high i.e. 28% can be reduced at each MLSP when compared to what is being spent now.

e) By the research study it is observed that huge amounts spent on transportation of PDS can be minimized and significant savings can be achieved by adoption of these supply chain techniques in real life problems

C) Cloud Computing Model

A cloud based model was developed for PDS supply chain system that will enhance the current state of working of PDS supply chain in the Warangal District. The unified data of inventory at one place will help in eliminating the leakages that are there in the system. The system will also eliminate the bogus cards in the system by using the smart ration card. Integration of district portal with Fair price shop is done. The web portal will give access to all the information citizens requires about their account and inventory intake.

The whole system can be accessed with full privileges to few higher authorities like District Magistrate, FCI administrator with all firewall protection for security. The information is made available on public portal- State-wise Stakeholder Report, Ration Card Report, Allocation Details, and Godown Report. Grievance redressel mechanism which will look into the complaints of the citizens.

Online registration and management would improve the efficiency of the system, and enable the timely distribution of food grain to the beneficiary. Delays in movement and off-take of grain could be identified by delays in authentication and immediately flagged on the system. This would also create new spaces for civil society to engage and monitor delivery of entitlements to the poor. Such system will definitely help in curbing the menace of corruption in the supply chain of PDS in Warangal district.

D) Limitations:

The limitations of the present research are given here under.

a) The implementation of the inventory, transportation and computing model depends upon computing skill of the personnel of the department.
b) The success of the model depends upon the level of computer literacy of the beneficiaries.
c) Depends upon the adoption of technology by the government for implementation of models.
d) Poor infrastructure facilities in rural areas may affect the model

6.1. Future Scope

Public distribution system (PDS) is being implemented in India in each and every State as it is one of the popular schemes. There are 29 States in India, process of implementation is same, and however the distribution of commodities may differ from State to State. The scope of the research work undertaken is limited to Warangal district as huge data is needed from various sources like government agencies, government officials Fair shop dealers and beneficiaries, which involves tremendous field work and herculean task for collection of data. The research work studied existing working of public distribution system in Warangal district collected and analyzed the data pertains to Warangal district. The study in the thesis in chapter 3 and chapter 4, is related to the data which is taken as deterministic. The analysis will need probability techniques when the data under consideration is stochastic in nature. Further this can be extended for entire State by making district level case studies individually. The thesis work is focused on development of inventory and transportation models for single item called rice, as the consumption of rice under PDS is huge and heavy subsidized by the both the Governments. Similarly, the inventory and transportation models for multi items like sugar, wheat etc. can also be developed even though the allotments and consumptions are very less.

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Publications

Journals and Conferences

1) Development and analysis of Transportation model of public distribution system for Warangal District, Published in International Journal for Management science and Technology(IJMST) Volume 1, Issue 2, (2013)

2) Consumer information system for public distribution system (PDS) in Warangal district, Telangana State, published in International Journal of Management and Commerce Innovations Volume 3, Issue 1, (2015).

3) Minimization of warehouse expenditure in Public Distribution System for Warangal District, Telangana State,- International Conference on Advances in Production and Industrial Engineering organized by National Institute of Technology (NIT) Tiruchirappally, February 2015.

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