ROUTE OPTIMIZATION FOR EFFICIENT MILK PROCUREMENT BY FPO OWNED DAIRY UNIT

BY

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B.Sc. (Ag.)

PROJECT REPORT SUBMITTED TO THE
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
AWARD OF THE DEGREE OF

MASTER OF BUSINESS ADMINISTRATION
(AGRIBUSINESS MANAGEMENT)

CHAIRPERSON: Mr. N.T. KRISHNA KISHORE

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2020-21

DECLARATION

I, **S SHAIK HUSSAIN JAVEED**, hereby declare that the project report entitled "**ROUTE OPTIMIZATION FOR EFFICIENT MILK PROCUREMENT BY FPO OWNED DAIRY UNIT"** submitted to **Acharya N.G. Ranga Agricultural University, Guntur** for the degree of **MASTER OF BUSINESS ADMINISTRATION (AGRIBUSINESS MANAGEMENT)** is the result of original research work done by me. I also declare that no material contained in this project report has been published earlier in any manner.

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I.D. No. TMBA/2018-05

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CERTIFICATE

This is to certify that **Mr. S SHAIK HUSSAIN JAVEED** has satisfactorily prosecuted the course of research and that the project entitled **"ROUTE OPTIMIZATION FOR EFFICIENT MILK PROCUREMENT BY FPO OWNED DAIRY UNIT"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the project report nor its part thereof has been previously submitted by him for a degree of any university.

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CERTIFICATE

This is to certify that the project report entitled **"ROUTE OPTIMIZATION FOR EFFICIENT MILK PROCUREMENT BY FPO OWNED DAIRY UNIT"** submitted in partial fulfillment of the requirements for the award of degree of **MASTER OF BUSINESS ADMINISTRATION** of the Acharya N.G. Ranga Agricultural University, Guntur, is a record of the bonafide research work carried out by **Mr. S SHAIK HUSSAIN JAVEED** under our guidance and supervision.

No part of the project report has been submitted by the student for any other degree or diploma. The published part and all assistance and help received during the course of investigation have been duly acknowledged by the author of the project report.

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ACKNOWLEDGEMENTS

*It is by the immense blessing of **ALLAH** for grace and blessings showered on me in each and every step of my life, that I could achieve this goal.*

*Accomplishment of this thesis is the result of benevolence of **Almighty ALLAH,** blessings of **my Parents** and **Teachers.***

*I am inexpressibly ecstatic to extend my deep sense of gratitude to luminous educationalist and esteemed chairperson of my Advisory Committee **Mr. N.T. Krishna Kishore,** Assistant professor, Institute of Agribusiness Management, S.V. Agricultural College, Tirupati for his affectionate guidance, encouragement and unabated help throughout the investigation which made it possible to bring out a refined dissertation successfully to reckon with set standards.*

*I deem it a privilege in expressing my deep sense of gratitude and thanks to **Dr. N. Vani,** Assistant Professor, Department of Agricultural Economics and member of my advisory committee for her valuable suggestions, affectionate encouragement and constructive criticism during the course of present study.*

*I accord my sincere thanks to **Dr. P. Lavanya Kumari,** Assistant Professor and Head, Dept. of Statistics and Computer Applications, S.V. Agricultural College, Tirupati and member of my advisory committee for her timely and valuable help rendered during the course of investigation.*

*I wish to express my cordial thanks to **Dr. I. Bhavani Devi**, Professor and Head, Institute of Agribusiness Management, S.V. Agricultural College, Tirupati for her articulate criticism, transcendent suggestions and persistent encouragement and for providing congenial atmosphere for the study.*

*I wish to place on record my sincere and heartfelt regards to **Smt. Y. Prabhavathi** Assistant Professor, Institute of Agribusiness Management S.V. Agricultural College, Tirupati for her kind co-operation and suggestions during the course.*

*I extend my profound thanks to **Associate Dean**, **Professors** of **S.V. Agricultural College, Tirupati** and the staff of **Regional library, S.V.***

Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University *for their encouragement, administrative support and during my course period.*

I also thank ***Dr. T.N. Venkat Reddy,*** *Professor, Department of Agricultural marketing, GKVK campus, Bangalore for the constant support and inspiration with his immense knowledge.*

I'm extremely grateful to ***Sri. Jayatheertha Chary,*** *Chief Executive and* ***Sri. Y Krupakara Rao,*** *Head-Purchase and HR for providing me the opportunity to work as intern in* ***Shreeja Mahila Milk Producer Company Limited.***

I'm also thankfull to ***Sri Thimmappa S R,*** *Head-Procurment and PIB,* ***Sri. Suryakanth Reddy*** *Head Quality Assurance and all other supporting staff members (administrative and field level) for their humongous support throughout the project period.*

Words are not enough to express my genuflect love, unbound gratitude and sense of affection to my parents ***S Shaik Hussain Saheb*** *and* ***S Umeen Banu,*** *my brother* ***S Hassan Ali Jameer*** *and my sister* ***Dr. S Jasmine Banu*** *for their everlasting love, inestimable encouragement and dedicated efforts to educate me this level and whose unparalleled affection and persistent encouragement in keeping my career go a long throughout my life.*

I will never forget all chats and beautiful moments with my classmates. They were fundamental in supporting me during stressful and difficult moments in these two years. ***Sadik, Sowmya, Anusha, Naveen, Dileep sir, Rajesh, Bala, Sri Hari, Supraja, Renuka, Yaswanth and Azmath*** *for their support especially during this project period.*

It gives me immense pleasure to express my profound thanks to my seniors ***Bharat, Uday, Prasad, Murali, Phani, Ashok, Sreekanth Abdul, Charwaka, Madhavi, Swarna, Charishma, Jyothsna, Geetha, Indrani and Prem*** *for their affection and help.*

I thank all my junior friends ***Ananya, Krishna Reddy, Sai Krishna, Sai Kumar, Murthy, Rama Devi, Kavitha, Sabera, Divya, Chandu, Nihith and Lavanya*** *for their affection and co-operation.*

No words could justice to express my deepest sense of love and gratitude towards my very special friends ***Engineer Habeeb from Saudi, Gali, Firoz, Bandar, Zaheer, Nazeer Mamu, Vamsi, Kavitha, Haseena, Sireesha, Dr. Kandeeban sir, Joash, Sadik, Sowmya, Y Prasad, Dr. Ramu, Affia and Deepa*** *for their excellent company, inspiration, moral support, boost up, healthy friendship.*

I also express my pleasure to thank ***all my friends*** *and* ***family members*** *for all their love, help and support.*

I am very much grateful to ***Institute of Agribusiness Management, Acharya N.G. Ranga Agricultural University, Guntur*** *for all the facilities and financial help provided in the form of stipend during my course of study.*

It is the right occasion to express my heartful thanks to Non-teaching staff members ***Lokhanadam*** *and* ***Prasad*** *of our Institute of Agribusiness Management, Tirupati for their sustained help and cooperation during my research work.*

In finale, I thank all my well-wishers and others who helped me directly or indirectly not placed here, for their kind cooperation and support rendered to me.

S SHAIK HUSSAIN JAVEED…✍

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
<	:	Less than
>	:	Greater than
Avg.	:	Average
BMC Unit	:	Bulk Milk Cooling Unit
e.g.,	:	Example
et al.	:	and other
etc.	:	and so on
Fig.	:	Figure
FPO	:	Farmer Producer Organization
GDP	:	Gross Domestic Product
GOI	:	Government of India
GPS	:	Global Position System
i.e.	:	That is
Kg	:	Kilogram
KL	:	Kilo Litres
lts	:	Litres
Max.	:	Maximum
Min.	:	Minimum
mins.	:	Minutes
PERT	:	Program Evaluation Review Technique
MPP	:	Milk Pooling Point
NDDB	:	National Dairy Development Board
NDP	:	National Dairy Plan
No.	:	Number
Rs.	:	Rupees
S. No.	:	Serial Number
TSP	:	Travelling Salesman Problem
viz.,	:	Namely

ABSTRACT

Author of the project	:	**S SHAIK HUSSAIN JAVEED**
Title of the thesis	:	**"ROUTE OPTIMIZATION FOR EFFICIENT MILK PROCUREMENT BY FPO OWNED DAIRY UNIT"**
Degree to which it is submitted	:	**MBA (AGRIBUSINESS MANAGEMENT)**
Faculty	:	**AGRICULTURE**
Discipline	:	**AGRIBUSINESS MANAGEMENT**
Chairperson	:	**Mr. N.T. KRISHNA KISHORE**
University	:	**ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY**
Year of submission	:	**2021**

The present study "Route Optimization for Efficient Milk Procurement by FPO Owned Dairy Unit" has been taken up with the objectives *viz.,* to assess the quality control practices followed at farmers level, at milk pooling points and at bulk milk cooling units. Shreeja Mahila Milk Producer Company Limited is the only Farmer Producer Organization (FPO) owned milk Producer Company in South India. The present study was under taken in Chittoor district of Andhra Pradesh purposively in view of presence of highest milk procuring BMC units in the district. In the selected bulk milk cooling (BMC) unit all the thirty milk pooling points (MPP) were selected for optimization of routes. From all the milk pooling point operators of each MPP and all the transport service providers in the three routes have been chosen. Primary data was collected from all the MPP operators and transport service providers using a schedule through personal interview method. The data collected was analyzed by using frequencies and percentages, PERT, Travelling Salesman Problem model, Garrett's ranking technique and Construction indices.

In the present study the identified BMC unit has installed capacity of preserving four thousand kilo litres per day, catering the needs of 554 registered milk pourers belonging to thirty five villages. There were nine, eleven and ten milk pooling points in route-1, route-2 and route-3 respectively that serves 13 villages, 11 villages and 11 villages, covering 30 MPPs. The present identified BMC unit has three vehicle routes covering with three vehicles commuting a distance of 194.6 kilometers per day. The maximum milk procured was 758 liters in route-1, 1296 liters in route-2 and 1157 in

route-3 per day that has been the basis for deciding the vehicle capacities for collection of milk cans from milk pooling points.

The FPO owned dairy unit has adopted a system of milk collection through village level milk pooling points (MPPs). Each MPP is provided with all the essential utilities for the milk collection and also the testing equipment such as digital milk analyzers. Each MPP has been allotted a time slot of 30 minutes, on an average the 30 minutes time slot time of each MPP has been divided in pre-operative, operative and post-operative activities with 10 minutes each. The time delays in operations at Milk pooling points was ranging from 0 to 10 minutes. The standard deviation of delays in milk pooling point operations was estimated to be 4.49 minutes in route-1, 3.99 minutes in route-2 and 4.64 minutes in route-3.

The major reasons for time delay in MPP operations were delay in milking by farmers beyond the regular timings, delay by farmers due to attending other work during MPP slot time, large no. of pourers to accommodate with in the given MPP slot time and all the farmers come at the same time to the MPP to pour milk. The major reasons to hold the collected milk at MPPs were delay due to late supply of milk by few farmers even after slot time ends, delay in preparation of reports, delay in arrival of milk cans collection vehicle and delay in canning the collected milk.

Perception of MPP operators on importance given to pre-operative activities reveal that 53 per cent of MPP operators considered opening of MPP at right time as most important, 43 per cent of MPP operators perceived washing of hands and cleaning of cans as most important and 43 per cent of MPP operators have mentioned cleaning the equipment before testing and milk pooling as important. Perception of MPP operators on importance given to operative activities reveal that 50 per cent of MPP operators considered maintenance of timely procurement as most important, 63 per cent perceived sampling of milk from each farmer as most important, 60 per cent have mentioned testing of milk samples of each milk producer during procurement as most important, 70 per cent considered transfer of milk into milk carrying cans as most important and 60 per cent have mentioned acknowledging the recorded values to the milk producers as most important. Perception of MPP operators on importance given to post-operative activities reveal that 60 per cent of MPP operators considered filling the milk carrying cans as most important, 47 per cent perceived proper fixing of the lid as important, 50 per cent have mentioned loading milk carrying cans into vehicles as not important, 37 per cent considered sanitizing the MPP as most important, 60 per cent have mentioned maintenance and correction of recorded data as most important and 57 per cent considered reporting any delays at MPP to BMC unit as most important.

Awareness of MPP operators on importance given to pre-operative activities was high only among 36.7 per cent of MPP operators while around 63.3 per cent of MPP operators awareness levels on importance given to pre-operative activities lies between low to moderate. Awareness levels of MPP operators on importance given to operative activities was equal among all the 30 MPP operators *i.e.*, 33.3 per cent. Awareness levels of MPP operators on importance given to post-operative activities was high only among 40 per cent of MPPs while around 60 per cent of MPP operators awareness levels on importance given to post-operative activities lies between low to moderate.

Time motion studies reveal that the total trip time in route-1 to travel the distance of 48.5 kilometers from BMC unit to cover nine milk pooling points and returning back to BMC unit was 85 minutes and 10 seconds and it was less than the schedule time of 90 minutes. Time motion studies reveal that the total trip time in route-2 to travel the distance of 28.5 kilometers from BMC unit to cover 11 milk pooling points and returning back to BMC unit was 86 minutes and 49 seconds and it was less than the schedule time of 90 minutes. Time motion studies reveal that the total trip time in route-3 to travel the distance of 20.3 kilometers from BMC unit to cover 10 milk pooling points and returning back to BMC unit was 78 minutes 28 seconds and it was less than the schedule time of 90 minutes.

The average cost of raw milk transportation per day from milk pooling points to BMC unit was 51 paise per litre per kilometer in route-1, where as in route-2 it was 22 paise per litre per kilometer and in route-3 it was 18 paise per litre per kilometer.

The major constraints faced by the transport operators were unwanted waiting times at MPPs and improving price fixed by the company per kilometer in raw milk transport as per raising fuel prices. Awareness of transport service providers cum drivers on timely milk collection and spoilage of milk due to delay reveal that they were aware about timely collection of milk cans from MPPs and optioned as most important activity. They are aware that any delay in transportation of cans to BMC unit would spoil milk. The transport service provider-cum-drivers were not willing to accept any responsibility for quality milk collection as they confine themselves as transporters only not as stakeholders in the value chain. All of the transport service providers thought that they were always willing to maintain schedule times as indicated for the routes. Further they are aware about the importance of handling milk cans properly and Showing utmost care. The transport service providers-cum-drivers are aware and always practicing fuel filling before stating time, willing to repair and service vehicles regularly and never driving the vehicle over speed to achieve schedule time.

Optimization of routes through Travelling Salesman Problem reveal that in route-1 the optimized distance is 48.2 kilometers, time travelled to cover all the milk pooling points is 83.5 minutes and the total cost per trip is around 345 rupees. In route-2 optimized distance is 26.7 kilometers, time travelled to cover all the milk pooling points is 76 minutes and the total cost per trip is around 191 rupees. In route-3 optimized distance is 18.4 kilometers, time travelled to cover all the milk pooling points is 71 minutes and the total cost per trip is around 132 rupees.

A comparison of the distance, time and cost in the optimized routes with existing routes reveal that there was a significance reduction of total distance, time and cost in raw milk transportation for the identified bulk milk cooling unit with the optimization of routes was observed. Throughout the year an annual cost saving of 20,356 rupees per annum for the identified BMC unit could be achieved.

Proposed schedule times of MPP operations and vehicle for optimized routes reveal that the proposed schedules aims to procure milk from MPPs to BMC unit within a schedule time of 90 minutes in all the routes without any delays through optimization of distance, time and cost.

RECOMMENDATIONS:

- Developing futuristic solutions based on smart mobile application for live temperature and time tracking of cans by using RFID or GPS tags or QR codes integrating with mobile application based reporting system would lead to digitalization of operations at MPP level eliminating avoidable delays leading to bench mark standards in achieving maximum efficiency in milk procurement. Implementation of QR code or Bar code tagging on the milk collection cans would enable to capture vital information about the quality and quantity of milk inside the cans to improve transparency.

- The results of awareness levels of MPP operators emphasize the need for training programs, result oriented demonstration, role plays and posters display to be organized on regular basis to increase awareness on importance of operations at MPP level.

- To create awareness among milk pourers and MPP operators on importance of timely milk procurement, avoiding delays in MPP operations and holding the collected milk beyond slot times at the MPPs, wall painting of pictorial messages should be painted on the wall of MPPs. The same should be stressed in all training programs and meetings conducted for milk pourers and MPP operators by FPO.

- The emphasis on increasing awareness on timely milk collection and spoilage due to delays among the farmers and MPP operators could be achieved through introducing activities like pledge taking, slogans during various events, trainings and general body meetings conducted by FPO.

- Introduction of Smart mobile application for GPS based operation punching method for timely following schedules preventing unwanted delays at MPP operators, transport service providers and BMC operator would be more effective to sustain timely milk collection.

- A digital rating system may be designed based on various parameters for efficient milk procurement practices for timely milk collection. The MPP operators and transport service providers may be rated on the system and identify the best performing MPP operators and transport service providers on consistence of performance and recognize them through prizes or certificates during general body meetings or company events.

Chapter –I

Introduction

Chapter I

INTRODUCTION

Dairying activity in India dates back around 8,000 years ago with domestication of cattle. Even though dairying has been prime activity in Vedic period, those days increase in dependency on agricultural activities confined dairying to meet subsistence needs of the family. Introduction of modern milk processing technologies, establishment of National Dairy Development Board (NDDB), cooperatives and revolutionary initiatives like "Operation Flood" have commercialized Indian dairy industry. Today dairying is resilient in contributing a promising share to farm household incomes suffering from fragmentation of land holdings and drought conditions.

India is the world's largest producer of whole fresh buffalo milk with 71.67 per cent share in world's buffalo milk production, it ranks 2nd in whole fresh cow milk production with 12.38 per cent of world's whole fresh cow milk production after to USA (MOFPI, Annual Report 2018-19). Dairy industry in India has a large growing domestic market and plays a vital role in agribusiness as it has broader social and economic dimensions. About 70 million rural households are engaged in dairying, with one of every two rural households have women contributing significantly to Indian dairy sector (National Action Plan for Dairy Development, VISION-2022).

Under the Phase I of the National Dairy Plan, measures were taken to increase the productivity of milch animals through scientific breeding and nutrition to meet rapidly growing milk demand. It is essential to ensure that the increased milk quantity is duly tapped by the organized dairy segment through enduring a fair and transparent quality milk procurement system to protect the interest of rural milk producers and consumers well-being. In organized dairy sector, cooperative sector retains 50 per cent share of the marketable surplus extrapolating the importance of these producer driven value chain. The new generation cooperatives namely Farmer Producers Organizations (FPO's) are working to play their role in integrating across the producer driven milk value chains.

Traditionally, dairying has been treated as an allied activity to generate supplementary income to farm income. However, due to uncertainty in changing climatic conditions, highly volatile market prices, highly fluctuating share of farm income compared to income from dairying which is more stable, consistent and spread throughout the year have made it sustainable income for rural livelihoods and motivating rural households to take up dairying for sustenance. Community models like Self-Help Groups (SHGs), Cooperatives, Farmer Producer Organizations (FPOs) are contributing in developing dairy sector with various interventions like huge investments making it a commercially viable livelihood option which aids in building access to fairly priced quality inputs, enhance capabilities of farmers for modern dairy farming practices and improve market linkages, thereby creating sustainable livelihood in villages. Indian dairy sector is mainly comprised of milk producers who are primarily small and marginal farmers including landless labourers who are instrumental in shaping the outlook of sector, the organizational nature of co-operatives and Farmer Producer Organizations (FPOs) are enhancing their capabilities in this sector.

The success of dairying depends on four components which include production, procurement, processing and distribution of milk and its products. Among these four components, milk procurement plays a major role. Milk pooling activities under National Dairy Plan (NDP) broadly consists of milk collection, testing for quality and payment to producers for the milk supplied. It is essential that the milk collected is measured and tested in the presence of producer members with standardized, duly calibrated equipment (electronic weighing scale, analyzers and lactometer etc.,). Payment to the milk producers is done through cash on daily basis, shift-wise or cycle-wise (it may be weekly, fortnightly or10 days). To ensure that milk producer members get their payment promptly and accurately. Considering India’s tropical climate, milk is highly perishable and handling of raw milk is the most critical activity in entire dairy value chain. Poor handling of raw milk at the village level impacts quality and safety of milk. Efficiency in milk procurement greatly depends on the operations namely developing a network for collection, transportation and cooling of milk and these can be attained through employing optimized routes considering various factors like fleet size, capacity of vehicles, spatial variation, timely payment to fleet organizers *i.e.*, transport service providers etc. It is essential to optimize time, distance from Milk Pooling Points (MPP) where milk collection takes place to Bulk Milk Cooling (BMC) units. Manual milking is a common practice among farmers, who put their extracted milk in stainless steel milk cans and bring the milk to milk pooling points (MPP), where the milk is collected in large stainless steel cans of 40 litres.

On an average 100 to 200 litres of milk is pooled from each village. Pooled milk from villages is carried in light motor vehicles daily to BMC unit, which is located in the range of 30-40 km. These operations are carried out under normal temperatures. At this level use of cold chain is highly unviable and costly affair due to scattered availability of milk in small quantities. In BMC units milk will be chilled to 4^{o}C within two to three hours from milking, chilled milk from BMC units is transported to dairy plant for further processing which is located within 100 to 150 km from BMC units in large insulated tankers under controlled temperatures of 4^{o}C and the collected milk is processed within a maximum period of eight hours (*Source*: National Action Plan for Dairy Development, VISION-2022).

Thus optimization of time, cost and distance from MPPs to BMC unit results in restriction of bacterial growth in milk so it reduces souring and other quality deterioration of milk, this improves the quality of milk received at the dairy plant which leads to manufacturing of high quality milk and milk products. Organizations owned and controlled by farmers are the most appropriate institutional form to mobilize them and build capacity of farmers. In Indian dairying sector, FPOs can play an important role in integration of small & marginal farmers in modern dairy value chain. FPOs have enabled member control throughout the dairy value chain- i.e. milk procurement, processing & marketing, especially reduction of overall production cost, quality enhancement will give competitive advantage and directly increase income level of farmers who are major stakeholders in FPO owned dairy unit. An FPO owned dairy unit called Shreeja Mahila Milk Producer Company is identified in South India located in Chittoor district of Andhra Pradesh with its headquarters at Tirupati and it has been operational since 2014. The area under milk procurement for this FPO is gradually increasing in the district, hitherto, just a few studies have been conducted especially on vehicle routing in the firm. A detailed study in this regard would help this FPO owned dairy unit to have first-hand knowledge on the serious impediments being faced during procurement of raw milk from rural areas and outcome of the study would be rewarding to the milk producers. Hence this study is taken up through a research entitled "Route Optimization for Efficient Milk Procurement by FPO Owned Dairy Unit" to understand current operations in milk pooling, to estimate cost, time and distance of raw milk transportation from the village level till it reaches the cold chain and to understand constraints during procurement *i.e.*, especially during raw milk transportation in rural areas. Objectives of the study are as follows:

1.1 OBJECTIVES OF INVESTIGATION

1. to study the current operations at village level milk pooling points.
2. to estimate time, cost and distance of raw milk transportation to bulk milk cooling (BMC) units.
3. to understand constraints during transportation of raw milk to bulk milk cooling (BMC) units.
4. to optimize routes for efficient procurement of raw milk from rural areas to bulk milk cooling (BMC) units.

1.2 SCOPE OF THE STUDY

The results of the study focus on optimization of routes for efficient milk procurement. This study helps the FPO owned dairy unit to have first-hand knowledge on the serious impediments being faced during transportation of raw milk from rural areas and outcome of this would be rewarding to the milk producers. The findings will be useful to fleet organizers, academicians and FPO.

1.3 LIMITATIONS OF THE STUDY

Any work will always be confronted with various bottlenecks. Consequently the present study was not an exception to these limitations. The study was based on primary data and secondary data. As the study was done by single person during the lean season and in between outbreak of covid-19, it was confronted with limitation of time, fund, covid-19 pandemic and other facilities. Inspite of all these limitations, utmost care was taken in collection of reliable data.

1.4 PLAN OF PROJECT

The research study is organized into five chapters. The chapter I provides a brief introduction along with specific objectives. In second chapter, previous studies are reviewed and presented in consonance with the objectives. Chapter III describes main features of the study area, sampling size, and analytical tools and concepts terms employed in the analysis of the data. The results obtained are presented in chapter IV. An overview of the work is done with conclusions was given in the last chapter i.e., summary and conclusions.

COMPANY PROFILE

Shreeja Mahila Milk Producer Company Limited (Shreeja MMPCL) is the world's largest only women milk producer company, with Head Office in Tirupati, had started functioning from 15th September 2014. Its operations are spread over the districts of Andhra Pradesh and bordering villages of Karnataka and Tamil Nadu, covering about 1350+ Revenue Villages with a membership of about 74,000+ through 3,000+ Milk Pooling Points, planned to grow current membership base to 0.84 lakhs by 2019-20 and to grow from approximately Rs. 415 cr. in 2018-19 to around Rs. 500 cr. in 2019-20.

Shreeja MMPCL was formed with the objective of maximizing returns to its members through professional management and by harnessing capital, markets and technology thus ensuring business growth without undermining the basic Cooperative principles of democratic governance and autonomy.

Vision 2025

Vision statement of Shreeja Mahila Milk Producer Company Limited is "Shreeja Mahila Milk Producer Company Limited will be among the top 10 Dairy Enterprises in the country."

Mission

Mission statement of Shreeja Mahila Milk Producer Company is "we are committed to benefiting our members by providing them a competitive price for the milk supplied and services to increase milk productivity as well as reduce the cost of milk production."

Values

- Goal Driven
- Transparency
- Innovation
- Quality in every aspect
- Trust and Team Work

- Honest and Accountability
- Passion for Excellence

MPP Milk Collection

Shreeja MMPCL is sourcing the best quality of milk from 1350+ revenue villages spread across the four districts of Andhra Pradesh viz. Chittoor, Nellore, Cuddapah and Anantapur through its 3000+ state of the art milk pooling points (MPPs). The quality is checked as per the set standard operating procedures using analyzers and Data processing units at the MPPs. The pourer is also provided with a printed receipt denoting the quality and quantity of milk at the time of milk collection at MPPs. The milk is collected in food grade stainless steel cans at the MPPs and are sent to BMCUs.

BMCU

The milk has to be chilled after pooling, to retain its quality hence the pooled milk is sent to a Bulk Milk Cooling Unit (BMCU) after pooling. The capacity of BMCU is from 1Kilo Litres to 5Kilo Litres of Milk Storage. Milk is weighed and the quality is checked in the BMCU again to ensure the quality. The Milk is placed in a SILO and with compressors the milk is chilled to 4 degrees within 2 to 3 hours. These BMCU's are operated by professionals and the quality of the milk is reassured at the BMCU level. From the BMCUs, the milk is transported to the plant location in stainless steel tanker Lorries.

Chapter – II

Review of Literature

Chapter-II

REVIEW OF LITERATURE

To attain comprehension on any study, it is necessary to review various concepts, research methodology and analytical tools used by the researcher in earlier studies conducted by them. The findings of earlier studies would give researcher in setting appropriate hypotheses, objectives and enable to evaluate the validity of own findings. This attempt would also help the researcher to have better understanding to modify and improve the analytical framework in the right direction to suit the problem at hand. This chapter briefly reviews findings of the past studies which are relevant to the present study. In this chapter an attempt has been made to summarize the results of the research related to objectives of the present study. The review have been grouped in the following sub-heads.

2.1 Studies on operations at village level milk pooling points

2.2 Studies on estimation of distance, time and cost during raw milk transportation.

2.3 Studies on constraints involved in raw milk transportation, and

2.4 Studies on optimization of routes in perishables

2.1 STUDIES ON OPERATIONS AT VILLAGE LEVEL MILK POOLING POINTS

Demirbas *et al*. (2007) conducted a study on knowledge and practices in milk collection centres (MCCs) of Turkey. It was reported that milk collection centres played an important role between the dairy farming and dairy industry in Turkey. MCCs, when rationally managed can supply safe, quality, adequate and low cost milk for the dairy industry. After examining the knowledge levels, practices and perceptions of the MCC managers the authors of the study determined that the knowledge level of MCC's managers on food safety, quality and practices was in adequate. Thus the authors conclude in their study that in order to assure food safety in the milk sector, the managers and staff of the MCC's as well as farmers and also the staff of processing facilities must be informed on food safety, food codex and regulations and practices.

Demirbas *et al.* (2009) worked on practices in milk collection centres (MCC) for quality milk production: a case from the Aegean region of Turkey to demonstrate the role of MCCs in supplying good quality, safe milk to the Turkish dairy sector. The study reported that MCCs played an important role in supply of high-quality, safe and adequate raw milk required by dairy processing firms and thus acted as a bridge between the dairy farms and dairy processing industry. As MCCs were small and medium sized, raw milk analyses cannot be fully achieved due to absence of qualified personnel and equipment inadequacies. The study recommended for provision of subsidies and incentives for purchase of necessary technical equipment useful to determine the quality of the milk supplied to MCCs.

Raheem (2010) reported that the prevailing supply chain management system in milk collection and distribution across Pakistan was very old and traditional and needs an overhaul. To formalize and improve the industry, a private sector led 'Pakistan Dairy Development Company' has emerged with guarantee backup by government of Pakistan. The platform proposes to improve the dairy sector through improved research facilities, training and capacity building of farmers, training veterinarians, improving cold chain through milk chillers, promoting healthy pasteurized milk, develop model commercial dairy farms, focus on breed improvement, facilitation of credit financing to dairy farmers and linking the rural area based farmer to the market mechanism. Thus the author opinioned that this initiative shall improve and formalize the dairy sector in Pakistan.

Kumar and Mohan (2014) attempted to understand the conceptual frame work in prevailing models of dairy supply chain management practices in the Indian dairy market. The major findings of the study were an increased competition was seen between supply chains rather than individual companies and management of dairy supply chain held to be key in maintaining firm's competitiveness. The study recommended that designing and operating efficient dairy supply chain through the use of information technology, will further help dairy companies to achieve competitive advantage through improved organisational performance.

Subburaj *et al*. (2015) conducted a study on strengthening the operational efficiency of dairy supply chain in Tamil Nadu state and identified five focus areas namley creation of special dairy zone, implementing dynamic milk procurement method, strengthening cooperative societies, creation of feed bank and increasing fodder productivity, integrated animal health plan and information technology.

Amentie *et al.* (2016) conducted a study on milk post-harvest handling practices across the supply chain in Eastern Ethiopia. The study revealed that the majority of milk handling operations in the study area was carried out by females. The majority of respondent milk producers (87.5-92.5 per cent), collectors and transporters (88.9-100 per cent), vendors (77.5-90.7 per cent) and some consumers (37.5-47.5 per cent) performing milk handling operations were illiterate. Most of the respondent milk producers (87.5-97.5 per cent), all traders and some consumers (12.5-32.5 per cent) were using plastic containers for milk handling. Milk was transported to market places using poor means of transportation such as donkeys, small vehicles not equipped with refrigerators. In almost all cases delivery of raw milk to the next actors was carried out in the open sunshine and at roadsides on the ground. In general, the study indicated that milk handling activities performed across the supply chain in the study area were unhygienic and therefore suggested the need for improving hygienic practices.

Daburon *et al*. (2016) in their study on evolution of milk sheds and role of alternative milk collection centres in Egypt analysed that, evolution over the past 50 years was divided into four phases: before 1980, dairy products were primarily sold on the local market; from 1980 to 2000, a "milk shed centred" development drove the dairy sector, from 2001 to 2011, the sector was driven by the demand in Greater Cairo and since 2011, the arrival of the agro-industry, in association with a non-governmental organization began setting up milk collection centres within producer's organizations which had introduced new dynamics in local milk collection. Locally, the development of collection centres led to a rise in milk prices, hygiene conditions and improvement of milk quality. During the study period, the agro-industry was struggling to penetrate into the highly competitive local milk collection centres, indicating as uncertainty in the model. Finally, the authors recommended for building inclusive value chains for benefit of both the investing company and local stakeholders that could contribute to a more sustainable territory.

Devi and Devi (2017) conducted a study on milk procurement in Andhra Pradesh state. The study reported that through the adoption of innovative strategies in milk procurement like installation of bulk milk chillers (BMC), automated milk collection units (ACMU), data processor-based milk collection units (DPMCU), state milk grid and quality assurance plan (QAP) for procurement oversight and to address quality assurance challenges like detecting possible adulteration, determining milk purchase price for each of the milk producers at the purchasing point in real time and ensuring milk producers maintenance of hygiene while bringing milk to collection centers.

Selvam *et al*. (2017) in their study on performance assessment of milk procurement co-operatives (MPCS) in Tamil Nadu state reported that milk procurement and its marketing was largely dependent upon unorganized channels and the performance of milk procurement co-operatives (MPCs) particularly in milk procurement and its distribution were essential in order to keep the interest of various stakeholders *viz.*, farmers, consumers and dairy co-operatives in particular. The results of the study revealed an unwelcoming trend of decrease in the procurement of milk by milk procurement co-operatives.

Kotnala and Kumar (2018) conducted a study on milk procurement pattern in Nanital district of Uttarakhand state. The findings of the study reported were procurement pattern showed an increasing trend in the monthly procurement of milk and identified major factors affecting milk procurement. The milk procurement was at peak in the month of March and lowest in June month (summer season). It has been found that procurement of milk was usually low in lean season thereafter rising progressively in mean season followed by flush season. The study reported that as seasonality factor affects the level of milk procurement, imparting training to farmer members at primary level shall help in increasing of milk procurement followed by improvement in processing and distribution of milk.

2.2 STUDIES ON ESTIMATION OF DISTANCE, TIME AND COST DURING MILK TRANSPORTATION

Rangasamy (2001) studied economics of milk procurement in a cooperative dairy plant in Tamil Nadu state and reported that average procurement cost of milk was Rs. 1.43 per litre. The share of collection, transportation, chilling and reception cost were observed to be Rs. 0.68, 0.42, 0.28 and 0.05 per litre, respectively. The study concluded that milk procurement cost could be reduced by increase in the quantity of milk procured.

Rangaswamy (2005, a) studied the cost of transportation of milk in a co-operative sector dairy plant in Tamil Nadu state. In the study it was seen that by installing bulk coolers vehicles transport the milk from collection centres to plant only once per day. He suggested that underutilization of tankers should be avoided, efficient route planning should be done to reduce the distance covered by vehicle and perfect links should be maintained between the subsidiary and main route.

Rangaswamy (2005, b) studied on cost of transportation of milk in a co-operative sector dairy plant in Tamil Nadu state. He concluded that the average cost per litre of transportation of raw milk from collection centres to plants directly and from collection centres to chilling centres was the same 37 Paisa. The average cost per litre of transporting of milk from chilling centre to plants was found to be 5 Paisa.

Rangasamy and Dhaka (2007) reported that efficiency of milk procurement was heavily dependent on the operational efficiency *viz.,* milk collection, transportation, chilling and reception of milk. The per litre procurement cost of milk was higher in co-operative dairy plant than the private dairy plant and the same increased between flush, transitory and lean seasons. It could be attributed to increase in the reception cost of milk and marginal increase in transportation cost of milk in the co-operative dairy plant. Finally they suggested that efforts should be made to install bulk milk coolers in rural areas to facilitate reduction in transportation cost. Co-operative dairy plant should make regular payments or advance payments to milk producer members and can avoid members selling milk to private dairy plants or milk vendors. Development of efficient milk collection centres and transportation networks at farmer's level by co-operative dairy plant would help strengthen the linkages between dairy farmers and dairy industry.

Brar and Saini (2011) in their study on milk run logistics discussed about the procurement system to present an over view of its implementation practices adopted by manufacturing organizations. Milk run system is all about logistics support for the supply chain. Milk run system results in reduction in cost of transportation, travelling path and fuel consumption. The authors finally concluded that by introducing the milk run logistics under heavily congested traffic conditions, the supplier can have full control on the procurement process. Also, the number of trucks on road can be reduced thus resulting in improvement in traffic conditions.

Quinlan *et al.* (2012) conducted a study on milk transport costs under differing seasonality assumptions for the Irish dairy industry. The study revealed that total milk transport costs were not very sensitive to seasonality. Savings in total transport costs of 3-4 per cent were obtained when switching to less seasonal milk supply pattern and increases in transport costs of 1-2.5 per cent were incurred when a more seasonal approach was followed. As milk output increased, savings in total milk transport cost increased from €1.5 to €2.2

million per annum when a more even milk supply was adopted and when a more seasonal milk supply pattern was simulated (volume effect) savings in total milk transport costs increased from €0.5 to €1.5 million per annum. In this paper, authors examined only the impact of even milk supply patterns on milk transport costs and suggested that supplementary studies on the impact of an even milk supply on production costs and processing costs are essential before any definitive decisions are made on the optimum milk supply for the Irish dairy industry.

Chauhan *et al*. (2015) conducted a study on value chain analysis of milk and milk products in milk-shed area of Ballabhgarh milk plant located in Faridabad of Haryana state. The findings of the study revealed that out of total cost involved in milk procurement, the cost of transportation was highest *i.e.*, Rs. 1.11 per litre of (66.47 per cent) followed by chilling cost accounting to Rs. 0.12 per litre).

Belmar *et al*. (2016) in their study on milk collection problem with blending by a firm, located in south of Chile indicated that the cost of collecting milk from producers in the milk production supply chain had a significant impact on profit. Milk producers were frequently scattered over extended rural areas, sometimes far from processing plants, making transportation cost a relevant component of total cost.

Ruangwittayanusorn *et al*. (2016) in their study on monitoring the hygiene of raw milk from farms to milk retailers reported that after milking, raw milk samples were collected for standard plate count (SPC) test. Additionally, the time for milk transportation, environmental and milk temperatures in milk bucket were also recorded. These parameters were repeatedly recorded at milk collection centre (MCC) before being poured into the bulk tank. Cooled raw milk in the bulk tank was sampled before packed in five kg plastic bag and carried to nine milk retailers in town. The results found that the average time for milk transport from dairy farm to MCC was 76.29 minutes. Milk temperatures decreased from farm to MCC for all seasons. The average time taken for milk transportation from MCC to milk retailers was 89.44, 178 and 156.11 minutes in summer, raining and winter seasons respectively. Other recommendations of the study included were more attention to be paid to milk hygiene and temperature during milking by milk producers, especially in the summer season. The microorganism could grow rapidly during milk transportation from farm to MCC in raining season. Thus, cooling down the milk or rapid delivery of milk bucket to MCC should be considered seriously.

Sethanan and Pitakaso (2016) conducted a study on differential evolution (DE) algorithms for scheduling raw milk transportation for determining routes for raw milk collection from collection centres to dairy factories with the objective of minimizing the total costs. The authors considered the study not only to be a special case of the vehicle routing problem (VRP) but also as a complex one when compared to the general VRP, since each vehicle contained more than one tank with heterogeneous capacity to collect raw milk and raw milk from different collection centres cannot be transferred into the same compartment. The computational results revealed that the modified DE algorithms were used to yield higher relative improvement (RI) on the total costs and also there is RI on the number of vehicles used. Thus they conclude in their findings that the proposed method was useful not only for reducing cost, but also for efficient management of number of vehicles used.

Gawali and Gadekar (2017) in their study on enhancing milk collection and transportation efficiency using milk run concept in a cooperative milk processing plant reported that the milk run concept was one of the useful strategy in bringing improvement in transportation and milk collection efficiency, in reducing milk wastage, transportation and labour cost. Application of the milk run concept positively helped in elevating the dairy plant performance through building cost competitiveness and improving profitability.

Weerasinghe *et al*. (2017) in their study on factors affecting the quality of raw milk in small farms of Sri Lanka revealed that time taken for transportation of chilled milk and improper field level practices contributed for bacterial density in raw milk. They finally concluded that time taken for transportation of chilled milk was a major factor affecting microbial load at the reception of milk at the processing factory and recommended to maintain good field level practices to improve the quality of milk.

2.3 STUDIES ON CONSTRAINTS INVOLVED IN RAW MILK TRANSPORTATION

Rajendran and Mohanty (2004) revealed that involvement of intermediaries, lack of bargaining power by the producers, lack of adequate infrastructure facilities for collection, storage, transportation and processing were identified as the major constraints faced by the dairy co-operatives in milk marketing, thereby affecting the prices received by producers. The study concluded that milk quality, product development, infrastructure support development and global marketing would be future challenges of India's milk marketing.

Babu (2010) in his study on constraints faced at milk procurement, processing and marketing levels identified that poor road conditions for milk haulage was the main constraint among milk transporters of a co-operative plant. The researcher suggested that farmers should be educated on the importance of quality milk and getting better prices for the milk supplied and also supplying sufficient quantity of raw milk to the processing units and getting quality processed product for their co-operative society and thereby sustaining co-operative efforts in milk processing necessary aspect.

Sharma and Kalla (2010) in their investigation to determine the constraints perceived by the personnel engaged in processing of milk at union level in 'URMUL' milk union found that less volume of milk was procured for processing in comparison to installed capacity of the plant due to poor quality of milk which is containing acidity suspended foreign material. The results further indicate that the constraints of union personnel were found negatively and significantly associated with their in-service training and job satisfaction.

Hegde *et al*. (2014) conducted a study on design of mobile raw milk chilling unit for rural areas and revealed that transportation of raw milk from village to the dairy requires lot of care, as there was no chilling unit at the village collecting centre. They found that freshly collected raw milk at village co-operative societies was transported to chilling unit in the route specified by the milk federation. In such a chilling unit, milk collected from many such routes was chilled and then transported to secondary processing unit once a day. In this paper the authors indicated that since the quantity of milk collected was less (40 – 200 liters), chilling does not take place at village co-operative societies as bulk milk chillers were not suitable for this purpose at this level. In the study they also found that the current raw milk transport method was not hygienic and loading-unloading methods were very crude without ergonomic consideration. Thus, the authors suggested to transport raw milk in a refrigeration system with a proper layout while storage facility for milk cans and handling equipment will reduce the effort and time required to load and unload the milk cans.

Meena *et al*. (2017) conducted a study on problem and prospects of dairy industry revealed that productivity of Indian dairy animals was lower compared to other countries, lack of scientific livestock feeding practice, improper milk marketing facilities and uncertain price of milk for producers, inadequate infrastructure for milk collection, transportation and processing, lack of adequate veterinary and extension services, milk losses due to lack of cold chain facilities, lack of sufficient milk production standards and clean milk production practices and few private companies on large scale due to lack of incentives were the problems of Indian dairy industry.

Roman (2018) conducted focused interviews with chairmen of cooperatives and directors for purchase and transport of milk in six dairy plants in various parts of Poland to identify problems with the logistics of supplying dairy plants. Based on the research conducted, the problems identified were the number and size of the suppliers, seasonal character of milk production, continuous collection of milk, the suppliers location and problems with the organisation of transport.

Wanjala *et al*. (2018) in their study on coliforms contamination and hygienic status of milk chain in emerging economies. The author indicated that the population was at risk of illnesses from food-borne pathogens as a result of poor milk handling along the informal milk value chains. The regulatory bodies from these low and middle income countries were usually underfunded; therefore the safety standards of the milk chain cannot be sufficiently provided, endangering public health. The author finally emphasized that low and middle income countries have to invest in infrastructures and establishments such as potable water supply to the dairy actors, improve the transport infrastructure, increase the electricity connectivity from national grid and off-grid and financial support of the standards regulatory institutions.

Lipińska *et al*. (2019) in their study on identifying factors associated with food losses during transportation conducted in a large dairy cooperative in Poland, revealed that it was possible to recover 25.08 tons of dairy products during transportation. Taking into account the total weight of the cargo carried by all the transport units during the analysed period, which was approximately 0.5 per cent of the full load capacity of all transport units in a two-year period.

Zirmire and Kulkarni (2019) in their study identified the constraints faced by milk processing units from Karnataka and Maharashtra states at collection centre and transportation level. As revealed by Garrett scores, the study indicated poor quality of the milk, lack of availability of sufficient quantity of raw milk, delayed payments by collection centre and high transportation cost were the most serious constraints faced by the collection centre and at transportation level.

2.4 STUDIES ON OPTIMIZATION OF ROUTES IN PERISHABLES

Hahsler and Hornik (2007) in their study on infrastructure for the Traveling Salesperson Problem (TSP) revealed that TSP was a well-known and important combinatorial problem. The goal was to find the shortest tour that visits each city in a given list exactly once and then returns to the starting city. Finally they introduced R package TSP providing a basic infrastructure for handling and solving the traveling sales person problem.

Hsu *et al*. (2007) conducted a study on vehicle routing problem with time windows (VRPTW), by considering the randomness of the perishable food delivery process and constructing a specialized vehicle routing problem with time windows (SVRPTW) model, with an objective to minimize not only the fixed costs for dispatching vehicles, but also the transportation, inventory, energy and penalty costs for violating time windows and to obtain optimal delivery routes, loads, fleet dispatching and departure times for delivering perishable food from distribution centre.

Ngigi *et al*. (2012) conducted a study on GIS in logistics and transportation for a Dairy Co-Operative Society in Kenya. This study was carried out to address milk collection challenges of a local rural dairy company in Kenya which involved determination of optimal routes in milk collection chain with 10 routes and 40 collection centres. The milk processing factory, collection centres, road network, trading centres were mapped from both primary and secondary data sources. A topologically clean geometrical network dataset of the roads were created together with vehicular information. The most economical and efficient routes were determined through the application of vehicle routing problem (VRP) solution in a GIS environment. A comparison was undertaken to compare the current costs in terms of time and distance which revealed substantial saving in time and distance if the dairy could adopt the vehicle routing problem (VRP) solution. From the results, it was evident that application of GIS and logistics in route planning and scheduling would bring benefits to the dairy company both in terms of cost reduction and quality improvement.

Lemma *et al*. (2014) in their study on optimization approach for loss in perishable food supply chain indicated that 20 to 60 percent from the total production was lost in the food supply chain, so the authors presented a review of literature with respect to perishable supply chain management modelling and optimization approach focusing on loss minimization along the supply chain. In the study authors revealed that researchers would give more attention to maximize the availability of food products, and as a result thought to use different operation research tools to optimize the food supply chain to support decision making process.

Scaria and Joseph (2014) conducted a project on optimization of transportation route for a milk dairy in Kerala state in India. The study revealed that finding out efficient vehicle routes for milk distribution was an important logistics problem. In food supply chain, it was observed that the products like milk had very short life span and easily perishable, so they designed new transportation routes for the delivery of milk at all the nodes in each route with minimum distance, transportation cost and investment on the vehicles used for the transportation. Hence concluded that if the total distance covered in each route is reduced by employing optimized design, then the total expense of transportation in each route will be reduced as total distance will be reduced.

Bornare *et al.* (2016) in their study revealed that travel times from production place to utility has an important effect on quality and freshness of perishable items. As the choice of routes are dependent on the shelf life of the products so as to prevent losses, decisions pertaining to optimal routes, schedules of delivery and number of vehicles to be used play a major role for retaining the freshness of the produce. Hence, for efficient flow of materials and information between the stakeholders of supply chain, the authors recommended to integrate supply chain operations to make a strong presence and being competitive in global market while reducing the operating costs.

Singhal and Pandey (2016) in their study on travelling salesman problem by dynamic programming algorithm illustrated a travelling salesman problem which was solved to make clear the proposed method. The study concluded that the proposed method was very easy to understand and apply to find optimal solution of travelling salesman problems occurring in real life situations.

Erdoğan (2017) in his research found that vehicle routing problem (VRP) was one of the most frequently encountered optimization problem in logistics and through his research paper the author introduced VRP Spreadsheet Solver, an open source Excel based tool for solving many variants of the vehicle routing problems. It was concluded that the author would believe in VRP Spreadsheet Solver to have the potential to be used throughout the world due to its ease of use, flexibility, and accessibility and achieve savings for many small and medium entreprises (SMEs).

Caria *et al*. (2018) conducted a study on modelling the collection and delivery of sheep milk in Sardinia found that the presence of about 12,000 dairy sheep farms, located in rural areas with poor condition of road network, made collection of milk a significant impact on profit, affecting the costs of milk transportation. The authors in their study revealed that dairy sheep farming was characterized by seasonal production, which meant that the amount of milk produced by each farm differs significantly over the year. They also revealed that a tool was developed using GPS map location and milk volumes of farms to calculate the cost per litre of milk for regular routing, and to recalculate the same cost for the optimised collecting route. Results of the study showed that the tool improved efficiency of milk collection, reducing the number of routes and the driving distances.

Connor *et al*. (2018) in their study on distance optimization of milk transportation revealed a desktop milk collection route simulation model which focused on the development of optimal routing plan for a designated fleet of articulated lorries (trucks) and tankers used in the collection, transportation and varying seasonal delivery patterns of milk from farms to processors over a national road network vis-à-vis, the Irish road network. The authors reported that the model was devised to encompass a broad spectrum approach tasked with the efficient solving of numerous variations of the well-known vehicle routing problem (VRP) across multiple environments and was also designed to robustly cater for the specific characteristic needs that uniquely occur within the Irish dairy industry. Furthermore, the model was designed with the intention that future research can use this base model as a cornerstone for more in-depth research in the ever-evolving area of milk assembly.

Chokanat *et al*. (2019) in their research to solve the problem of raw milk collection and transportation system identified that transportation cost directly depends on the fuel usage which occurs during the transportation of the milk and during the waiting time when vehicles arrives at the factory and cannot transfer the raw milk into the production tank. Thus they developed a modified differential evolution algorithm (MDE) to solve the proposed problem. Finally the computational result shows that the MDE outperforms the originalevolution algorithm DE in finding a better solution.

Chapter – III

Material and Methods

Chapter III

METHODOLOGY

This chapter presents the methodology employed in the study. It also deals with the sampling procedure, sources and nature of data and the analytical techniques, which were used in the analysis. These are presented under the following headings.

3.1 Sampling Procedure

3.2 Collection of Data

3.3 Analytical Techniques

3.4 Concepts and Terms Used

3.1 SAMPLING PROCEDURE

3.1.1 Selection of the dairy:

Shreeja MMPCL dairy in Chittoor district was selected purposively as it is the only farmer producer organization (FPO) owned dairy unit operating and supplying milk in South India.

A satellite view of Shreeja MMPCL dairy office (*Source: Google maps)*

3.1.2 Selection of the district:

The present study was under-taken in Chittoor district of Andhra Pradesh in view of presence of highest milk procuring bulk milk cooling (BMC) units in the district.

Chittoor district is a part of Rayalaseema region of Andhra Pradesh. The district occupies an area of 15,359 square kilometers (5,930 sq mts). The district is bounded by Anantapur district to the northwest, Kadapa district to the north, Nellore district to the northeast, Krishnagiri district, Vellore district and Tiruvallur district of Tamil Nadu state to the south and Kolar district of Karnataka state to the west. Chittoor district lies extreme south of the Andhra Pradesh state approximately between 12°37'-14°8' north latitudes and 78°3'-79°55' east longitudes. Thirty percent of the total land area is covered by forests in the district.

3.1.3 Selection of the Bulk Milk Cooling (BMC) unit:

From the selected district highest milk collecting bulk milk cooling (BMC) unit was selected purposively after consultation with the procurement officers in procurement department of the company.

3.1.4 Selection of Milk Pooling Points (MPP):

All the milk pooling points (MPP) were selected purposively based on the villages covered by the bulk milk cooling (BMC) unit.

3.2 COLLECTION OF DATA

For the study both the primary and secondary data were collected.

3.2.1 Primary Data:

Primary data was collected at the village level from the milk pooling points (MPPs). The information on operations at MPPs, distance of MPPs from bulk milk cooling (BMC) unit, timings of procurement and constraints faced by the transport service providers were collected.

3.2.3 Secondary Data:

Secondary data with regard to procurement and quantity of milk supplied were collected from the records of Shreeja MMPCL dairy MPPs and bulk milk cooling (BMC) unit, statistical abstracts, journals, websites among others.

3.2.4 Method of survey:

A well-structured schedule was prepared and questions were posed to each MPP operator or Pala mitra and the transport service provider of the selected bulk milk cooling (BMC) unit on the information associated with procurement. The data were collected by direct interview method and observation. The data collected from the MPP operator or Pala mitra and transport service providers pertaining to the year 2020.

The information on distance and time taken to cover the routes was collected and cross checked with the help of observation sheets framed in the questionnaire through an android application in fourth generation (4G) cellular networking mobile phone called "Speedometer & Odometer- TripMaster Car and Bike". It is a speedometer and odometer application works on global positioning system (GPS) which is a satellite based navigation system in the android mobile of investigator and was used to augment or verify the information provided by the personnel involved in milk procurement in the given study area.

3.3 ANALYTICAL TECHNIQUES

The collected data were analyzed by using statistical tools such as Garrett's ranking technique, PERT (Program Evaluation and Review Technique) Travelling Salesman Problem (TSP) model in Python software, so as to make meaningful inferences.

3.3.1 Tabular analysis

The collected data regarding procurement activities, schedule of operations and other data was presented in tabular form to facilitate easy comparison.

3.3.2 Program Evaluation Review Technique

Program Evaluation and Review Technique (PERT) is a tool that would help a project manager in planning and control. It would enable him in continuously monitoring a project and taking corrective measures wherever necessary.

In PERT, it is assumed that it is not possible to have precise time estimate for each activity and instead, probabilistic estimates of time alone are possible. A multiple time estimate approach was followed here. In probabilistic time estimate, the following 3 types of estimate are possible:

1. Pessimistic time estimate (t_p)
2. Optimistic time estimate (t_o)
3. Most likely time estimate (t_m)

The optimistic estimate of time is based on the assumption that an activity will not involve any difficulty during execution and it can be completed within a short period. On the other hand, a pessimistic estimate is made on the assumption that there would be unexpected problems during the execution of an activity and hence it would consume more time. The most likely time estimate is made in between the optimistic and the pessimistic estimates of time. Thus the three estimates of time have the relationship.

$$t_o \leq t_m \leq t_p$$

Practically speaking, neither the pessimistic nor the optimistic estimate may hold in reality and it is the most likely time estimate that is expected to prevail in almost all cases. Therefore, it is preferable to give more weight to the most likely time estimate.

Hence a weight of 4 to most likely time estimate and a weight of l each to the pessimistic and optimistic times estimates. A time estimate (t_e) as the weighted average of these estimates as follows:

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$

Since 6 units were taken (l t_p, 4 for t_m and 1 for t_o), the sum is divided by 6. With this estimate, one can determine the project completion time. Here in this study this was used for estimation of time delays in MPP operations and average delay in time of MPP operations is arrived.

Measures of Certainty

The 3 estimates of time are such that

$$t_o \leq t_m \leq t_p$$

Therefore the range for the time estimate is $t_p - t_o$.

The time taken by an activity in a project network follows a distribution with a standard deviation of one sixth of the range, approximately.

i.e., The standard deviation = $\sigma = \frac{t_p - t_o}{6}$

and the variance = $\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$

The certainty of the time estimate of an activity can be analysed with the help of the variance. The greater the variance, the more uncertainty in the time estimate of an activity.

3.3.3 Travelling Salesman Problem (TSP)

The Travelling Salesman Problem is a well-known and important combinatorial optimization problem. The travelling salesman problem goal is a given set of cities and distance between them which requires finding the shortest path of visiting each city only once. The goal is to find the shortest tour that visits each city in a given list exactly once and then returns to the starting city.

Min. $z = \sum_{j=1}^{n} c_{ij} x_{ij}$; [i= 1,2,3,…,n, j= 1,2,3,…, n]

Subject to constraints:

(i) $\sum_{i=1}^{n} x_{ij} = 1$; j = 1,2,…, n

(ii) $\sum_{j=1}^{n} x_{ij} = 1$; i = 1,2,3,…, n

Where $x_{ij} = \begin{cases} 1; & \text{if the salesman travel from city i to city j} \\ 0; & \text{otherwise} \end{cases}$

c_{ij} = Distance (or cost or time) of going from city i to city j.

z = Min. The total cost of matrix.

3.3.4 Garrett's Ranking Technique

Garrett's ranking technique was adopted to understand the reasons for extension of slot time beyond the regular timing at milk pooling points (MPPs) operating in villages and reasons for holding the milk beyond prescribed time at MPP. The MPP operators were asked to rank the factors from 1 to 10 giving 1 to the most important reason and 10 to the least important reason.

The order of merit as given by the MPP operators were changed into percent position by using the following formula

Per cent position = 100 (R_{ij} – 0.5)/ N_j.

Where,

R_{ij} = Rank given for i_{th} variable by the j_{th} individual.

N_j = Number of variables ranked by the j_{th} individual.

For each calculated per cent position, scores were obtained from corresponding Garrett's tables.

3.3.5 Construction Indices:

Level 1: Construction Indices

(Based on response obtained on multiple statements)

$$X_i = \sum_{j=1}^{m} X_{ij}$$

X_{ij} = score of j^{th} Statement for i^{th} respondent

J=1, 2…m, no of statements considered

i=1, 2, 3….n, where n=no of sample respondents

(Score is obtained for each respondent)

Index $I_i = \frac{x_i \text{-Mini } x_i}{\text{Max } x_i \text{- Mini } x_i}$, Index lies between zero and one.

Low: value of index is less than Mean – half standard deviation

Moderate: Value of Index lies between (Mean- half Standard Deviation) ≤ I_i ≥ (Mean + half Standard Deviation)

High: value of index is more than Mean + half standard deviation

Based on Value of Index – sample respondents awareness, perception and knowledge levels towards identified parameters can be grouped as Low, Moderate and High.

3.3.6 Focus Group Discussion

Focus group discussion is frequently used as a qualitative approach to gain an in-depth understanding of social challenges. The method aims to obtain data from a purposely selected group of individuals rather than from a statistically representative sample of a broader population.

To obtain information regarding the constraints faced by the transport service providers in raw milk transportation this technique was employed in which the transport service providers of the identified BMC unit were facilitated with meetings to discuss about the constraints and the opinions were recorded for further analysis.

3.4 CONCEPTS AND TERMS USED

Milk Pooling Point (MPP): Milk Pooling Point is a common place in villages where the farmers pool their milk.

Farmer Producers Organizations (FPO's): Farmer Producers Organizations are the new generation cooperatives which are working to play a vital role in integrating across the producer driven milk value chains.

Float Time: float or slack is the amount of time that a task in a project network can be delayed without causing delay to subsequent tasks project completion time.

Procurement: Procurement is the act of obtaining goods or services, typically for business purposes. Procurement is most commonly associated with businesses because companies need to solicit services or purchase goods, usually on a relatively large scale.

Program Evaluation and Review Technique (PERT): Program Evaluation and Review Technique is a tool that would help a project manager in planning and control. It would enable him in continuously monitoring a project and taking corrective measures wherever necessary.

Standard Deviation: Standard deviation is defined as the positive square-root of the arithmetic mean of square of the deviations of the given observation from arithmetic mean. The standard deviation is denoted by the Greek letter σ (sigma).

Chapter – IV

Results & Discussion

Chapter IV

RESULTS AND DISCUSSION

Keeping in view of specific objectives of the present study, the data collected regarding the operations identified milk pooling points (MPPs) during milk pooling, distance, time, cost and constraints in involved in raw milk transportation from MPPs to identified BMC Unit (Bulk Milk Cooling) have been subjected to various statistical tools as outlined in materials and methods. The results have been reported in this chapter under the following headings.

4.1 Study of existing operations at village level milk pooling points

4.2 Distance, time and cost estimation of raw milk transportation from milk pooling points to bulk milk cooling unit

4.3 Constraints during transportation of raw milk from milk pooling points to bulk milk cooling unit in the study area

4.4 Route optimization for efficient procurement of raw milk from milk pooling points to bulk milk cooling unit

4.1 STUDY OF EXISTING OPERATIONS AT VILLAGE LEVEL MILK POOLING POINTS

The primary function of Milk Pooling Points (MPPs) is to expedite milk collection operations at village level. MPPs facilitate the FPO owned dairy unit in procurement from production centers (villages) to BMC unit. To conjugate this, a complex system has been implemented. This system documents the data regarding the quantity of milk collected, results of sample tests and maintaining the data for traceability. The operations identified at the MPPs were divided into three categories namely pre operational, operational and post operational activities. In this section details on milk pooling at each MPP have been discussed.

4.1.1 Milk Procurement

Milk procurement is the starting point of FPO's dairy supply chain. The procurement process starts with advisory services of field staff to the registered milk pourers. A separate team lends support regarding animal nutrition and animal health services. The milk collected from registered pourers is regularly monitored for the quality and quantity by the MPP operator and transported to BMC unit by company hired vehicles twice a day *i.e.*, both in the morning and evening hours.

Raw milk quality and quantity is the corner stone of excellent dairy products. Milk procurement guards this with an eagle eye and ensures that company's production needs are met. The procurement team of Farmer Producer Company ensures that raw milk losses are kept to the absolute minimum. Each BMC unit acts as a hub for preserving quality of the collected milk and the MPPs in the surrounding villages act as spokes feeding the BMC hub with quality milk representing a typical hub and spoke model. The main function of BMC unit is to cool the collected milk to 4^{0}C as soon as possible and maintain congenial temperature to prevent the spoilage of milk till it reaches the main processing plant for further processing.

In the present study the identified BMC unit has installed capacity of preserving four thousand kilo litres per day, catering the needs of 554 registered milk pourers belonging to thirty-five villages. There are thirty Milk pooling points spread over these thirty-five villages that collect the milk and transport it to BMC unit twice a day *i.e.*, both in the morning and evening hours. MPPs are located in a 30kms radius to the BMC unit for efficient milk procurement, but in few cases it may extend beyond the prescribed radius to utilize the capacity of BMC unit. The present identified BMC unit has three vehicle routes covering with three vehicles commuting a distance of 194.6 kilometers per day.

4.1.2 Details of Milk Pooling Activities at Village Level

The FPO owned dairy unit has adopted a system of milk collection through village level milk pooling points (MPPs). MPP is a common place in villages where the farmers pool their milk. The person who collects the milk from the farmers is called as "Pala Mitra" / "MPP operator". The "Pala Mitra" or "MPP operator" is a person from local community for sampling, testing and collecting the milk and is nominated by the registered milk pourers. The MPP operator is paid commission by the FPO, based on the quantity and quality of milk (in litres) collected by him/her. Each MPP is provided with all the essential utilities for the milk collection and also the testing equipment such as digital milk analyzers.

At MPP level, MPP operator maintains the record of all the milk producers who supply the milk to MPP. The milk samples from each milk producer are tested and collected. The entries of the details regarding milk quality and quantity supplied to MPP are entered in a passbook issued to every registered milk pourers by the MPP operator. Digital processing units at MPPs maintain records of all the registered pourers. Milk producers are paid directly by the FPO every fortnight for the milk poured by them.

A brief account of all the MPPs at the identified BMC unit has been presented in Table 4.1.

Table 4.1. Details of Milk Pooling Points Served by the Bulk Milk Cooling Unit

Route	MPP-code	Distance from BMC (km)	No. of villages covered
Route-1	MPP-01	8.6	1
	MPP-02	23.8	2
	MPP-03	17.0	2
	MPP-04	18.0	2
	MPP-05	15.0	1
	MPP-06	13.0	2
	MPP-07	9.0	1
	MPP-08	7.0	1
	MPP-09	3.0	1
Route-2	MPP-10	10.9	1
	MPP-11	10.5	1
	MPP-12	9.0	1
	MPP-13	7.0	1
	MPP-14	7.5	1
	MPP-15	5.0	1
	MPP-16	5.5	1
	MPP-17	5.0	1
	MPP-18	4.8	1
	MPP-19	1.0	1
	MPP-20	0.4	1
Route-3	MPP-21	5.3	2
	MPP-22	5.7	1
	MPP-23	4.0	1
	MPP-24	4.5	1
	MPP-25	1.5	1
	MPP-26	3.0	1
	MPP-27	2.8	1
	MPP-28	2.0	1
	MPP-29	0.3	1
	MPP-30	0.2	1
Total	**30MPPs**		**35**

It can be inferred from Table 4.1 that there were nine, eleven and ten milk pooling points in route-1, route-2 and route-3 respectively that serves 13 villages, 11 villages and 11 villages. The number of villages and MPPs vary as the milk pooled from the habitations that feed the bulk milk cooling unit.

4.1.3 Details of Milk Procurement Activities at Milk Pooling Points

Information of milk pourers and average milk collection from each milk pooling point (MPP) has been presented in Table 4.2. Based on seasonal variation of the milk collected in the study area information of one year (2019-2020) is grouped into three seasons *i.e.*, peak season (July to October), mean season (November to February) and lean season (March to June) covering 30 MPPs (35 villages) with a total number of 554 total registered milk pourers. It can be inferred that on any given day irrespective of the season, on an average each MPP has been catering the needs of 12 milk pourers.

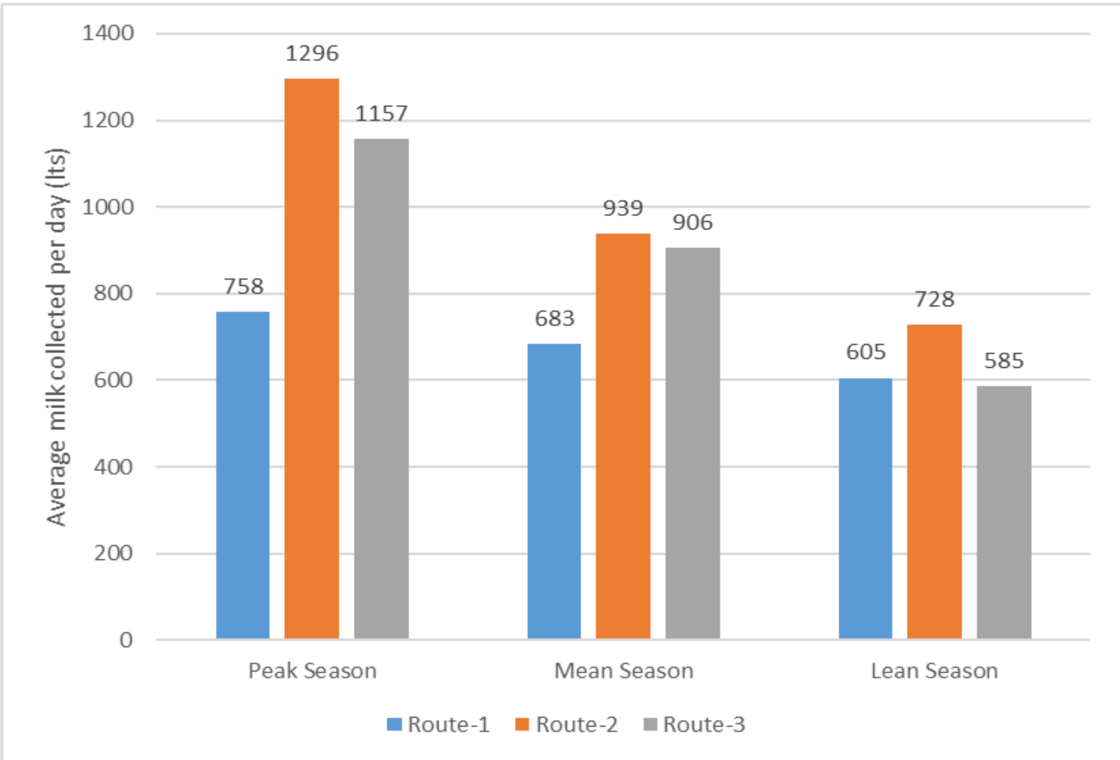

Fig 4.1. Season wise average milk collected per day (lts)

Table 4.2. Details of Milk Procurement Activities at Milk Pooling Points during 2019-20

Route	MPP-code	Total No. of Registered milk pouring members	No. of current milk pourers	Seasonal (peak season) no. of milk pourers	Peak Season Average milk collected/day in two trips (litres)	Regular (mean season) no. of milk pourers	Mean Season Average daily milk collected (litres)	Off season (lean season) no. of milk pourers	Lean Season Average daily milk collected (litres)
Route-1	MPP-01	15.0	12.0	12.0	102.0	10.0	60.0	12.0	45.0
	MPP-02	24.0	17.0	17.0	131.0	20.0	130.0	17.0	107.5
	MPP-03	14.0	14.0	14.0	127.0	13.0	61.0	14.0	50.0
	MPP-04	13.0	10.0	0.0	0.0	0.0	0.0	10.0	89.0
	MPP-05	17.0	11.0	11.0	94.0	11.0	79.0	11.0	67.0
	MPP-06	30.0	20.0	21.0	155.0	16.0	107.5	20.0	98.0
	MPP-07	25.0	21.0	0.0	0.0	22.0	127.0	21.0	74.0
	MPP-08	21.0	11.0	11.0	83.0	16.0	70.0	11.0	38.0
	MPP-09	15.0	10.0	10.0	66.0	6.0	48.0	10.0	36.0
Total	**9 MPPs**	**174**	**126***	**96****	**758**	**114**	**683**	**126**	**605**
Route-2	MPP-10	14.0	10.0	10.0	95.0	13.0	83.0	10.0	68.0
	MPP-11	12.0	7.0	2.0	72.0	5.0	32.5	7.0	20.0
	MPP-12	25.0	19.0	21.0	163.0	21.0	163.0	19.0	114.0
	MPP-13	18.0	14.0	14.0	155.0	17.0	111.0	14.0	89.0
	MPP-14	11.0	7.0	8.0	92.0	7.0	58.5	7.0	36.0

	MPP-15	15.0	14.0	14.0	133.0	13.0	117.0	14.0	100.0
	MPP-16	14.0	6.0	7.0	65.0	6.0	54.0	6.0	49.0
	MPP-17	10.0	7.0	7.0	56.0	5.0	46.0	7.0	35.0
	MPP-18	23.0	14.0	16.0	188.0	18.0	103.0	14.0	70.0
	MPP-19	16.0	10.0	11.0	117.0	10.0	79.0	10.0	71.6
	MPP-20	24.0	14.0	19.0	160.0	16.0	92.0	14.0	75.0
Total	**11 MPPs**	**182**	**122**	**129**	**1296**	**131**	**939**	**122**	**728**
Route-3	MPP-21	13.0	9.0	8.0	97.0	10.0	75.0	9.0	37.0
	MPP-22	13.0	9.0	9.0	70.0	9.0	70.0	9.0	38.5
	MPP-23	13.0	9.0	8.0	72.0	10.0	54.0	9.0	38.0
	MPP-24	39.0	15.0	18.0	70.0	18.0	70.0	15.0	23.0
	MPP-25	10.0	3.0	3.0	37.0	3.0	37.0	3.0	14.0
	MPP-26	20.0	11.0	14.0	98.0	13.0	69.0	11.0	45.0
	MPP-27	13.0	4.0	5.0	36.0	5.0	34.0	4.0	31.0
	MPP-28	32.0	20.0	22.0	347.0	23.0	264.0	20.0	179.0
	MPP-29	19.0	17.0	18.0	185.0	15.0	117.0	17.0	104.0
	MPP-30	26.0	19.0	19.0	145.0	21.0	116.0	19.0	75.0
Total	**10 MPPs**	**198**	**116**	**124**	**1157**	**127**	**906**	**116**	**585**

(* Indicate that the current (126) milk pourers in Route one have increased than the peak season ** milk pourers (96) and it is due to addition of two new MPPs i.e., MPP-04 and MPP-07)

A perusal of Table 4.2 infers that during the year 2019-2020 the average milk collected per day in route-1 was 758 liters, 683 liters, and 683 liters during peak, mean, and lean seasons respectively. In route-2 average milk collected per day during peak, mean, and lean seasons were 1296 litres, 939 litres and 728 litres correspondingly. In route-3 average milk collected per day was varying from 1157 litres, 906 litres, and 585 litres during peak, mean, and lean seasons. It can be concluded that the maximum milk procured was 758 liters in route-1, 1296 liters in route-2 and 1157 in route-3 per day that has been the basis for deciding the vehicle capacities for collection of milk cans from milk pooling points.

4.1.4 Schedule of Operations at Milk Pooling Points

Detailed schedule of operations at the MPPs at the identified BMC unit were collected and cross tabulated in Table 4.3.

Table 4.3. Schedule of Operations at Milk Pooling Points

Route	MPP code	Schedule of raw milk procurement operations						
		Pre-operative activities		Operating activities		Post-operative activities		Total time in (mins.)
		Start	End	Start	End	Start	End	
Route-1	MPP-01	T-20	T-10	T-10	T	T	T+10	30
	MPP-02	T	T+10	T+10	T+20	T+20	T+30	30
	MPP-03	T+10	T+20	T+20	T+30	T+30	T+40	30
	MPP-04	T+20	T+30	T+30	T+40	T+40	T+50	30
	MPP-05	T+25	T+35	T+35	T+45	T+45	T+55	30
	MPP-06	T+25	T+35	T+35	T+45	T+45	T+55	30
	MPP-07	T+40	T+50	T+50	T+60	T+60	T+70	30
	MPP-08	T+40	T+50	T+50	T+60	T+60	T+70	30
	MPP-09	T+50	T+60	T+60	T+70	T+70	T+80	30
Route-2	MPP-10	T-5	T+5	T+5	T+15	T+15	T+25	30
	MPP-11	T-5	T+5	T+5	T+15	T+15	T+25	30
	MPP-12	T	T+10	T+10	T+20	T+20	T+30	30
	MPP-13	T+10	T+20	T+20	T+30	T+30	T+40	30
	MPP-14	T+20	T+30	T+30	T+40	T+40	T+50	30
	MPP-15	T+25	T+35	T+35	T+45	T+45	T+55	30
	MPP-16	T+30	T+40	T+40	T+50	T+50	T+60	30
	MPP-17	T+45	T+55	T+55	T+65	T+65	T+75	30
	MPP-18	T+50	T+60	T+60	T+70	T+70	T+80	30
	MPP-19	T+55	T+65	T+65	T+75	T+75	T+85	30
	MPP-20	T+55	T+65	T+65	T+75	T+75	T+85	30
Route-3	MPP-21	T+5	T+15	T+15	T+25	T+25	T+35	30
	MPP-22	T+10	T+20	T+20	T+30	T+30	T+40	30
	MPP-23	T+15	T+25	T+25	T+35	T+35	T+45	30
	MPP-24	T+20	T+30	T+30	T+40	T+40	T+50	30
	MPP-25	T+30	T+40	T+40	T+50	T+50	T+60	30
	MPP-26	T+35	T+45	T+45	T+55	T+55	T+65	30
	MPP-27	T+40	T+50	T+50	T+60	T+60	T+70	30
	MPP-28	T+50	T+60	T+60	T+70	T+70	T+80	30
	MPP-29	T+60	T+70	T+70	T+80	T+80	T+90	30
	MPP-30	T+65	T+75	T+75	T+85	T+85	T+95	30

It can be observed from the Table 4.3 that schedule has been well planned in relevance with the other dependent activities in BMC unit. The “T” in the table indicates the start time of first operation scheduled in BMC unit operations *i.e.*, starting time of milk can collection vehicle from BMC unit. To match the time of arrival of collection vehicle and completion of all the operations at MPP, the schedule has been well planned to prevent any delays. Further the start time of MPP operation are variably planned to prevent any waiting time of milk collected to be retained at MPPs at normal temperatures. This has helped the BMC unit in collection of fresh milk as farmers will schedule their milking activity based on the MPP collection timings. Further, it is observed that each MPP has been allotted a time slot of 30 minutes, which is sub-divided into pre-operative activities covering cleaning of testing equipment and cans. The operative activities include sampling, testing, collection, loading raw milk into cans and entering the information into passbook of milk pourers. The post-operative activities were closing the lid of cans, tagging and report generation. On an average the 30 minutes time slot time of each MPP has been divided in pre-operative, operative and post-operative activities with 10 minutes each. It has been observed in ground level that all the MPP operators have to adhere to the slot timings allotted to them with a flexibility of time allocation to pre-operative, operative and post-operative timings.

4.1.5 Estimated Time Delays in Milk Pooling Point Operations in Route-1

The information regarding the delays in MPP operation in route-1 has been collected, analyzed and presented in Table 4.4.

Table 4.4. Time Delays Estimated at Milk Pooling Points in Route-1

S. No.	Work station	Scheduled/ optimistic delay time estimate of operations (to) (in mins)	Most likely delay time estimate of operations (tm) (in mins)	Pessimistic delay time estimate (tp) of operations (in mins)	Average Time delay estimate (te) of MPP operations	Probability for Delay in operations at MPP
1	MPP-01	0	3	5	3	0.13
2	MPP-02	0	5	10	5	0.25
3	MPP-03	0	5	10	5	0.25
4	MPP-04	0	3	5	3	0.13
5	MPP-05	0	3	5	3	0.13
6	MPP-06	0	5	10	5	0.25
7	MPP-07	0	5	10	5	0.25
8	MPP-08	0	5	10	5	0.13
9	MPP-09	0	3	5	3	0.25

From Table 4.4 it can be inferred that the time delays in operations at Milk pooling points was ranging from 0 to 10 minutes. The optimistic time (to) delay of all the MPPs in the route-1 was zero, as the most optimistic situations were to complete the operations at MPPs as per schedule. The pessimistic time (tp) delays were previous worst time delays occurred in experiences of MPP operators which was ranging from 5 to 10 minutes. The average time delay (te) of MPP operations was calculated to be 3 minutes at MPP-01, MPP-04 MPP-05 and MPP-09. Similarly the Average time delay (te) of MPP operations at MPP-02, MPP-03, MPP-06, MPP-07 and MPP-08 was 5 minutes. The probability of occurrence of these time delays was calculated to be 13 percent at MPP-01, MPP-04 MPP-05, MPP-09 and 25 percent at MPP-02, MPP-03, MPP-06, MPP-07 and MPP-08 respectively.

4.1.6 Estimated Time Delays in Milk Pooling Point Operations in Route-2

The information regarding the delays in MPP operation in route-2 has been collected, analyzed and presented in Table 4.5.

Table 4.5. Time Delays Estimated at Milk Pooling Points in Route-2

S. No.	Work station	Scheduled/ optimistic delay time estimate of operations (to) (in mins)	Most likely delay time estimate of operations (tm) (in mins)	Pessimistic delay time estimate (tp) of operations (in mins)	Average Time delay estimate (te) of MPP operations	Probability for Delay in operations at MPP
1	MPP-10	0.00	2.50	5.00	3	0.25
2	MPP-11	0.00	2.50	5.00	3	0.08
3	**MPP-12**	**0.00**	**5.00**	**10.00**	**5**	**0.33**
4	MPP-13	0.00	5.00	10.00	5	0.25
5	MPP-14	0.00	2.50	5.00	3	0.08
6	MPP-15	0.00	5.00	10.00	5	0.25
7	MPP-16	0.00	2.50	5.00	3	0.13
8	**MPP-17**	**0.00**	**2.50**	**5.00**	**3**	**0.05**
9	MPP-18	0.00	2.50	5.00	3	0.25
10	MPP-19	0.00	2.50	5.00	3	0.08
11	MPP-20	0.00	5.00	10.00	5	0.25

From Table 4.5 it can be inferred that the time delays in operations at Milk pooling points was ranging from 0 to 10 minutes. The optimistic time (to) delay of all the MPPs in the route-2 was zero, as the most optimistic situations were to complete the operations at MPPs as per schedule. The pessimistic time (tp) delays were previous worst time delays occurred in experiences of MPP operators which was ranging from 5 to 10 minutes. The average time delay (te) of MPP operations was calculated to be 3 minutes at MPP-10, MPP-11, MPP-14, MPP-16, MPP-17, MPP-18 and MPP-19. Similarly the average time delay (te) of MPP operations at MPP-12, MPP-13, MPP-15 and MPP-20 was 5 minutes. The probability of occurrence of these delays was calculated to be 5 per cent at MPP-17, 8 per cent at MPP-11, MPP-14 and MPP-19, 13 per cent at MPP-16, 25 per cent at MPP-10, MPP-13, MPP-15 and MPP-18 and 33 per cent at MPP-12.

4.1.7 Estimated Time Delays in Milk Pooling Point Operations in Route-3

The information regarding the delays in MPP operation in route-3 has been collected, analyzed and presented in Table 4.6.

Table 4.6. Time Delays Estimated at Milk Pooling Points in Route-3

S. No.	Work station	Scheduled/ optimistic delay time estimate of operations (to) (in mins)	Most likely delay time estimate of operations (tm) (in mins)	Pessimistic delay time estimate (tp) of operations (in mins)	Average Time delay estimate (te) of MPP operations	Probability for Delay in operations at MPP
1	MPP-21	0	2.5	5	3	0.13
2	MPP-22	0	5.0	10	5	0.13
3	MPP-23	0	2.5	5	3	0.13
4	MPP-24	0	5.0	10	5	0.25
5	**MPP-25**	**0**	**2.5**	**5**	**3**	**0.05**
6	MPP-26	0	5.0	10	5	0.25
7	MPP-27	0	5.0	10	5	0.05
8	**MPP-28**	**0**	**5.0**	**10**	**5**	**0.42**
9	MPP-29	0	5.0	10	5	0.25
10	MPP-30	0	5.0	10	5	0.25

From Table 4.6 it can be inferred that the time delays in operations at Milk pooling points was ranging from 0 to 10 minutes. The optimistic time (to) delay of all the MPPs in the route-3 was zero, as the most optimistic situations were to complete the operations at MPPs as per schedule. The pessimistic time (tp) delays were previous worst time delays occurred in experiences of MPP operators which was ranging from 5 to 10 minutes. The average time delay (te) of MPP operations was calculated to be 3 minutes at MPP-21, MPP-23 and MPP-25. Similarly the average time delay (te) of MPP operations at MPP-22, MPP-24, MPP-26, MPP-27, MPP-28, MPP-29 and MPP-30 was 5 minutes. The probability of occurrence of these time delays was calculated to be 5 per cent at MPP-25, 13 per cent at MPP-21, MPP-22, MPP-23, 25 per cent at MPP-24, MPP-26, MPP-29 and MPP-30 and 42 per cent at MPP-28.

4.1.8 Effect of estimated time delays at Milk Pooling Point Operations on Vehicle Timings in Route-1

The information regarding time delays occurred during MPP operations were collected and analyzed to estimate the impact on the overall milk collection time in vehicle route-1, the same is presented in Table 4.7.

Table 4.7. Estimated time delays at Milk Pooling Point Operations on Vehicle Timings in Route-1

S. No.	Events	Estimation of time delays in MPP operations in route-1				Estimation of time delays in Vehicle route-1			
		Scheduled end time of operation at MPP	Average Time delay (te) in MPP operations	variance	Probability for Delay in operations at MPP	Scheduled Vehicle Departure time Earliest arrival time	Latest Departure time	Total available float time in operations	Cumulative delay in route (min)
1	Departure of Collection vehicle from BMC					T			
2	MPP-01 Milk Procurement	T+10	3	0.69	0.13	T+10	T+13	0	3
3	MPP-02 Milk Procurement	T+30	5	2.78	0.25	T+30	T+35	3	5
4	MPP-03 Milk Procurement	T+40	5	2.78	0.25	T+40	T+45	5	5
5	MPP-04 Milk Procurement	T+50	3	0.69	0.13	T+50	T+55	3	5
6	MPP-05 Milk Procurement	T+55*	3	0.69	0.13	T+55	T+60	3	5
7	MPP-06 Milk Procurement	T+55*	5	2.78	0.25	T+55	T+65	0	10
8	MPP-07 Milk Procurement	T+70*	5	2.78	0.25	T+70	T+80	5	10
9	MPP-08 Milk Procurement	T+70*	5	2.78	0.13	T+70	T+85	0	15
10	MPP-09 Milk Procurement	T+80	3	0.69	0.25	T+80	T+95	3	15
11	Arrival of Collection vehicle to BMC					T+85	T+100		
12	Totals		37					22.00	15.00
13	Variance			20.14					
14	Standard deviation			4.49					

(* indicates that both milk pooling points were located in same village with negligible travelling time)

From Table 4.7, it can be inferred that the sum of average time delays (te) estimated at every milk pooling point was 37 minutes, but the cumulative time delay in route-1 was estimated to be 15 minutes. This was due to the availability of float time of 22 minutes in the scheduled operations. The standard deviation of delays in milk pooling point operations was estimated to be 4.49 *i.e.*, around 5 minutes. It can be inferred that an extra time of 5 minutes to MPP operations at each MPP can prevent delays in the milk procurement in route-1.

4.1.9 Effect of estimated time delays at Milk Pooling Point Operations on Vehicle Timings in Route-2

The information regarding time delays occurred during MPP operations were collected and analyzed to estimate the impact on the overall milk collection time in vehicle route-2, the same is presented in Table 4.8.

Table 4.8. Estimated time delays at Milk Pooling Point Operations on Vehicle Timings in Route-2

S. No.	Events	Estimation of time delays in MPP operations in route-2				Estimation of time delays in Vehicle route-2			
		Scheduled end time of operation at MPP	Average Time delay (te) in MPP operations	variance	Probability for Delay in operations at MPP	Scheduled Vehicle Departure time Earliest arrival time	Latest Departure time	Total available float time in operations	Cumulative delay in route (min)
1	Departure of Collection vehicle from BMC					T			
2	MPP-10 Milk Procurement	T+25	3	0.69	0.25	T+25	T+28	0	3
3	MPP-11 Milk Procurement	T+25	3	0.69	0.08	T+25	T+28	3	3
4	MPP-12 Milk Procurement	T+30	5	2.78	0.33	T+30	T+35	3	5
5	MPP-13 Milk Procurement	T+40	5	2.78	0.25	T+40	T+45	5	5
6	MPP-14 Milk Procurement	T+50	3	0.69	0.08	T+50	T+55	3	5
7	MPP-15 Milk Procurement	T+55	5	2.78	0.25	T+55	T+60	5	5
8	MPP-16 Milk Procurement	T+60	3	0.69	0.13	T+60	T+65	3	5
9	MPP-17 Milk Procurement	T+75	3	0.69	0.05	T+75	T+80	3	5
10	MPP-18 Milk Procurement	T+80	3	0.69	0.25	T+80	T+85	3	5
11	MPP-19 Milk Procurement	T+85*	3	0.69	0.08	T+85	T+90	3	5
12	MPP-20 Milk Procurement	T+85*	5	2.78	0.25	T+85	T+90	5	5
13	Arrival of Collection vehicle to BMC	T+90				T+90	T+95	36	5
14	Totals		41						
15	Variance			15.97					
16	Standard deviation			3.99					

(* indicates that both milk pooling points were located in same village with negligible travelling time)

From Table 4.8, it can be inferred that the sum of average time delays (te) estimated at every milk pooling point was 41 minutes, but the cumulative time delay in route-2 was estimated to be 5 minutes. This was due to the availability of float time of 36 minutes in the scheduled operations. The standard deviation of delays in milk pooling point operations was estimated to be 3.99 *i.e.*, around 4 minutes. It can be inferred that an extra time of 5 minutes to MPP operations at each MPP can prevent delays in the milk procurement in route-2.

4.1.10 Effect of Estimated Time Delays at Milk Pooling Point operations on Vehicle Timings in Route-3

The information regarding time delays occurred during MPP operations were collected and analyzed to estimate the impact on the overall milk collection time in vehicle route-3, the same is presented in Table 4.9.

Table 4.9. Estimated Time Delays at Milk Pooling Point Operations on Vehicle Timings in Route-3

S. No.	Events	Estimations of time delays in MPP operations in route-3				Estimation of time delays in Vehicle route-3			
		Scheduled end time of operation at MPP	Average Time delay (te) in MPP operations	variance	Probability for Delay in operations at MPP	Scheduled Vehicle Departure time Earliest arrival time	Latest Departure time	Total available float time in operations	Cumulative delay in route (min)
1	Departure of Collection vehicle from BMC					T+25			
2	MPP-21 Milk Procurement	T+35	3	0.69	0.13	T+35	T+38	0	3
3	MPP-22 Milk Procurement	T+40	5	2.78	0.13	T+40	T+45	3	5
4	MPP-23 Milk Procurement	T+45	3	0.69	0.13	T+45	T+50	3	5
5	MPP-24 Milk Procurement	T+50	5	2.78	0.25	T+50	T+55	5	5
6	MPP-25 Milk Procurement	T+60	3	0.69	0.05	T+60	T+65	3	5
7	MPP-26 Milk Procurement	T+65	5	2.78	0.25	T+65	T+70	5	5
8	MPP-27 Milk Procurement	T+70	5	2.78	0.05	T+70	T+75	5	5
9	MPP-28 Milk Procurement	T+80	5	2.78	0.42	T+80	T+85	5	5
10	MPP-29 Milk Procurement	T+90	5	2.78	0.25	T+90	T+95	5	5
11	MPP-30 Milk Procurement	T+95	5	2.78	0.25	T+95	T+100	5	5
12	Arrival of Collection vehicle to BMC	T+100				T+100	T+105	39	5
13	Totals		44						
14	Variance			21.53					
15	Standard deviation			4.64					

From Table 4.9, it can be inferred that the sum of average time delays (te) estimated at every milk pooling point was 44 minutes, but the cumulative time delay in route-3 was estimated to be 5 minutes. This was due to the availability of float time of 39 minutes in the scheduled operations. The standard deviation of delays in milk pooling point operations was estimated to be 4.64 *i.e.*, around 5 minutes. It can be inferred that an extra time of 5 minutes to MPP operations at each MPP can prevent delays in the milk procurement in route-3.

4.1.11 Reasons for Time Delays in Milk Pooling Point Operations

The information regarding the reasons for time delay in MPP operations beyond the schedule timings at MPPs was collected. The collected data was subjected to Garrett ranking. The milk pooling point operators were asked to assign the rank for all the reasons and the outcome of such ranks had converted into score value with the help of per cent position formula. With the help of Garrett's table the per cent position estimation was converted into scores. Then for each factor, the scores of each MPP were added and then the total value of scores and mean values of the score were calculated. The factors having highest mean value was considered to be the most important factor and the results were presented in the Table 4.10.

Table 4.10. Reasons for Time Delays in Milk Pooling Point Operations

S. No.	Reasons for time delay in milk pooling operations	Total Score	Garett's Mean score	Rank
1	Delay in milking by farmers	60	72.97	1
2	Poor knowledge about timing of MPP-slots among the farmers	72	67.47	2
3	Delay by farmers due to attending other work in slot time	41	63.77	3
4	Large no. of pourers to accommodate with in the given time	65	62.43	4
5	All the farmers come at the same time to pour milk	55	61.33	5
6	Delay in opening of the MPP	83	49.53	6
7	Delay caused at MPP-in milk sample testing and collection due to frequent power cut issues	18	42.63	7
8	Due to poor operation of milk collection equipment at MPP	50	40	8
9	Delay due to far location of MPP-from farmers house	36	37.43	9
10	No Proper transportation facility to reach MPP-from farmers place	29	30.17	10
11	Delay in milk sampling and testing due to poor skills of operator at MPP	46	27.27	11

It can be inferred from Table 4.10, that, delay in milking by farmers was the major reason for time delay in MPP operations beyond the regular timings at MPPs with mean score of 72.97 followed by the poor knowledge about timing of MPP-slots among the farmers with a mean score of 67.47, delay by farmers due to attending other work during MPP slot time with a mean score of 63.77, large no. of pourers to accommodate with in the given

MPP slot time (Garrett's mean score of 62.43), all the farmers come at the same time to the MPP to pour milk (Garrett's mean score of 61.33), delay in opening of the MPP (Garrett's mean score of 49.53), delay caused at MPP-in milk sample testing and collection due to frequent power cut issues (Garrett's mean score of 42.63) and due to poor operation of milk collection equipment at MPP (Garrett's mean score of 40). The least preferred reasons for time delay in MPP operations include, delay due to far location of MPP-from farmers house (Garrett's mean score of 37.43), no Proper transportation facility to reach MPP-from farmers place and delay in milk sampling and testing due to poor skills of operator at MPP that has Garrett's mean score of 30.17 and 27.27 respectively. Thus there was a time delay in MPP operations beyond the regular timings mainly due to delay in milking by farmers, poor knowledge about timing of MPP-slots among the farmers, delay by farmers due to attending other work during MPP slot time, large no. of pourers to accommodate with in the given MPP slot time and all the farmers come at the same time to the MPP to pour milk.

4.1.12 Reasons for holding the Collected Milk beyond Schedule Time at Milk Pooling Points

The information regarding the reasons for holding the collected milk beyond prescribed time at the MPPs was collected. The collected data was subjected to Garrett ranking, as per this method milk pooling point operators were asked to assign the rank for all the reasons and the outcome of such ranks had converted into score value with the help of per cent position formula. With the help of Garrett's table the per cent position estimation was converted into scores. Then for each factor, the scores of each MPP were added and then the total value of scores and mean values of the score were calculated. The factors having highest mean value was considered to be the most important factor and the results were presented in the Table 4.11.

Table 4.11. Reasons for holding the Collected Milk beyond Schedule Time at Milk Pooling Points

S. No.	Reasons for holding the collected milk beyond prescribed time	Total Score	Garett's Mean score	Rank
1	Delay due to late supply of milk by few farmers even after slot time ends	35	69.23	1
2	Delay in preparation of reports	50	58.03	2
3	Delay in arrival of milk cans collection vehicle	79	55.27	3
4	Delay in canning the collected milk	66	52.63	4
5	Delay in testing the milk collected	58	51.93	5
6	Delay due to frequent power cut issues while collection of milk	44	37.07	6
7	Delay due to improper communication with BMC unit regarding collection of milk quantities at MPP	22	27.40	7

It can be inferred from Table 4.11 that, delay due to late supply of milk by few farmers even after slot time ends was the major reason to hold the collected milk at MPPs (Garrett's mean score 69.23) followed by delay in preparation of reports (Garrett's mean score 58.03), delay in arrival of milk cans collection vehicle (Garrett's mean score 55.27), delay in canning the collected milk (Garrett's mean score 52.63) and delay in testing the collected milk (Garrett's mean score 51.93). The least preferred reasons to hold the milk include, delay due to frequent power cut issues while collection of milk and delay due to improper communication with BMC unit regarding collection of milk quantities at milk pooling points that has Garrett's mean score of 37.07 and 27.40 respectively. Thus the milk pooling point operators preferred delay due to late supply of milk by few farmers even after slot time ends, delay in preparation of reports, delay in arrival of milk cans collection vehicle and delay in canning the collected milk as the main reasons to hold the collected milk beyond prescribed time at the MPPs.

4.1.13 Perception of Milk Pooling Point operators / Pala mitras on Importance given to Pre-operative activities

The responses of MPP operator's perception on important factors effecting pre-operative slot time activities during milk collection was collected on three point scale with scaling responses categorized as most important, important and not important. The data collected was subjected to simple percentage analysis and the results are presented in Table 4.12.

Table 4.12. Perception of Milk Pooling Point operators / Pala mitras on importance given to Pre-operative activities

S. No.	Pre-operative activities	Most Important (%)	Important (%)	Not Important (%)	Total
1	Opening of MPP at right time	**53%**	33%	13%	**100%**
2	Washing of hands and cleaning of cans	**43%**	**43%**	13%	**100%**
3	Cleaning the equipment before testing & milk pooling	40%	**43%**	17%	**100%**

As per the result of Table 4.12 perception of MPP operators with regard to opening of MPP at right time, 53 per cent of MPP operators considered as most important, while 33 per cent considered as important and remaining 13 per cent perceived as not important. Perception on washing of hands and cleaning of cans revealed that MPP operators perceiving most important and important were 43 per cent and 43 per cent respectively and remaining 13 per cent felt as not important. Perception of MPP operators to clean the equipment before testing and milk pooling, 43 per cent of MPP operators mentioned cleaning the equipment before testing and milk pooling as important, while 40 per cent and 17 per cent considered it as most important and not important.

Hence, 53 per cent of MPP operators considered opening of MPP at right time as most important, 43 per cent of MPP operators perceived washing of hands and cleaning of cans as most important and 43 per cent of MPP operators have mentioned cleaning the equipment before testing and milk pooling as important.

4.1.14 Estimation of Awareness Index Scores of Milk Pooling Point Operators / Pala mitras towards Pre-operative activities

Data about importance given to pre-operative activities on three point scale, awareness index was constructed. The scores of each MPP operators for each factor were summated and index score was estimated for each MPP operator. Likewise for 30 MPPs operators the index score was estimated. Index value lies between zero to one.

Those indices having value less than mean minus half standard deviation was categorized as MPP operators having "low" awareness towards importance given to pre-operative activities while those MPP operators having indices value more than mean plus half standard deviation was categorized as farmers MPP operators having "high" awareness towards importance given to pre-operative activities and MPP operators whose index value lies between greater than mean minus half standard deviation and less than mean half standard deviation were giving "moderate" importance to pre-operative activities.

Table 4.13. Construction of Awareness Index of Milk Pooling Point operators/ Pala mitras towards Pre-operative activities

S. No.	Contents	Aggregates
1	No. of MPPs	30
2	Mean of Indices	0.66
3	Half standard deviation of indices	0.14
4	Mean – Half standard deviation	0.52
5	Mean + Half standard deviation	0.80

A look through Table 4.13 infers that the mean and half standard deviation estimated values obtained MPP operators awareness indices were 0.66 and 0.14 respectively. The Mean + Half standard deviation and Mean – Half standard deviation value were 0.80 and 0.52 respectively.

4.1.15 Awareness Index of MPP operators / Pala mitras on Pre-operative activities

After categorizing the MPP operators according to awareness levels towards importance given to pre-operative activities as shown in Table 4.14.

Table 4.14. Frequency Distribution of MPP operators Awareness on Importance given to Pre-operative activities

S. No.	Index	Frequency	Per cent
1	**High**	**11**	**36.7**
2	Moderate	9	30.0
3	Low	10	33.3
4	Total	30	100.0

It can be inferred from Table 4.14 that out of 30 MPP operators, 36.7 per cent of MPP operators were having high awareness on importance given to pre-operative activities during raw milk procurement while 33.3 per cent of MPP operators were having low awareness on importance given to pre-operative activities and 30 per cent of MPP operators were having moderate awareness on importance given to pre-operative activities. Thus with regard to awareness of MPP operators on importance given to pre-operative activities was high only among 36.7 per cent of MPP operators while around 63.3 per cent of MPP operators awareness levels on importance given to pre-operative activities lies between low to moderate.

4.1.16 Perception of Milk Pooling Point Operators / Pala mitras on Importance given to Operative Activities

The responses of MPP operator's perception on important factors effecting operative slot time activities during milk collection was collected on three point scale with scaling responses categorized as most important, important and not important. The data collected was subjected to simple percentage analysis and the results are presented in Table 4.15.

Table 4.15. Perception of Milk Pooling Point Operators / Pala mitras on Importance given to Operative Activities

S. No.	Operative activities	Most Important (%)	Important (%)	Not Important (%)	Total
1	Maintenance of timely procurement	**50%**	33%	17%	**100%**
2	Sampling of milk from each farmer	**63%**	37%	0%	**100%**
3	Testing the milk samples of each milk producer during procurement	**60%**	40%	0%	**100%**
4	Transfer of milk into milk carrying cans	**70%**	30%	0%	**100%**
5	Acknowledging the recorded values to the milk producers	**60%**	40%	0%	**100%**

As per the result of Table 4.15 perception of MPP operators with regard to maintenance of timely procurement, 50 per cent of MPP operators considered as most important, while 33 per cent considered as important and remaining 17 per cent perceived as not important. Perception on sampling of milk from each farmer revealed that MPP operators perceiving most important and important were, 63 per cent and 37 per cent respectively. Perception on testing the milk samples of each milk producer during procurement, 60 per cent of MPP operators mentioned testing of milk samples of each milk producer during procurement as most important, while remaining 40 per cent as important. Perception with regard to transfer of milk into milk carrying cans, 70 per cent of MPP operators considered as most important, while 30 remaining 30 per cent felt as important. With regards to acknowledging the recorded values to the milk producers, 60 per cent of MPP operators have mentioned as most important and remaining 40 per cent as important.

Hence, 50 per cent of MPP operators considered maintenance of timely procurement as most important, 63 per cent of MPP operators perceived sampling of milk from each farmer as most important, 60 per cent of MPP operators have mentioned testing of milk samples of each milk producer during procurement as most important, 70 per cent of MPP operators considered transfer of milk into milk carrying cans as most important, 60 per cent of MPP operators have mentioned acknowledging the recorded values to the milk producers as most important.

4.1.17 Estimation of Awareness Index Scores of Milk Pooling Point Operators / Pala mitras towards Operative Activities

Data about importance given to operative activities on three point scale, awareness index was constructed. The scores of each MPP operators for each factor were summated and index score was estimated for each MPP operator. Likewise for 30 MPPs operators the index score was estimated. Index value lies between zero to one.

Those indices having value less than mean minus half standard deviation was categorized as MPP operators having “low” awareness towards importance given to operative activities while those MPP operators having indices value more than mean plus half standard deviation was categorized as farmers MPP operators having “high” awareness towards importance given to operative activities and MPP operators whose index value lies between greater than mean minus half standard deviation and less than mean half standard deviation were giving “moderate” importance to operative activities.

Table 4.16. Construction of Awareness Index of MPP Operators / Pala mitras towards Operative Activities

S. No.	Contents	Aggregates
1	No. of MPPs	30
2	Mean of Indices	0.79
3	Half standard deviation of indices	0.07
4	Mean – Half standard deviation	0.72
5	Mean + Half standard deviation	0.86

A look through Table 4.17 infers that the mean and half standard deviation estimated values obtained MPP operators awareness indices were 0.79 and 0.07 respectively. The Mean + Half standard deviation and Mean – Half standard deviation value were 0.86 and 0.72 respectively.

4.1.18 Awareness Index of Milk Pooling Point Operators / Pala mitras on Operative Activities

After categorizing the MPP operators according to awareness levels towards importance given to operative activities as shown in Table 4.17.

Table 4. 17. Frequency Distribution of MPP operators Awareness on Importance given to Operative Activities

S. No.	Index	Frequency	Per cent
1	High	10	33.3
2	Moderate	10	33.3
3	Low	10	33.3
4	Total	30	100.0

It can be inferred from Table 4.17 that out of 30 MPP operators, 33.3 per cent of MPP operators were having high awareness on importance given to operative activities during raw milk procurement while 33.3 per cent were having low awareness on importance given to operative activities and 33.3 per cent were having moderate awareness on importance given to operative activities. Thus with regard to awareness of MPP operators on importance given to operative activities was equal among all the 30 MPP operators *i.e.*, 33.3 per cent.

4.1.19 Perception of Milk Pooling Point operators / Pala mitras on Importance given to Post-operative Activities

The responses of MPP operator's perception on important factors effecting post-operative slot time activities during milk collection was collected on three point scale with scaling responses categorized as most important, important and not important. The data collected was subjected to simple percentage analysis and the results are presented in Table 4.18.

Table 4.18. Perception of Milk Pooling Point Operators / Pala mitras on Importance given to Post-operative Activities

S. No.	Post-operative activities	Most Important (%)	Important (%)	Not Important (%)	Total
1	Filling the milk carrying cans	**60%**	33%	7%	**100%**
2	Proper fixing of the lid	33%	**47%**	20%	**100%**
3	Loading of milk carrying cans into vehicles	20%	30%	**50%**	**100%**
4	Sanitizing the MPP	**37%**	**37%**	27%	**100%**
5	Maintaining and correcting the recorded data	**60%**	40%	0%	**100%**
6	Reporting any delays to BMC unit	**57%**	43%	0%	**100%**

As per result of Table 4.18 perception of MPP operators with regard to filling the milk carrying cans, 60 per cent of MPP operators considered as most important, while 33 per cent considered as important and remaining 7 per cent as not important. Perception on proper fixing of the lid revealed that MPP operators perceiving important and most important were, 47 per cent and 33 per cent respectively and remaining 20 per cent felt as not important. Perception of MPP operators to load milk carrying cans into vehicles, 50 per cent of MPP operators have mentioned loading of cans into vehicles as not important, while 30 per cent and 20 per cent of MPP operators considered it as important and most important. Perception with regard to sanitizing the MPP, 37 per cent of MPP operators considered as most important, while 37 per cent have mentioned as important and remaining 27 per cent felt as not important. With regards to maintenance and correction of recorded data at MPP, 60 per cent of MPP operators have mentioned as most important, while remaining 40 per cent of MPP operators perceived as important. Perception of MPP operators to report any delays at MPP to BMC unit, 57 per cent of MPP operators considered as most important and remaining 43 per cent as important.

Hence, 60 per cent of MPP operators considered filling the milk carrying cans as most important, 47 per cent of MPP operators perceived proper fixing of the lid as important, 50 per cent of MPP operators have mentioned loading milk carrying cans into vehicles as not important, 37 per cent of MPP operators considered sanitizing the MPP as most important, 60 per cent of MPP operators have mentioned maintenance and correction of recorded data as most important and 57 per cent of MPP operators considered reporting any delays at MPP to BMC unit as most important.

4.1.20 Estimation of Index Scores of Milk Pooling Point Operators / Pala mitras towards Importance given to Post-operative Activities

Data about importance given to post-operative activities on three point scale, awareness index was constructed. The scores of MPP operators for each factor were summated and index score was estimated for each MPP operator. Likewise for 30 MPPs index score was estimated. Index value lies between zero to one.

Those indices having value less than mean minus half standard deviation was categorized as MPP operators having “low” awareness towards importance given to post-operative activities while those MPP operators having indices value more than mean plus half standard deviation was categorized as MPP operators having “high” awareness towards importance given to post-operative activities and MPP operators whose index value lies between greater than mean minus half standard deviation and less than mean half standard deviation were giving “moderate” importance to post-operative activities.

Table 4.19. Construction of Awareness Index of Milk Pooling Point Operators / Pala mitras towards Post-operative Activities

S. No.	Contents	Aggregates
1	No. of MPPs	30
2	Mean of Indices	0.64
3	Half standard deviation of indices	0.09
4	Mean – Half standard deviation	0.55
5	Mean + Half standard deviation	0.73

A look through Table 4.18 infers that the mean and half standard deviation estimated values obtained MPP operators awareness indices were 0.64 and 0.09 respectively. The Mean + Half standard deviation and Mean – Half standard deviation value were 0.73 and 0.55 respectively.

4.1.21 Awareness Index of Milk Pooling Point Operators / Pala mitras on Post-operative Activities

After categorizing the MPP operators according to awareness levels towards importance given to post-operative activities as shown in Table 4.19.

Table 4.20. Frequency Distribution of MPP operators Awareness on Importance given to Post-operative Activities

S. No.	Index	Frequency	Per cent
1	**High**	**12**	**40.0**
2	Moderate	8	26.7
3	Low	10	33.3
4	Total	30	100.0

It can be inferred from Table 4.19 that out of 30 MPPs, 40 per cent of MPP operators were having high awareness on importance given to post-operative activities during raw milk procurement while 33.3 per cent were having low awareness on importance given to post-operative activities and 26.7 per cent were having moderate awareness on importance given to post-operative activities. Thus with regard to awareness of MPP operators on importance given to post-operative activities was high only among 40 per cent of MPPs while around 60 per cent of MPP operators awareness levels on importance given to post-operative activities lies between low to moderate.

4.2 DISTANCE, TIME AND COST ESTIMATION OF RAW MILK TRANSPORTATION FROM MILK POOLING POINTS TO BULK MILK COOLING UNIT

The data pertaining to distance, time and cost of raw milk transportation from milk pooling points to bulk milk cooling unit was collected and cross tabulated as per the scheduled routes that were operational at the time of study. Further Time-motion study was conducted for all the activities in all the three routes to estimate any time delays in transportation across the routes. The cost incurred in raw milk transportation in all the three routes was estimated and presented in the following sub heads for better presentation and understanding.

4.2.1 Distance, Time and Cost of Current Raw Milk Transportation Routes

The distance time and cost incurred in the current raw milk transportation routes were collected and presented in Table 4.21.

Table 4.21. Distance, Time and Cost of Unoptimized Raw Milk Transportation Routes

S. No.	Route	No. of MPPs covered	Distance covered per trip (in km)	Schedule time per trip (Minutes)	Cost per Kilometre (Rupees/km)	Total transportation cost per trip
1	Route-1	9	48.5	90	7.15	346.78
2	Route-2	11	28.5	90	7.15	203.78
3	Route-3	10	20.3	90	7.15	145.15

From Table 4.21 it can be inferred that the distance covered in route-1 was 48.5 kilometers in scheduled time of 90 minutes to collect milk from nine milk pooling points. The cost incurred in route-1 was 7.15 rupees per kilometer with a total transportation cost around 347 rupees per trip. Similarly in route-2 the distance covered was 28.5 kilometers in scheduled time of 90 minutes to collect milk from eleven milk pooling points. The cost incurred in route-2 was 7.15 rupees per kilometer with a total transportation cost around 204 rupees per trip. While in route-3 the distance covered was 20.3 kilometers in scheduled time of 90 minutes to collect milk from ten milk pooling points. The cost incurred in route-3 was 7.15 per kilometer with a total transportation cost around 145 rupees per trip. The price per kilometer is fixed by the farmer producer organization at 7.15 rupees per kilometer as per the prevailing market prices. Even though the distances are comparatively less in route-2 and route-3 than route-1 the scheduled time of trip was 90 minutes only as the milk pooling points in these routes were located along the interior approach roads where as in route-1 the milk pooling points are located along the highway.

4.2.2 Time Motion Study of Activities in Route-1

A time motion study was conducted using GPS device application using a smart phone and actual times were recorded to understand the time taken across the route-1 on real time basis. The results of the time motion study are presented in Table 4.22.

Table 4.22. Time Motion Study of Activities in Route-1

S. No.	MPP Route		Time Taken			Travel time in minutes	Total time in minutes	Total Distance Travelled (km)
	Start Node	End Node	Start time	End time	Service time			
1	BMC unit	MPP-01	T+1:23	T+14:25	00:27	13:02	13:29	8.6
2	MPP-01	MPP-02	T+14:52	T+32:36	00:48	17:44	18:32	12
3	MPP-02	MPP-03	T+33:24	T+44:40	00:25	11:16	11:41	6.5
4	MPP-03	MPP-04	T+45:05	T+50:13	00:53	05:08	06:01	3.2
5	MPP-04	MPP-05	T+51:06	T+55:20	00:49	04:14	05:03	2.4
6	MPP-05	MPP-06	T+56:09	T+60:57	00:51	04:48	05:39	2.4
7	MPP-06	MPP-07	T+61:48	T+70:39	00:43	08:51	09:34	5.2
8	MPP-07	MPP-08	T+71:22	T+75:12	00:22	03:50	04:12	2.2
9	MPP-08	MPP-09	T+75:34	T+80:20	00:26	04:46	05:12	3
10	MPP-09	BMC unit	T+80:46	T+86:33		05:47	05:47	3
Total	**9 MPPs**				**05:44**	**79:26:00**	**85:10:00**	**48.5**

From Table 4.22 it can be inferred that the service time at milk pooling points in route-1 was ranging from 22 seconds to 53 seconds based on number of milk cans to be loaded. Total service time for serving the nine milk pooling points was 5 minutes and 44 seconds. The travelling time from one point to another point was ranging from 4 minutes 14 seconds to 17 minutes 44 seconds based on the distance to be travelled between the milk pooling points. The total trip time to travel the distance of 48.5 kilometers from BMC unit to cover nine milk pooling points and returning back to BMC unit was 85 minutes and 10 seconds and it was less than the schedule time of 90 minutes.

4.2.3 Time Motion Study of Activities in Route-2

A time motion study was conducted using GPS device app on smart phone and actual times were recorded to understand the time taken across route-2 on real time basis. The results of the time motion study are presented in Table 4.23.

Table 4.23. Time Motion Study of Activities in Route-2

S. No.	MPP Route		Time Taken			Travel time in minutes	Total time in minutes	Total Distance Travelled (km)
	Start Node	End Node	Start time	End time	Service time			
1	BMC unit	MPP-10	T+3:21	T+26:38	00:53	23:17	24;10	10.9
2	MPP-10	MPP-11	T+27:31	T+28:59	02:35	01:28	04:03	0.3
3	MPP-11	MPP-12	T+31:34	T+35:54	01:35	04:20	05:55	1.3
4	MPP-12	MPP-13	T+37:29	T+42:10	00:57	04:41	05:38	1.9
5	MPP-13	MPP-14	T+43:07	T+50:55	00:35	07:48	08:23	3.3
6	MPP-14	MPP-15	T+51:30	T+57:45	01:46	06:15	08:01	2.6
7	MPP-15	MPP-16	T+59:31	T+62:19	01:03	02:48	03:51	0.5
8	MPP-16	MPP-17	T+63:22	T+77:22	02:27	14:00	16:27	5.7
9	MPP-17	MPP-18	T+79:49	T+80:38	00:49	00:49	01:38	0.1
10	MPP-18	MPP-19	T+81:27	T+85:10	01:32	03:43	05:15	1.4
11	MPP-19	MPP-20	T+86:42	T+87:18	00:47	00:36	01:23	0.1
12	MPP-20	BMC unit	T+88:05	T+90:10		02:05	02:05	0.4
Total	**11 MPPs**				**14:59**	**71:50:00**	**86:49:00**	**28.5**

From Table 4.23 it can be inferred that the service time at milk pooling points in route-2 was ranging from 35 seconds to 2 minutes 35 seconds based on number of milk cans to be loaded. Total service time for serving 11 milk pooling points was around 15 minutes. The travelling time from one point to another point was ranging from 36 seconds to 23 minutes 17 seconds based on the distance to be travelled between the milk pooling points. The total trip time to travel the distance of 28.5 kilometers from BMC unit to cover 11 milk pooling points and returning back to BMC unit was 86 minutes and 49 seconds and it was less than the schedule time of 90 minutes.

4.2.4 Time Motion Study of Activities in Route-3

A time motion study was conducted using GPS device app on smart phone and actual times were recorded to understand the time taken across route-3 on real time basis. The results of the time motion study are presented in Table 4.24.

Table 4.24. Time Motion Study of Activities in Route-3

S. No.	MPP Route		Time Taken			Travel time in minutes (trip)	Total time in minutes (trip)	Total Distance (km) covered (trip)
	Start Node	End Node	Start time	End time	Service time			
1	BMC unit	MPP-21	T+21:57	T+34:37	00:57	12:40	13:37	5.3
2	MPP-21	MPP-22	T+35:34	T+38:31	01:29	02:57	04:26	1.3
3	MPP-22	MPP-23	T+40:00	T+45:31	00:49	05:31	06:20	2.5
4	MPP-23	MPP-24	T+46:20	T+49:06	01:12	02:46	03:58	0.7
5	MPP-24	MPP-25	T+50:18	T+62:34	00:46	12:16	13:02	3.9
6	MPP-25	MPP-26	T+63:20	T+67:06	01:58	03:46	05:44	1.2
7	MPP-26	MPP-27	T+69:04	T+74:34	01:28	05:30	06:58	1.5
8	MPP-27	MPP-28	T+76:02	T+83:00	02:40	06:58	09:38	1.8
9	MPP-28	MPP-29	T+85:40	T+91:57	02:37	06:17	08:54	1.6
10	MPP-29	MPP-30	T+94:34	T+97:03	01:43	02:29	04:12	0.3
11	MPP-30	BMC unit	T+98:46	T+100:25		01:39	01:39	0.2
Total	**10 MPPs**				**15:39**	**62:49:00**	**78:28:00**	**20.3**

From Table 4.24 it can be inferred that the service time at milk pooling points in route-3 was ranging from 46 seconds to 2 minutes 40 seconds based on number of milk cans to be loaded. Total service time for serving 10 milk pooling points was around 16 minutes. The travelling time from one point to another point was ranging from 1 minute 39 seconds to 12 minutes 40 seconds based on the distance to be travelled between the milk pooling points. The total trip time to travel the distance of 20.3 kilometers from BMC unit to cover 10 milk pooling points and returning back to BMC unit was 78 minutes 28 seconds and it was less than the schedule time of 90 minutes.

4.2.5 Estimation of Cost Incurred in Raw Milk Transportation in Current Routes

The information regarding average cost of raw milk transportation per litre per day from milk pooling points to BMC unit has been worked out and presented in Table 4.25.

Table 4.25. Estimation of Cost of Raw Milk Transportation per Litre per Day

S. No.	Route	Total transportation cost per day	Peak season (Average milk collected per day in lts)	Peak season (per day per litre)	Mean season (Average milk collected per day in lts)	Mean season (per day per litre)	Lean season (Average milk collected per day in lts)	Lean season (per day per litre)	Average cost per litre per day per km
1	Route-1	693.56	758	0.46	683	0.51	605	0.57	0.51
2	Route-2	407.56	1296	0.16	939	0.22	728	0.28	0.22
3	Route-3	290.3	1157	0.13	906	0.16	585	0.25	0.18

Table 4.25 reflects that the average cost of raw milk transportation per day from milk pooling points to BMC unit was 51 paise per litre per kilometer in route-1, where as in route-2 it was 22 paise per litre per kilometer and in route-3 it was 18 paise per litre per kilometer.

4.3 CONSTRAINTS DURING TRANSPORTATION OF RAW MILK FROM MILK POOLING POINTS TO BULK MILK CHILLING UNIT

To understand and observe the qualitative aspects in raw milk procurement apart from the quantitative aspects, focus group discussions were carried out among the transport service providers to emphasize the importance of looking at the natural factors influencing the raw milk transportation.

4.3.1 General Information of Raw Milk Transportation in the Study area

The general information of raw milk transportation in the study area provides a comprehensive understanding of driving experience, literacy level of transport operators etc., serving the identified BMC unit has been collected and presented in Table 4.26.

Table 4.26. General information of raw milk transportation in the study area

S. No.	Contents	Route-1	Route-2	Route-3
1	Transport operators	Operator-1	Operator-2	Operator-3
2	Literacy level of Transport Operator	Secondary	Secondary	Secondary
3	Driving experience of Transport Operator (in years)	>6 years	3 to 6 years	3 to 6 years
4	Ownership details (owned / leased)	own	own	own
5	Driver details (driver / owner)	owner	owner	owner
6	No of vehicles	1	1	1
7	Maximum pay load of vehicle (kg)	750	750	750

A glance at the Table 4.26 shows that there are three transport operators or three transport service providers engaged for operating across the three routes. All the three transport operators were having literacy level up to secondary education. The driving experience of the transport operators was more than 6 years in route-1 where as it was between 3 years to 6 years in the rest two operators operating in route-2 and route-3. The ownership details revealed that in all the three routes the operators were operating their own vehicles and they were self-driving the vehicles without engaging drivers. The operators were owning only one vehicle each and the maximum pay load of the vehicle was750 kilograms.

4.3.2 Constraints Faced during Raw Milk Transport

The responses of transport service providers on constraints faced during transportation of raw milk was collected by conducting focus group discussion involving all the transport service providers cum drivers and the results are presented in Table 4.27.

Table 4.27. Constraints Faced during Raw Milk Transport

S. No.	Opinion Parameters	Group Opinion
1.	Overall Condition of the roads	Good
2.	Current routes for covering MPP’s	Well planned
3.	Unwanted waiting time at MPP	Sometimes
4.	Achieving the scheduled times is practical	Most of the times
5.	Price fixed by the FPO per km to transport service providers	Can be Improved as per fuel prices
6.	Quality of milk cans used for transportation	Very good

It can be understood from Table 4.27 during the focus group discussion the transport service providers cum drivers have optioned that the overall condition of roads in all the routes were considered good to transport raw milk to BMC unit. The opinion expressed by them on current routes revealed that they were well planned to cover all the MPPs. The group felt that that there were some times unwanted waiting time at MPPs. All of the transport service providers agree that achieving the scheduled times is practical most of the times. The transport service providers also opinioned that price fixed by the company per kilometer in raw milk transport need to be improved as per increase in fuel prices. The group optioned that quality of milk cans used for transportation were of very good quality. It can be inferred that the major constraints faced by the transport operator were unwanted waiting times at MPPs and improving price fixed by the company per kilometer in raw milk transport as per raising fuel prices.

4.3.3 Awareness of Transport Operators on Timely Milk Collection and Spoilage of Milk due to Delay

The information of awareness of transport service provider cum driver on timely milk collection and spoilage of milk due to delay has been collected through conducting focus group discussion and the results are presented in Table 4.28.

Table 4.28. Awareness Levels of Transport Service Providers

S. No.	Awareness Particulars	Group Opinion
1	On time collection of milk cans	Most Important
2	Delay in transporting cans to BMC leads to milk spoilage	Aware
3	Responsibility of transport service provider to maintain time for quality milk collection	Not responsible
4	Regular maintenance of prescribed times by FPO	Always
5	Proper handling of milk cans from MPP to BMC	Most Important
6	Fuel filling before starting the trip	Always
7	Proper repair and service of vehicle avoiding breakdowns	Always
8	Over Speed driving of vehicle to achieve schedule times	Never

From Table 4.28 the results of focus group discussion indicate that the transport service provider-cum-drivers were aware about timely collection of milk cans from MPPs and optioned as most important activity. They are aware that any delay in transportation of cans to BMC unit would spoil milk. The transport service provider-cum-drivers were not willing to accept any responsibility for quality milk collection as they confine themselves as transporters only not as stakeholders in the value chain. All of the transport service providers thought that they were always willing to maintain schedule times as indicated for the routes. Further they are aware about the importance of handling milk cans properly and Showing utmost care. The transport service providers-cum-drivers are aware and always practicing fuel filling before stating time, willing to repair and service vehicles regularly and never driving the vehicle over speed to achieve schedule time.

4.4 ROUTE OPTIMIZATION FOR EFFICIENT PROCUREMENT OF RAW MILK FROM MILK POOLING POINTS TO BULK MILK COOLING UNIT

The Distances from one node to other node have been collected, distance matrix for each route have been prepared to optimize the routes using travelling salesman problem model.

4.4.1 Distance Matrix of Route-1

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling point to another were used to prepare the distance matrix of route-1 and presented in Table 4.29.

Table 4.29. Distance Matrix of Route-1 (in km)

Locations	BMC unit	MPP-01	MPP-02	MPP-03	MPP-04	MPP-05	MPP-06	MPP-07	MPP-08	MPP-09
BMC unit	0.0	8.6	23.8	17.0	18.0	15.0	13.0	9.0	7.0	3.0
MPP-01	8.6	0.0	12.0	7.0	7.0	6.0	4.0	2.5	4.0	6.0
MPP-02	23.8	12.0	0.0	6.5	10.0	8.0	10.0	14.0	13.5	16.0
MPP-03	17.0	7.0	6.5	0.0	3.2	6.0	4.0	8.0	7.5	12.0
MPP-04	18.0	7.0	10.0	3.2	0.0	2.4	5.7	8.0	8.0	10.0
MPP-05	15.0	6.0	8.0	6.0	2.4	0.0	2.4	6.5	6.0	8.0
MPP-06	13.0	4.0	10.0	4.0	5.7	2.4	0.0	5.2	4.5	7.0
MPP-07	9.0	2.5	14.0	8.0	8.0	6.5	5.2	0.0	2.2	5.5
MPP-08	7.0	4.0	13.5	7.5	8.0	6.0	4.5	2.2	0.0	3.0
MPP-09	3.0	6.0	16.0	12.0	10.0	8.0	7.0	5.5	3.0	0.0

A perusal of Table 4.29 reveal that there was a maximum distance of 23.8 kilometers between BMC unit and MPP-02 and minimum distance of 2.2 between MPP-07 and MPP-08.

4.4.2 Distance Matrix of Route-2

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling point to another were used to prepare the distance matrix of route-2 and presented in Table 4.30.

Table 4.30. Distance Matrix of Route-2 (in km)

Locations	BMC unit	MPP-10	MPP-11	MPP-12	MPP-13	MPP-14	MPP-15	MPP-16	MPP-17	MPP-18	MPP-19	MPP-20
BMC unit	0.0	10.9	10.5	9.0	7.0	7.5	5.0	5.5	5.0	4.8	1.0	0.4
MPP-10	10.9	0.0	0.3	2.0	4.0	7.3	6.8	6.5	12.0	11.7	8.7	9.5
MPP-11	10.5	0.3	0.0	1.3	3.5	7.0	6.2	5.9	11.9	11.5	8.0	7.5
MPP-12	9.0	2.0	1.3	0.0	1.9	5.0	4.5	5.3	10.0	9.8	7.5	7.0
MPP-13	7.0	4.0	3.5	1.9	0.0	3.3	4.0	5.0	8.8	8.0	6.0	5.5
MPP-14	7.5	7.3	7.0	5.0	3.3	0.0	2.6	3.5	7.5	7.0	5.0	4.5
MPP-15	5.0	6.8	6.2	4.5	4.0	2.6	0.0	0.5	6.8	6.5	4.5	3.5
MPP-16	5.5	6.5	5.9	5.3	5.0	3.5	0.5	0.0	5.7	5.3	4.0	3.0
MPP-17	5.0	12.0	11.4	10.0	8.8	7.5	6.8	5.7	0.0	0.1	3.0	2.5
MPP-18	4.8	11.7	11.5	9.8	8.0	7.0	6.5	5.3	0.1	0.0	1.4	1.5
MPP-19	1.0	8.7	8.0	7.5	6.0	5.0	4.5	4.0	3.0	1.4	0.0	0.4
MPP-20	0.4	9.5	7.5	7.0	5.5	4.5	3.5	3.0	2.5	1.5	0.4	0.0

A perusal of Table 4.30 reveal that there was a maximum distance of 12 kilometers between MPP-10 and MPP-17 and minimum distance of 0.1 between MPP-17 and MPP-18.

4.4.3 Distance Matrix of Route-3

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling point to another were used to prepare the distance matrix of route-3 and presented in Table 4.31.

Table 4.31. Distance Matrix of Route-3 (in km)

Locations	BMC unit	MPP-21	MPP-22	MPP-23	MPP-24	MPP-25	MPP-26	MPP-27	MPP-28	MPP-29	MPP-30
BMC unit	0.0	5.3	5.7	4.0	4.5	1.5	3.0	2.8	2.0	0.3	0.2
MPP-21	5.3	0.0	1.3	3.4	2.5	4.7	5.8	6.2	5.5	5.1	4.9
MPP-22	5.7	1.3	0.0	2.5	4.0	6.3	6.7	7.7	5.2	5.6	5.5
MPP-23	4.0	3.4	2.5	0.0	0.7	3.2	4.0	4.3	3.5	3.7	3.8
MPP-24	4.5	2.5	4.0	0.7	0.0	3.9	4.2	5.4	2.7	4.2	4.1
MPP-25	1.5	4.7	6.3	3.2	3.9	0.0	1.2	1.3	1.4	1.3	1.1
MPP-26	3.0	5.8	6.7	4.0	4.2	1.2	0.0	1.5	2.5	2.8	2.7
MPP-27	2.8	6.2	7.7	4.3	5.4	1.3	1.5	0.0	1.8	2.6	2.5
MPP-28	2.0	5.5	5.2	3.5	2.7	1.4	2.5	1.8	0.0	1.6	1.5
MPP-29	0.3	5.1	5.6	3.7	4.2	1.3	2.8	2.6	1.6	0.0	0.3
MPP-30	0.2	4.9	5.5	3.8	4.1	1.1	2.7	2.5	1.5	0.3	0.0

A perusal of Table 4.31 reveal that there was a maximum distance of 7.7 kilometers between MPP-22 and MPP-27 and minimum distance of 0.2 kilometers between BMC unit and MPP-30.

4.4.4 Optimization of Route-1

In route-1 distances were optimized by employing Travelling Salesman Problem model and the results are presented in Table 4.32.

Table 4.32. Optimized Route-1 Summary

S. No.	Start Node	End Node	Distance from Node to Node (km)	Time taken (in minutes)	Cost (in Rupees)
1	BMC unit	MPP-08	7.0	10.5	50.05
2	MPP-08	MPP-07	2.2	5.0	15.73
3	MPP-07	MPP-01	2.5	5.5	17.88
4	MPP-01	MPP-02	12	18.5	85.8
5	MPP-02	MPP-03	6.5	12.0	46.48
6	MPP-03	MPP-04	3.2	6.0	22.88
7	MPP-04	MPP-05	2.4	5.0	17.16
8	MPP-05	MPP-06	2.4	5.5	17.16
9	MPP-06	MPP-09	7.0	9.5	50.05
10	MPP-09	BMC unit	3.0	6.0	21.45
11	**Total**	**09 MPPs**	**48.2**	**83.5**	**344.63**

A look through Table 4.32 reveals that 09 milk pooling points were considered in the optimization of route-1. As a result in route-1 the optimized distance is 48.2 kilometers, time travelled to cover all the milk pooling points is 83.5 minutes and the total cost per trip is around 345 rupees.

4.4.5 Optimization of Route-2

In route-2 distances were optimized by employing Travelling Salesman Problem model and the results are presented in Table 4.33.

Table 4.33. Optimized Route-2 Summary

S. No.	Start Node	End Node	Distance from Node to Node (km)	Time taken (in minutes)	Cost (in Rupees)
1	BMC unit	MPP-20	0.4	2.0	2.86
2	MPP-20	MPP-11	7.5	18.5	53.63
3	MPP-11	MPP-10	0.3	3.0	2.15
4	MPP-10	MPP-12	2.0	6.0	14.3
5	MPP-12	MPP-13	1.9	6.0	13.59
6	MPP-13	MPP-14	3.3	6.5	23.6
7	MPP-14	MPP-15	2.6	6.0	18.59
8	MPP-15	MPP-16	0.5	3.0	3.58
9	MPP-16	MPP-17	5.7	14.5	40.76
10	MPP-17	MPP-18	0.1	2.5	0.72
11	MPP-18	MPP-19	1.4	5.5	10.01
12	MPP-19	BMC unit	1.0	2.5	7.15
13	**Total**	**11 MPPs**	**26.7**	**76**	**190.91**

A look through Table 4.33 reveals that 11 milk pooling points were considered in the optimization of route-2. As a result in route-2 optimized distance is 26.7 kilometers, time travelled to cover all the milk pooling points is 76 minutes and the total cost per trip is around 191 rupees.

4.4.6 Optimization of Route-3

In route-3 distances were optimized by employing Travelling Sales man Problem model and the results are presented in Table 4.34.

Table 4.34. Optimized Route-3 Summary

S. No.	Start Node	End Node	Distance from Node to Node (km)	Time taken (in minutes)	Cost (in Rupees)
1	BMC unit	MPP-29	0.3	3.0	2.15
2	MPP-29	MPP-25	1.3	6.0	9.3
3	MPP-25	MPP-26	1.2	6.0	8.58
4	MPP-26	MPP-27	1.5	8.0	10.73
5	MPP-27	MPP-28	1.8	10.0	12.87
6	MPP-28	MPP-24	2.7	13.0	19.31
7	MPP-24	MPP-23	0.7	2.5	5.01
8	MPP-23	MPP-22	2.5	6.0	17.88
9	MPP-22	MPP-21	1.3	5.0	9.3
10	MPP-21	MPP-30	4.9	10.0	35.04
11	MPP-30	BMC unit	0.2	1.5	1.43
12	**Total**	**10 MPPs**	**18.4**	**71**	**131.56**

A look through Table 4.34 reveals that 10 milk pooling points were considered in the optimization of route-3. As a result in route-3 optimized distance is 18.4 kilometers, time travelled to cover all the milk pooling points is 71 minutes and the total cost per trip is around 132 rupees.

4.4.7 Comparison of Raw Milk Transportation before and after Optimization of Routes

A comparison of the distance, time and cost in the optimized routes with existing routes are presented in Table 4.35.

Table 4.35. Comparison of Raw Milk Transportation before and after Optimization of Routes

S. No.	Routes	Distance per day (km)		Time per day (minutes)		Cost per day (Rs.)	
		Current design	Optimized design	Current design	Optimized design	Current design	Optimized design
1	Route-1	97.0	96.6	170.0	167.0	693.55	690.69
2	Route-2	57.0	53.4	174.0	152.0	407.55	381.81
3	Route-3	40.6	36.8	157.0	142.0	290.29	263.12
Total for BMC		**194.6**	**186.8**	**501.0**	**461.0**	**1391.4**	**1335.6**

A cursory of Table 4.35 shows that the distance of raw milk transportation in optimized route-1 has been reduced from 97 kilometers to 96.6 kilometers there by reducing the travelling time from 170 minutes to 167 minutes and reducing the cost from 693.55 rupees to 690.69 rupees. The distance of raw milk transportation in optimized route-2 has been reduced from 57 kilometers to 53.4 kilometers thereby reducing the travelling time from 174 minutes to 152 minutes and reducing the cost from 407.55 rupees to 381.81 rupees. The distance of raw milk transportation in optimized route-3 has been reduced from 40.6 kilometers to 36.8 kilometers thereby reducing the travelling time from 157 minutes to 142 minutes and reducing the cost from 290.29 rupees to 263.12 rupees.

There was a significance reduction of total distance, time and cost in raw milk transportation for the identified bulk milk cooling unit with the optimization of routes was observed. The total distance for travelling to procure the milk has been reduced to 186.8 kilometers per day from 194.6

kilometers per day. The total time of travelling was reduced from 501 minutes per day to 461 minutes per day. The total cost incurred for transportation has reduced from 1391.4 rupees to 1335.6 rupees. With route optimization in all routes of identified bulk milk cooling unit at total reduction in cost of transportation of 55.77 rupees per day could be achieved. As these transportation operations are routine and need to be done throughout the year an annual cost saving of 20,356 rupees per annum for the identified BMC unit could be achieved.

4.4.8 Proposed Milk Pooling Point Operation Schedules for Optimized Route-1

Schedules have been prepared considering the delay times in milk pooling point operations to prevent overcome the delays in milk procurement for optimized route-1 and same has been presented in Table 4.36.

Table 4.36. Proposed Schedule Times of Milk Pooling Point Operations and Vehicle for Optimized Route-1

S. No.	Optimized Route-1	Start Time	End Time	MPP open (in mins)	Vehicle Schedule Time
1	Route start time				T
2	MPP-08	T-25	T+10	35	T+10
3	MPP-07	T-15	T+20	35	T+20
4	MPP-01	T-10	T+25	35	T+25
5	MPP-02	T+5	T+40	35	T+40
6	MPP-03	T+20	T+55	35	T+55
7	MPP-04	T+25	T+60	35	T+60
8	MPP-05	T+30	T+65	35	T+65
9	MPP-06	T+35	T+70	35	T+70
10	MPP-09	T+45	T+80	35	T+80
11	Route end time				T+90

From Table 4.36 it can be inferred that considering the standard deviation of delay of 4.49 minutes in MPP operations in route-1, to avoid the delays at milk pooling points the operating time has been increased to 35 minutes and schedules have been prepared for MPP operations. The vehicle route schedule time has been proposed as per the optimized routes. According the proposed schedule aims at procuring milk from MPPs and reach to BMC unit within a schedule time of 90 minutes without any delays through optimizing of distance, time and cost.

4.4.9 Proposed Milk Pooling Point Operation Schedules for Optimized Route-2

Schedules have been prepared considering the delay times in milk pooling point operations to prevent overcome the delays in milk procurement for optimized route-2 and same has been presented in Table 4.37.

Table 4.37. Proposed Schedule Times of Milk Pooling Point Operations and Vehicle for Optimized Route-2

S. No.	Optimized Route-2	Start time	End time	MPP open (in mins)	Vehicle Schedule Time
1	Route start time				T+5
2	MPP-20	T-25	T+10	35	T+10
3	MPP-11	T-5	T+30	35	T+30
4	MPP-10	T	T+35	35	T+35
5	MPP-12	T+5	T+40	35	T+40
6	MPP-13	T+10	T+45	35	T+45
7	MPP-14	T+15	T+50	35	T+50
8	MPP-15	T+20	T+55	35	T+55
9	MPP-16	T+25	T+60	35	T+60
10	MPP-17	T+40	T+75	35	T+75
11	MPP-18	T+45	T+80	35	T+80
12	MPP-19	T+50	T+85	35	T+85
13	Route end time				T+90

From Table 4.37 it can be inferred that considering the standard deviation of delay of 3.99 minutes in MPP operations in route-2, to avoid the delays at milk pooling points the operating time has been increased to 35 minutes and schedules have been prepared for MPP operations. The vehicle route schedule time has been proposed as per the optimized routes. According the proposed schedule aims at procuring milk from MPPs and reach to BMC unit within a schedule time of 90 minutes without any delays through optimizing of distance, time and cost.

4.4.10 Proposed Milk Pooling Point Operation Schedules for Optimized Route-3

Schedules have been prepared considering the delay times in milk pooling point operations to prevent overcome the delays in milk procurement for optimized route-1 and same has been presented in Table 4.38.

Table 4.38. Proposed Schedule Times of Milk Pooling Point Operations and Vehicle for Optimized Route-3

S. No.	Optimized Route-3	Start Time	End Time	MPP open (in mins)	Vehicle Schedule Time
1	Route start time				T+15
2	MPP-29	T-15	T+20	35	T+20
3	MPP-25	T-5	T+30	35	T+30
4	MPP-26	T	T+35	35	T+35
5	MPP-27	T+5	T+40	35	T+40
6	MPP-28	T+15	T+50	35	T+50
7	MPP-24	T+30	T+65	35	T+65
8	MPP-23	T+35	T+70	35	T+70
9	MPP-22	T+40	T+75	35	T+75
10	MPP-21	T+45	T+80	35	T+80
11	MPP-30	T+55	T+90	35	T+90
12	Route end time	T+95			T+95

From Table 4.38 it can be inferred that considering the standard deviation of delay of 4.64 minutes in MPP operations in route-3, to avoid the delays at milk pooling points the operating time has been increased to 35 minutes and schedules have been prepared for MPP operations. The vehicle route schedule time has been proposed as per the optimized routes. According the proposed schedule aims at procuring milk from MPPs and reach to BMC unit within a schedule time of 90 minutes without any delays through optimizing of distance, time and cost.

Chapter – V

Summary & Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

Dairying activity in India dates back around 8,000 years ago with domestication of cattle. Traditionally, dairying has been treated as an allied activity to generate supplementary income to farm income. However, due to uncertainty in changing climatic conditions, highly volatile market prices, highly fluctuating share of farm income compared to income from dairying which is more stable, consistent and spread throughout the year have made it sustainable income for rural livelihoods and motivating rural households to take up dairying for sustenance.

In organized dairy sector, cooperative sector retains 50 per cent share of the marketable surplus extrapolating the importance of these producer driven value chain. The new generation cooperatives namely Farmer Producers Organizations (FPO's) are working to play their role in integrating across the producer driven milk value chains. Farmer Producer Organizations (FPOs) are contributing in developing dairy sector with various interventions like huge investments making it a commercially viable livelihood option.

Major steps involved in milk supply chain are milk collection, processing, packing, storage and transportation. Among all these steps milk collection (procurement) is critical in quality control practices, as this process involves multiple players in value chain and control over this process is difficult. At village level, milk is procured from member farmers at milk pooling points and the milk was tested for fat content. Milk is then collected into large stainless steel cans which are used for transport to bulk milk cooling units. At bulk milk cooling units, the procured milk is brought under 4^{o}C temperature to control microbial growth.

A detailed study in this regard would help this FPO owned dairy unit to have first-hand knowledge on the serious impediments being faced during procurement of raw milk from rural areas and outcome of the study would be rewarding to the milk producers. Hence this study is taken up through a research entitled "Route Optimization for Efficient Milk Procurement by FPO Owned Dairy Unit" to understand current operations in milk pooling, to estimate cost, time and distance of raw milk transportation from the village level till it reaches the cold chain and to understand constraints during procurement *i.e.*, especially during raw milk transportation in rural areas. Objectives of the study are as follows:

5.1 OBJECTIVES OF INVESTIGATION

1. to study the current operations at village level milk pooling points.
2. to estimate time, cost and distance of raw milk transportation to bulk milk cooling (BMC) units.
3. to understand constraints during transportation of raw milk to bulk milk cooling (BMC) units.
4. to optimize routes for efficient procurement of raw milk from rural areas to bulk milk cooling (BMC) units.

5.2 METHODOLOGY

Shreeja Mahila Milk Producer Company Limited dairy in Chittoor district of Andhra Pradesh state was selected purposively as it is the only Farmer Producer Organization (FPO) owned milk producer company in South India. The present study was under taken in Chittoor district of Andhra Pradesh in view of presence of highest milk procuring bulk milk chilling units in the district. All the thirty milk pooling points (MPP) were selected as the study focused on route optimization. Primary data was collected from the MPP operators using a well-defined schedule through personal interview.

The data collected was analyzed to attain the stated objectives by using frequencies and percentages, PERT, Python software, Garrett's ranking and construction indices.

5.3 MAJOR FINDINGS OF THE STUDY

5.3.1 Study of Existing Operations at Village Level Milk Pooling Points (MPPs)

The information about milk procurement, milk pooling and procurement activities, schedule of operations at MPPs, estimated time delays in MPP operations, effect of estimated time delays at MPPs on vehicle route timings, reasons for delays in MPP operations, reasons for holding the collected milk beyond schedule time at MPPs, perception attributes and awareness attributes of MPP operators regarding importance given to activities at MPPs have been analyzed and presented below.

5.3.1.1 Milk Procurement

Milk procurement is the starting point of FPO's dairy supply chain. The procurement process starts with advisory services of field staff to the registered milk pourers. The milk collected from registered pourers is regularly monitored for the quality and quantity by the MPP operator and transported to BMC unit by company hired vehicles twice a day *i.e.*, both in the morning and evening hours. The main function of BMC unit is to cool the collected milk to 4^0C as soon as possible and maintain congenial temperature to prevent the spoilage of milk till it reaches the main processing plant for further processing.

5.3.1.2 Milk Pooling Activities at Village Level

MPP is a common place in villages where the farmers pool their milk. The person who collects the milk from the farmers is called as "Pala Mitra" / "MPP operator". Each MPP is provided with all the essential utilities for the milk collection and also the testing equipment such as digital milk analyzers. MPP operator maintains the record of all the milk producers who supply the milk to MPP. Milk producers are paid directly by the FPO every fortnight for the milk poured by them.

There were nine, eleven and ten milk pooling points in route-1, route-2 and route-3 respectively that serves 13 villages, 11 villages and 11 villages. The number of villages and MPPs vary as the milk pooled from the habitations that feed the bulk milk cooling unit.

5.3.1.3 Milk Procurement Activities at Milk Pooling Points

Based on seasonal variation of the milk collected in the study area information of one year (2019-2020) is grouped into three seasons *i.e.*, peak season (July to October), mean season (November to February) and lean season (March to June) covering 30 MPPs (35 villages) with a total number of 554 total registered milk pourers. It can be observed that on any given day irrespective of the season, on an average each MPP has been catering the needs of 12 milk pourers.

During the year 2019-2020 the average milk collected per day in route-1 was 758 liters, 683 liters, and 683 liters during peak, mean, and lean seasons respectively. In route-2 average milk collected per day during peak, mean, and lean seasons were 1296 litres, 939 litres and 728 litres correspondingly. In route-3 average milk collected per day was varying from 1157 litres, 906 litres, and 585 litres during peak, mean, and lean seasons. It can be concluded that the maximum milk procured was 758 liters in route-1, 1296 liters in route-2 and 1157 in route-3 per day that has been the basis for deciding the vehicle capacities for collection of milk cans from milk pooling points.

5.3.1.4 Schedule of Operations at Milk Pooling Points

The schedule has been well planned in relevance with the other dependent activities in BMC unit. The “T” was used to indicate the start time of first operation scheduled in BMC unit operations *i.e.*, starting time of milk can collection vehicle from BMC unit. To match the time of arrival of collection vehicle and completion of all the operations at MPP, the schedule has been well planned to prevent any delays. Further, it is observed that each

MPP has been allotted a time slot of 30 minutes. On an average the 30 minutes slot time of each MPP has been divided in pre-operative, operative and post-operative activities with 10 minutes each. It has been observed in ground level that all the MPP operators have to adhere to the slot timings allotted to them with a flexibility of time allocation to pre-operative, operative and post-operative timings.

5.3.1.5 Estimated Time Delays in Milk Pooling Point Operations

In route-1 the time delays in operations at milk pooling points was ranging from 0 to 10 minutes. The optimistic time (to) delay of all the MPPs in the route-1 was zero, as the most optimistic situations were to complete the operations at MPPs as per schedule. The pessimistic time (tp) delays were previous worst time delays occurred in experiences of MPP operators which was ranging from 5 to 10 minutes. The average time delay (te) of MPP operations was calculated to be 3 minutes at MPP-01, MPP-04 MPP-05 and MPP-09. Similarly, the Average time delay (te) of MPP operations at MPP-02, MPP-03, MPP-06, MPP-07 and MPP-08 was 5 minutes. The probability of occurrence of these time delays was calculated to be 13 percent at MPP-01, MPP-04 MPP-05, MPP-09 and 25 percent at MPP-02, MPP-03, MPP-06, MPP-07 and MPP-08 respectively.

In route-2 the time delays in operations at milk pooling points was ranging from 0 to 10 minutes. The optimistic time (to) delay of all the MPPs in the route-2 was zero, as the most optimistic situations were to complete the operations at MPPs as per schedule. The pessimistic time (tp) delays were previous worst time delays occurred in experiences of MPP operators which was ranging from 5 to 10 minutes. The average time delay (te) of MPP operations was calculated to be 3 minutes at MPP-10, MPP-11, MPP-14, MPP-16, MPP-17, MPP-18 and MPP-19. Similarly, the average time delay (te) of MPP operations at MPP-12, MPP-13, MPP-15 and MPP-20 was 5 minutes. The probability of occurrence of these delays was calculated to be 5 per cent at MPP-17, 8 per cent at MPP-11, MPP-14 and MPP-19, 13 per cent at MPP-16, 25 per cent at MPP-10, MPP-13, MPP-15 and MPP-18 and 33 per cent at MPP-12.

In route-3 the time delays in operations at milk pooling points was ranging from 0 to 10 minutes. The optimistic time (to) delay of all the MPPs in the route-3 was zero, as the most optimistic situations were to complete the operations at MPPs as per schedule. The pessimistic time (tp) delays were previous worst time delays occurred in experiences of MPP operators which was ranging from 5 to 10 minutes. The average time delay (te) of MPP operations was calculated to be 3 minutes at MPP-21, MPP-23 and MPP-25. Similarly the average time delay (te) of MPP operations at MPP-22, MPP-24, MPP-26, MPP-27, MPP-28, MPP-29 and MPP-30 was 5 minutes. The probability of occurrence of these time delays was calculated to be 5 per cent at MPP-25, 13 per cent at MPP-21, MPP-22, MPP-23, 25 per cent at MPP-24, MPP-26, MPP-29 and MPP-30 and 42 per cent at MPP-28.

5.3.1.6 Effect of Estimated Time Delays at Milk Pooling Point Operations on Vehicle Timings

In route-1 the sum of average time delays (te) estimated at every milk pooling point was 37 minutes, but the cumulative time delay in route-1 was estimated to be 15 minutes. This was due to the availability of float time of 22 minutes in the scheduled operations. The standard deviation of delays in milk pooling point operations was estimated to be 4.49 *i.e.*, around 5 minutes. It can be inferred that an extra time of 5 minutes to MPP operations at each MPP can prevent delays in the milk procurement.

In route-2 the sum of average time delays (te) estimated at every milk pooling point was 41 minutes, but the cumulative time delay in route-2 was estimated to be 5 minutes. This was due to the availability of float time of 36 minutes in the scheduled operations. The standard deviation of delays in milk pooling point operations was estimated to be 3.99 *i.e.*, around 4 minutes. It can be inferred that an extra time of 5 minutes to MPP operations at each MPP can prevent delays in the milk procurement.

In route-3 the sum of average time delays (te) estimated at every milk pooling point was 44 minutes, but the cumulative time delay in route-3 was estimated to be 5 minutes. This was due to the availability of float time of 39 minutes in the scheduled operations. The standard deviation of delays in milk pooling point operations was estimated to be 4.64 *i.e.*, around 5 minutes. It can be inferred that an extra time of 5 minutes to MPP operations at each MPP can prevent delays in the milk procurement.

5.3.1.7 Reasons for Time Delays in Milk Pooling Point Operations

The information regarding the reasons for time delay in MPP operations beyond the schedule timings at MPPs was collected. The collected data was subjected to Garrett ranking. The results reveal that, the major reasons for time delay in MPP operations were delay in milking by farmers beyond the regular timings, delay by farmers due to attending other work during MPP slot time, large no. of pourers to accommodate with in the given MPP slot time and all the farmers come at the same time to the MPP to pour milk.

5.3.1.8 Reasons for holding the Collected Milk beyond Schedule Time at Milk Pooling Points

The information regarding the reasons for holding the collected milk beyond prescribed time at the MPPs was collected. The collected data was subjected to Garrett ranking. The results reveal that, the major reasons to hold the collected milk at MPPs were delay due to late supply of milk by few farmers even after slot time ends, delay in preparation of reports, delay in arrival of milk cans collection vehicle and delay in canning the collected milk.

5.3.1.9 Perception and Awareness of Milk Pooling Point Operators / Pala mitras on Importance given to Activities

The responses of MPP operator's perception on important factors effecting pre-operative slot time activities during milk collection was collected on three point scale with scaling responses categorized as most important, important and not important. 53 per cent of MPP operators considered opening of MPP at right time as most important, 43 per cent of MPP operators perceived washing of hands and cleaning of cans as most important and 43 per cent of MPP operators have mentioned cleaning the equipment before testing and milk pooling as important.

Regarding awareness on importance given to pre-operative activities was high only among 36.7 per cent of MPP operators while around 63.3 per cent of MPP operators awareness levels on importance given to pre-operative activities lies between low to moderate.

The responses of MPP operator's perception on important factors effecting operative slot time activities during milk collection was collected on three point scale with scaling responses categorized as most important, important and not important. 50 per cent of MPP operators considered maintenance of timely procurement as most important, 63 per cent of MPP operators perceived sampling of milk from each farmer as most important, 60 per cent of MPP operators have mentioned testing of milk samples of each milk producer during procurement as most important, 70 per cent of MPP operators considered transfer of milk into milk carrying cans as most important, 60 per cent of MPP operators have mentioned acknowledging the recorded values to the milk producers as most important.

Regarding to awareness of MPP operators on importance given to operative activities, it was equal among all the 30 MPP operators *i.e.*, 33.3 per cent.

The responses of MPP operator's perception on important factors effecting post-operative slot time activities during milk collection was collected on three point scale with scaling responses categorized as most important, important and not important. 60 per cent of MPP operators considered filling the milk carrying cans as most important, 47 per cent of MPP operators perceived proper fixing of the lid as important, 50 per cent of MPP operators have mentioned loading milk carrying cans into vehicles as not important, 37 per cent of MPP operators considered sanitizing the MPP as most important, 60 per cent of MPP operators have mentioned maintenance and correction of recorded data as most important and 57 per cent of MPP operators considered reporting any delays at MPP to BMC unit as most important.

Regarding awareness of MPP operators on importance given to post-operative activities was high only among 40 per cent of MPP operators while around 60 per cent of MPP operators awareness levels on importance given to post-operative activities lies between low to moderate.

5.3.2 Distance, Time and Cost Estimation of Raw Milk Transportation from Milk Pooling Points to Bulk Milk Cooling Unit

The data pertaining to distance, time and cost of raw milk transportation from milk pooling points to bulk milk cooling unit was collected and cross tabulated as per the scheduled routes that were operational at the time of study. Further Time-motion study was conducted for all the activities in all the three routes to estimate any time delays in transportation across the routes. The cost incurred in raw milk transportation in all the three routes was estimated and presented in the following sub heads for better presentation and understanding.

5.3.2.1 Distance, Time and Cost of Unoptimized Raw Milk Transportation Routes

The distance covered in route-1 was 48.5 kilometers in scheduled time of 90 minutes to collect milk from nine milk pooling points. The cost incurred in route-1 was 7.15 rupees per kilometer with a total transportation cost around 347 rupees per trip. Similarly, in route-2 the distance covered was 28.5 kilometers in scheduled time of 90 minutes to collect milk from eleven milk pooling points. The cost incurred in route-2 was 7.15 rupees per kilometer with a total transportation cost around 204 rupees per trip. While in route-3 the distance covered was 20.3 kilometers in scheduled time of 90 minutes to collect milk from ten milk pooling points. The cost incurred in route-3 was 7.15 per kilometer with a total transportation cost around 145 rupees per trip. The price per kilometer is fixed by the farmer producer organization at 7.15 rupees per kilometer as per the prevailing market prices. Even though the distances are comparatively less in route-2 and route-3 than route-1 the scheduled time of trip was 90 minutes only as the milk pooling points in these routes were located along the interior approach roads where as in route-1 the milk pooling points are located along the highway.

5.3.2.2 Time Motion Study of Activities in Routes

A time motion study was conducted using GPS device application using a smart phone and actual times were recorded to understand the time taken across the route-1 on real time basis. The results indicate that the service time at milk pooling points in route-1 was ranging from 22 seconds to 53 seconds based on number of milk cans to be loaded. Total service time for serving the nine milk pooling points was 5 minutes and 44 seconds. The travelling time from one point to another point was ranging from 4 minutes 14 seconds to 17 minutes 44 seconds based on the distance to be travelled between the milk pooling points. The total trip time to travel the distance of 48.5 kilometers from BMC unit to cover nine milk pooling points and returning back to BMC unit was 85 minutes and 10 seconds and it was less than the schedule time of 90 minutes.

A time motion study was conducted using GPS device app on smart phone and actual times were recorded to understand the time taken across route-2 on real time basis. The results indicate that that the service time at milk pooling points in route-2 was ranging from 35 seconds to 2 minutes 35 seconds based on number of milk cans to be loaded. Total service time for serving 11 milk pooling points was around 15 minutes. The travelling time from one point to another point was ranging from 36 seconds to 23 minutes 17 seconds based on the distance to be travelled between the milk pooling points. The total trip time to travel the distance of 28.5 kilometers from BMC unit to cover 11 milk pooling points and returning back to BMC unit was 86 minutes and 49 seconds and it was less than the schedule time of 90 minutes.

A time motion study was conducted using GPS device app on smart phone and actual times were recorded to understand the time taken across route-3 on real time basis. The results indicate that the service time at milk pooling points in route-3 was ranging from 46 seconds to 2 minutes 40 seconds based on number of milk cans to be loaded. Total service time for serving 10 milk pooling points was around 16 minutes. The travelling time from one point to another point was ranging from 1 minute 39 seconds to 12 minutes 40 seconds based on the distance to be travelled between the milk pooling points. The total trip time to travel the distance of 20.3 kilometers from BMC unit to cover 10 milk pooling points and returning back to BMC unit was 78 minutes 28 seconds and it was less than the schedule time of 90 minutes.

5.3.2.3 Estimation of Cost of Raw Milk Transportation per Litre per Day

The information regarding average cost of raw milk transportation per litre per day from milk pooling points to BMC unit has been worked out and the average cost of raw milk transportation per day from milk pooling points to BMC unit was 51 paise per litre per kilometer in route-1, where as in route-2 it was 22 paise per litre per kilometer and in route-3 it was 18 paise per litre per kilometer.

5.3.3 Constraints during Transportation of Raw Milk from Milk Pooling Points to Bulk Milk Cooling (BMC) Unit

To understand and observe the qualitative aspects in raw milk procurement apart from the quantitative aspects, focus group discussions were carried out among the transport service providers to emphasize the importance of looking at the natural factors influencing the raw milk transportation.

5.3.3.1 General Information of Raw Milk Transportation in the Study area

The general information of raw milk transportation in the study area which provides a comprehensive understanding of driving experience, literacy level of transport operators etc., serving the identified BMC unit has been collected and it shows that there are three transport operators or three transport service providers engaged for operating across the three routes. All the three transport operators were having literacy level up to secondary education. The driving experience of the transport operators was more than 6 years in route-1 where as it was between 3 years to 6 years in the rest two operators operating in route-2 and route-3. The ownership details revealed that in all the three routes the operators were operating their own vehicles and they were self-driving the vehicles without engaging drivers. The operators were owning only one vehicle each and the maximum pay load of the vehicle was750 kilograms.

5.3.3.2 Constraints Faced during Raw Milk Transport

The responses of transport service providers on constraints faced during transportation of raw milk was collected by conducting focus group discussion involving all the transport service providers cum drivers and the results infer that during the focus group discussion the transport service providers cum drivers have optioned that the overall condition of roads in all the routes were considered good to transport raw milk to BMC unit. The opinion expressed by them on current routes revealed that they were well planned to cover all the MPPs. The group felt that that there were some times unwanted waiting time at MPPs. All of the transport service providers agree that achieving the scheduled times is practical most of the times. The transport service providers also opinioned that price fixed by the company per kilometer in raw milk transport need to be improved as per increase in fuel prices. The group optioned that quality of milk cans used for transportation were of very good quality. It can be inferred that the major constraints faced by the transport operator were unwanted waiting times at MPPs and improving price fixed by the company per kilometer in raw milk transport as per raising fuel prices.

5.3.3.3 Awareness of Transport Operators on Timely Milk Collection and Spoilage of Milk due to Delay

The information of awareness of transport service provider cum driver on timely milk collection and spoilage of milk due to delay has been collected through conducting focus group discussion and the results of focus group discussion indicate that the transport service provider-cum-drivers were aware about timely collection of milk cans from MPPs and optioned as most important activity. They are aware that any delay in transportation of cans to BMC unit would spoil milk. The transport service provider-cum-drivers were not willing to accept any responsibility for quality milk collection as they confine themselves as transporters only not as stakeholders in the value chain. All of the transport service providers thought that they were always willing to maintain schedule times as indicated for the routes. Further they are aware about the importance of handling milk cans properly and Showing utmost care. The transport service providers-cum-drivers are aware and always practicing fuel filling before stating time, willing to repair and service vehicles regularly and never driving the vehicle over speed to achieve schedule time.

5.3.4 Route Optimization for Efficient Procurement of Raw Milk from Milk Pooling Points to Bulk Milk Cooling Unit

The Distances from one node to other node have been collected, distance matrix for each route have been prepared to optimize the routes using travelling salesman problem model.

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling point to another point in route-1 reveal that there was a maximum distance of 23.8 kilometers between BMC unit and MPP-02 and minimum distance of 2.2 between MPP-07 and MPP-08.

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling point to another point in route-2 reveal that there was a maximum distance of 12 kilometers between MPP-10 and MPP-17 and minimum distance of 0.1 between MPP-17 and MPP-18.

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling point to another point in route-3 reveal that there was a maximum distance of 7.7 kilometers between MPP-22 and MPP-27 and minimum distance of 0.2 kilometers between BMC unit and MPP-30.

5.3.4.1 Optimization of Routes

In route-1 distances were optimized by employing Travelling Salesman Problem model and the results reveal that 09 milk pooling points were considered in the optimization of route-1. As a result in route-1 the optimized distance is 48.2 kilometers, time travelled to cover all the milk pooling points is 83.5 minutes and the total cost per trip is around 345 rupees.

In route-2 distances were optimized by employing Travelling Salesman Problem model and the results reveal that 11 milk pooling points were considered in the optimization of route-2. As a result in route-2 optimized distance is 26.7 kilometers, time travelled to cover all the milk pooling points is 76 minutes and the total cost per trip is around 191 rupees.

In route-3 distances were optimized by employing Travelling Sales man Problem model and the results reveal that 10 milk pooling points were considered in the optimization of route-3. As a result in route-3 optimized distance is 18.4 kilometers, time travelled to cover all the milk pooling points is 71 minutes and the total cost per trip is around 132 rupees.

5.3.4.2 Comparison of Raw Milk Transportation before and after Optimization of Routes

A comparison of the distance, time and cost in the optimized routes with existing routes shows that the distance of raw milk transportation in optimized route-1 has been reduced from 97 kilometers to 96.6 kilometers there by reducing the travelling time from 170 minutes to 167 minutes and reducing the cost from 693.55 rupees to 690.69 rupees. The distance of raw milk transportation in optimized route-2 has been reduced from 57 kilometers to 53.4 kilometers thereby reducing the travelling time from 174 minutes to 152 minutes and reducing the cost from 407.55 rupees to 381.81 rupees. The distance of raw milk transportation in optimized route-3 has been reduced from 40.6 kilometers to 36.8 kilometers thereby reducing the travelling time from 157 minutes to 142 minutes and reducing the cost from 290.29 rupees to 263.12 rupees.

It can also be inferred that there was a significance reduction of total distance, time and cost in raw milk transportation for the identified bulk milk cooling unit with the optimization of routes was observed. The total distance for travelling to procure the milk has been reduced to 186.8 kilometers per day from 194.6 kilometers per day. The total time of travelling was reduced from 501 minutes per day to 461 minutes per day. The total cost incurred for transportation has reduced from 1391.4 rupees to 1335.6 rupees. With route optimization in all routes of identified bulk milk cooling unit at total reduction in cost of transportation of 55.77 rupees per day could be achieved. As these transportation operations are routine and need to be done throughout the year an annual cost saving of 20,356 rupees per annum for the identified BMC unit could be achieved.

5.3.4.3 Proposed Schedule Times of Milk Pooling Point Operations and Vehicle for Optimized Routes

Schedules have been prepared considering the delay times in milk pooling point operations to prevent overcome the delays in milk procurement for optimized routes, it can be inferred that considering the standard deviation of delay of 4.49 minutes in MPP operations in route-1, to avoid the delays at milk pooling points the operating time has been increased to 35 minutes and schedules have been prepared for MPP operations. The vehicle route schedule time has been proposed as per the optimized routes. According the proposed schedule aims at procuring milk from MPPs and reach to BMC unit within a schedule time of 90 minutes without any delays through optimizing of distance, time and cost.

It can also be inferred that considering the standard deviation of delay of 3.99 minutes in MPP operations in route-2, to avoid the delays at milk pooling points the operating time has been increased to 35 minutes and schedules have been prepared for MPP operations. The vehicle route schedule time has been proposed as per the optimized routes. According the proposed schedule aims at procuring milk from MPPs and reach to BMC unit within a schedule time of 90 minutes without any delays through optimizing of distance, time and cost.

In route-3 the standard deviation of delay of 4.64 minutes in MPP operations, to avoid the delays at milk pooling points the operating time has been increased to 35 minutes and schedules have been prepared for MPP operations. The vehicle route schedule time has been proposed as per the optimized routes. According the proposed schedule aims at procuring milk from MPPs and reach to BMC unit within a schedule time of 90 minutes without any delays through optimizing of distance, time and cost.

CONCLUSIONS:

- In the present study the identified BMC unit has installed capacity of preserving four thousand kilo litres per day, catering the needs of 554 registered milk pourers belonging to thirty five villages. There were nine, eleven and ten milk pooling points in route-1, route-2 and route-3 respectively that serves 13 villages, 11 villages and 11 villages, covering 30 MPPs.

- The present identified BMC unit has three vehicle routes covering with three vehicles commuting a distance of 194.6 kilometers per day. The maximum milk procured was 758 liters in route-1, 1296 liters in route-2 and 1157 in route-3 per day that has been the basis for deciding the vehicle capacities for collection of milk cans from milk pooling points.

- The FPO owned dairy unit has adopted a system of milk collection through village level milk pooling points (MPPs). Each MPP is provided with all the essential utilities for the milk collection and also the testing equipment such as digital milk analyzers.

- Each MPP has been allotted a time slot of 30 minutes, on an average the 30 minutes time slot time of each MPP has been divided in pre-operative, operative and post-operative activities with 10 minutes each.

- The time delays in operations at Milk pooling points was ranging from 0 to 10 minutes. The standard deviation of delays in milk pooling point operations was estimated to be 4.49 minutes in route-1, 3.99 minutes in route-2 and 4.64 minutes in route-3.
- The major reasons for time delay in MPP operations were delay in milking by farmers beyond the regular timings, delay by farmers due to attending other work during MPP slot time, large no. of pourers to accommodate with in the given MPP slot time and all the farmers come at the same time to the MPP to pour milk.
- The major reasons to hold the collected milk at MPPs were delay due to late supply of milk by few farmers even after slot time ends, delay in preparation of reports, delay in arrival of milk cans collection vehicle and delay in canning the collected milk.
- Perception of MPP operators on importance given to pre-operative activities reveal that 53 per cent of MPP operators considered opening of MPP at right time as most important, 43 per cent of MPP operators perceived washing of hands and cleaning of cans as most important and 43 per cent of MPP operators have mentioned cleaning the equipment before testing and milk pooling as important.
- Awareness of MPP operators on importance given to pre-operative activities was high only among 36.7 per cent of MPP operators while around 63.3 per cent of MPP operators awareness levels on importance given to pre-operative activities lies between low to moderate.
- Perception of MPP operators on importance given to operative activities reveal that 50 per cent of MPP operators considered maintenance of timely procurement as most important, 63 per cent perceived sampling of milk from each farmer as most important, 60 per

cent have mentioned testing of milk samples of each milk producer during procurement as most important, 70 per cent considered transfer of milk into milk carrying cans as most important and 60 per cent have mentioned acknowledging the recorded values to the milk producers as most important.

- Awareness levels of MPP operators on importance given to operative activities was equal among all the 30 MPP operators *i.e.*, 33.3 per cent.
- Perception of MPP operators on importance given to post-operative activities reveal that 60 per cent of MPP operators considered filling the milk carrying cans as most important, 47 per cent perceived proper fixing of the lid as important, 50 per cent have mentioned loading milk carrying cans into vehicles as not important, 37 per cent considered sanitizing the MPP as most important, 60 per cent have mentioned maintenance and correction of recorded data as most important and 57 per cent considered reporting any delays at MPP to BMC unit as most important.
- Awareness levels of MPP operators on importance given to post-operative activities was high only among 40 per cent of MPPs while around 60 per cent of MPP operators awareness levels on importance given to post-operative activities lies between low to moderate.
- Time motion studies reveal that the total trip time in route-1 to travel the distance of 48.5 kilometers from BMC unit to cover nine milk pooling points and returning back to BMC unit was 85 minutes and 10 seconds and it was less than the schedule time of 90 minutes.
- Time motion studies reveal that the total trip time in route-2 to travel the distance of 28.5 kilometers from BMC unit to cover 11 milk

pooling points and returning back to BMC unit was 86 minutes and 49 seconds and it was less than the schedule time of 90 minutes.

- Time motion studies reveal that the total trip time in route-3 to travel the distance of 20.3 kilometers from BMC unit to cover 10 milk pooling points and returning back to BMC unit was 78 minutes 28 seconds and it was less than the schedule time of 90 minutes.
- The average cost of raw milk transportation per day from milk pooling points to BMC unit was 51 paise per litre per kilometer in route-1, where as in route-2 it was 22 paise per litre per kilometer and in route-3 it was 18 paise per litre per kilometer.
- The major constraints faced by the transport operators were unwanted waiting times at MPPs and improving price fixed by the company per kilometer in raw milk transport as per raising fuel prices.
- Awareness of transport service providers cum drivers on timely milk collection and spoilage of milk due to delay reveal that they were aware about timely collection of milk cans from MPPs and optioned as most important activity. They are aware that any delay in transportation of cans to BMC unit would spoil milk. The transport service provider-cum-drivers were not willing to accept any responsibility for quality milk collection as they confine themselves as transporters only not as stakeholders in the value chain. All of the transport service providers thought that they were always willing to maintain schedule times as indicated for the routes. Further they are aware about the importance of handling milk cans properly and Showing utmost care. The transport service providers-cum-drivers are aware and always practicing fuel filling before stating time, willing to repair and service vehicles regularly and never driving the vehicle over speed to achieve schedule time.

- Optimization of routes through Travelling Salesman Problem reveal that in route-1 the optimized distance is 48.2 kilometers, time travelled to cover all the milk pooling points is 83.5 minutes and the total cost per trip is around 345 rupees.

- Optimization of routes through Travelling Salesman Problem reveal that in route-2 optimized distance is 26.7 kilometers, time travelled to cover all the milk pooling points is 76 minutes and the total cost per trip is around 191 rupees.

- Optimization of routes through Travelling Salesman Problem reveal that in route-3 optimized distance is 18.4 kilometers, time travelled to cover all the milk pooling points is 71 minutes and the total cost per trip is around 132 rupees.

- A comparison of the distance, time and cost in the optimized routes with existing routes reveal that there was a significance reduction of total distance, time and cost in raw milk transportation for the identified bulk milk cooling unit with the optimization of routes was observed. Throughout the year an annual cost saving of 20,356 rupees per annum for the identified BMC unit could be achieved.

- Proposed schedule times of MPP operations and vehicle for optimized routes reveal that the proposed schedules aims to procure milk from MPPs to BMC unit within a schedule time of 90 minutes in all the routes without any delays through optimization of distance, time and cost.

RECOMMENDATIONS:

- Developing futuristic solutions based on smart mobile application for live temperature and time tracking of cans by using RFID or GPS tags or QR codes integrating with mobile application based reporting system would lead to digitalization of operations at MPP level eliminating avoidable delays leading to bench mark standards in achieving maximum efficiency in milk procurement. Implementation of QR code or Bar code tagging on the milk collection cans would enable to capture vital information about the quality and quantity of milk inside the cans to improve transparency.
- The results of awareness levels of MPP operators emphasize the need for training programs, result oriented demonstration, role plays and posters display to be organized on regular basis to increase awareness on importance of operations at MPP level.
- To create awareness among milk pourers and MPP operators on importance of timely milk procurement, avoiding delays in MPP operations and holding the collected milk beyond slot times at the MPPs, wall painting of pictorial messages should be painted on the wall of MPPs. The same should be stressed in all training programs and meetings conducted for milk pourers and MPP operators by FPO.
- The emphasis on increasing awareness on timely milk collection and spoilage due to delays among the farmers and MPP operators could be achieved through introducing activities like pledge taking, slogans during various events, trainings and general body meetings conducted by FPO.

- Introduction of Smart mobile application for GPS based operation punching method for timely following schedules preventing unwanted delays at MPP operators, transport service providers and BMC operator would be more effective to sustain timely milk collection.
- A digital rating system may be designed based on various parameters for efficient milk procurement practices for timely milk collection. The MPP operators and transport service providers may be rated on the system and identify the best performing MPP operators and transport service providers on consistence of performance and recognize them through prizes or certificates during general body meetings or company events.

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