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Impact of Transportation System in Logistics Chain: A Case Study of Dairy Company

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Abstract:
A supply chain consists of the organization, people, resources, and information involved in moving a product or service from supplier to customer. Transportation is the major function of a supply chain, which provides the movement of products. The purpose of this paper is to analyze the impact of transportation systems on the logistic chain of the dairy company. The collection of milk is a major problem still faced by the dairy sector. Bridging the gap between costs and routing problems simultaneously by forming an effective and efficient route of milk collection network for the dairy processor is a problem faced by the dairy sector in Pakistan because a major part of the cost is associated with it. Previous work has not considered such a real scenario with 62 milk collection centers. This research was considered to describe the importance of transportation systems in the logistics chain to logistics managers, planners, transportation managers so that comprehensive procedures can be made and implemented for reduction of transportation cost of the company to improve the logistics chain. For this, the technique of operations research including minimum spanning tree was used to obtain optimized results.

Keywords: Logistics chain, transportation system, transportation cost, shortest route algorithm

Introduction

Overview of Logistics Management

Logistics is defined as, supply chain part, which is responsible for the movement of goods from one place to another, which can control the flow of goods, storage of goods, distribution of goods, and information from origin to consumption point so that customer requirements can be met.[Keenan, P.B, 1998]It is also defined in the form of five important key elements, which consist of logistics, inbound logistics, management of material, physical distribution of product, and management of supply chain. Logistics describe the whole process of the product moving into the

firm, getting through the process, and getting out towards the consumption point. Inbound logistics describe the flow of material from supplier towards firm for the conversion of material into a product. In contrast, the management of material describes the movement of material during processing in different stages. Physical distribution describes flow moving out of the firm towards the final consumption point, and the total communication network from supplying, processing to the consumption of the product in a larger perspective is collectively described as supply chain management. [Lahrichi, N,2012]. A competitive and globalized market has brought a huge change due to advancements in financial and commercial technologies. Managing activities related to logistics and transportation is one of the important tasks to maintain the economy of a company. Customers and even stakeholders are pressuring to reduce the cost and increase profit as well by considering the effectiveness and efficiency of performance. Generally, procurement is considered as more than 70% of total logistics cost, but transportation accounts for the highest percentage of cost, about 43.57% [S.&. Lambert,2001].

Without an upgraded and developed transported system, logistics could not bring its benefit to full. A better transportation system means an efficient logistics system, which helps in the reduction of operations costs and increases service quality. Improvement in transportation system will help in the reduction of overall logistics cost, and well-operated logistics system means a growth of the company and competitive advantage for a company. In business logistics, transportation is one of the most important factors to be studied as it has a significant impact on the overall economic conditions of a company. Almost one-third and even sometimes two-third part of the logistics cost is associated with the transportation system. According to research, the cost of transportation accounted for 6.5% of market revenue and 44% of logistics costs. In another study of Australian companies, it has been indicated that transportation cost occupies 29.4% of total logistics cost, which means a huge proportion. In this way, improvement in transportation costs can help us to have a better logistics system for a company.

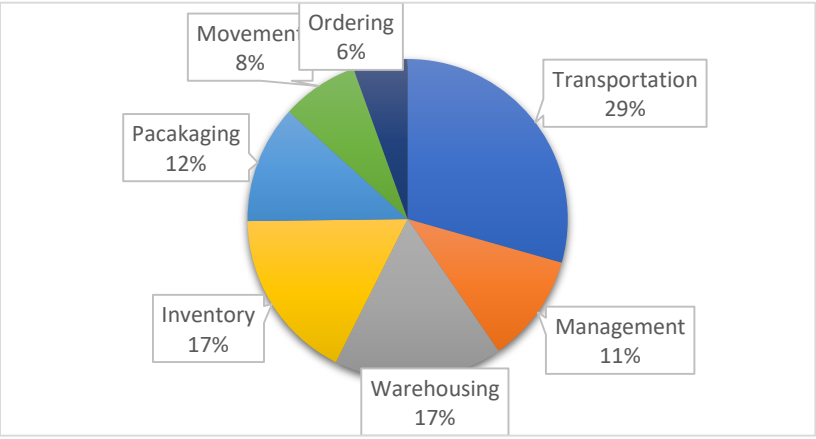

Figure 1: Proportions of Logistics cost [S.Lambert, 2001]

Role of logistics and its impact on the dairy sector

A boost is raised in the milk industry due to the support of the government by reducing tax, duty-free machinery imports, and availability of currency financing in 1990 [Erdogan, G, 20q7]. The production of milk has increased almost 3.2% [Erdogan D] in 2013 and 2014 as compared to

the production of last year. Pakistan is the third-largest milk-producing country on the globe as it is producing 42.4 million tons during 2014 and 2015 [European Commission]. Milkman is collecting milk from small milk producers, which are about 100 liters [Heinschink, K, Shallow,2013]. It can be solved either by using the maximum capacity of the fleet or scheduling routes on proper grounds. One of the successful kinds of milk-producing companies in India has worked on a three-tiered structure called Anand, which comprises milk producers (that should be of the same area), district union, and cooperatives to improve their milk collection system and its marketing system within India and outside it. In

In Malaysia, a case study was done to obtain an effective transportation system in the automobile tires industry. Data was formulated with the help of the simplex method of LP [Laporte G]. Individually, time is wasted in negligible amounts, but based on an aggregate [Les Foulds Iberia, 2009], huge waste is associated due to it. By forgetting all such problems, Pakistan is producing 48 million tons of milk [Masson, R, Lahrichi,2016] annually. It is one of the largest milk-producing countries. In contrast, India is ranked first in its bovine population. With 276 million animals [McElory], they are working for optimization of their milk collection centers, and they are increasing 4.7% in milk production on an annual basis since 1971. As in Pakistan, animals are usually fed with agro-industrial waste, grass, and crops [Micha, E,2017]. It has been observed that small-scale farmers are 4.5 times [Murimi Ngigi] more careful and worried about the quality of milk and its nutrients as compared to large-scale farmers. Milk and other dairy products can meet the needs of nutrients [Mwangi Ngigi] somehow as they are in access as compared to meat. Transportation of milk is as important a factor to maintain quality and safety as there can be a loss faced by a company due to milk spoilage [O Connor D, D,2014]. The supply chain of the dairy sector is more complex than other chains because It is necessary to maintain appropriate nutrients, and the most challenging problem in the dairy industry is especially transportation. The Supply chain of the milk industry begins with raw material and ends with the final product. Companies provide support activities such as packaging because different processes and steps are included after which milk is ready to transport to the end consumer. The important role in milk collection is its distribution across the country, and its marketing is played by Gawala and Dudhi. A Community of milk collectors is increasing and crosses millions in number. Companies have started spending investment on a highly effective logistic system and a more economical and synchronized supply chain without compromising the needs and expectations of customers. Like other companies, milk companies are working in national as well as multinational markets. They are spending on upgrading their technologies. Even small milk-producing firms knew that technology improvement is a necessity for market survival. All these investments can be improved by improving and incorporating the value chain and whole production chain from supplier to end consumer. Due to the difference between geographical areas, different countries have different logistic costs. In the USA, the annual cost associated with logistic activities is 8.6% [M. Younas,2013] of its GDP, and in Brazil, it's 12.6% of total GDP. Traditional activities were not bothering the issue of activity that could affect the environment. The only objective was to reduce the cost and increase the profit. Environmental issues are another important concern by the consumer as modified from price to quality. They are demanding environmentally friendly products so that the environmental effect can be controlled. To overcome the use of fossil fuels and to maintain cycle time [R.L.a.U.J.Kohls, 1985] is still competitive. All companies should also consider the environmental effect due to transportation routing plans. The main focus of this research is to create a highly efficient and dynamic routing solution that can be employed to

produce cost-efficient route collection schedules for milk assembly in a fast-changing environment. Milk assembly comprises a myriad of input variables that are often unique to the activity. Therefore, any solution proposed must be designed so that it is flexible enough to accommodate what is a highly sophisticated and complex process that can be described as being uniquely dependent on an exceptionally distinctive set of input variables. The research undertaken in this paper highlights that the solution arrived at must provide a very flexible working model that can be efficiently tested with simulated data. Moreover, it must be constructed with the potential to be a useful modeling tool with the capabilities to support the milk collection route scheduling needs of the dairy industry. Based on the research in the area of logistical optimization, the model must further be able to provide practical routes that can be used by schedulers to service their load building needs. Initially, the model needs to be able to recommend realistic routes for milk collection that take into account the unique factors encountered by the dairy sector.

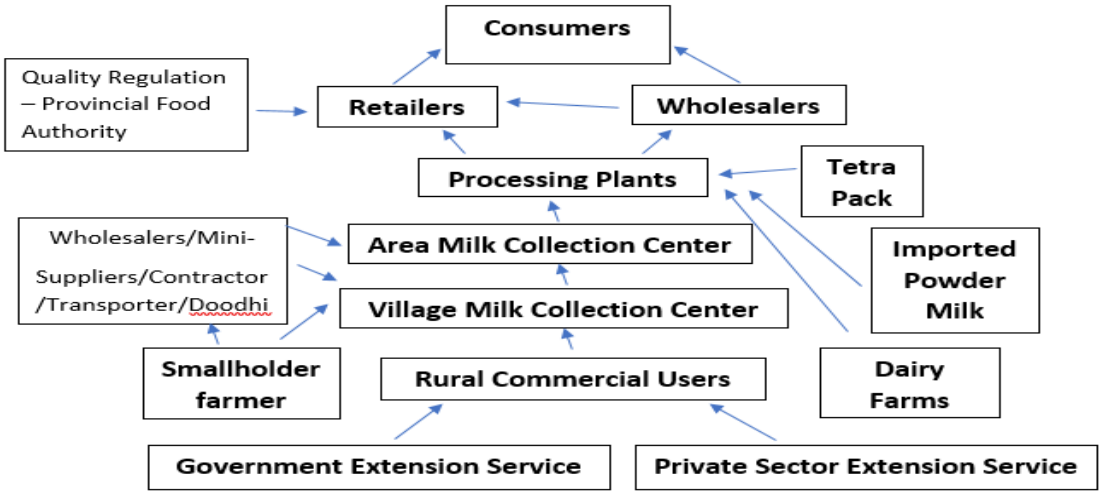

Figure 2: General supply chain of processed milk supply [R. Ansari, 2018]

The important role in milk collection, its distribution across the country, and its marketing are played by Gawala and Dudhi. The community of milk collectors is increasing and has crossed millions in number. Companies have started spending investment on highly effective logistic systems and more economical and synchronized supply chains without compromising the needs and expectations of customers. Like other companies, milk companies are working in national as well as multinational markets. They are spending on upgrading their technologies. Even small milk-producing firms knew that technology improvement is a necessity for market survival. All these investments can be improved by improving and incorporating the value chain and whole production chain from supplier to end consumer. Due to differences between geographical areas, different countries have different logistic costs. It is, therefore, said that, to improve overall logistics, cost it is better to look upon controllable variables first. In this regard, transportation is considered as one of the important variables of logistics that can be optimized in terms of distance, time, and quality which will lead to overall cost reduction. In the USA, the annual cost associated with logistic activities is 8.6% [D. Bowersox,2007] of its GDP, and in Brazil, it's 12.6% of total GDP. Traditional activities were not bothering the issue of activity that could affect the environment. The only objective was to reduce the cost and increase the profit. Environmental

issues are another important concern by consumers as they are modified from price to quality. They are demanding environmentally friendly products so that environmental effects can be controlled. To overcome the use of fossil fuels and to maintain cycle time [K. Logozar] is still competitive. All companies should also consider environmental effects due to transportation routing plans.

Research Methodology

Collection of Data

For this research work, data is collected from diverse sources by keeping in view, technologies of optimization, parameters of supply chain and logistics, facilities of transport, and trade-off. Data include 62 different depots from where milk is collected, routes into which these milk collection depots were divided, number of fleets, the capacity of each collection center, and constraint of time. In the first section, the Collection depot was located in the town of Sheikhupura. To make data as realistic as possible, initially, we have fixed one depot in Sheikhupura. The individual mega-collection points were located around this depot with the help of Google Satellite View. The network of milk collection company was based on many mega-collection points with capacity ranges up to 6000 liters Reasonable widespread was used to analyze the real road distance of 62 collection centers the location of each collection center was chosen randomly on google map and its latitude had longitude distance has been measured. The merit of using Google Maps is that real distance can be calculated which can further be used to analyzed actual data This section also comprises of no of fleets available and the original route structure of the company from which milk is being collected by utilizing the maximum capacity of the vehicle. The last section will indicate information that has been gathered about expenses and costs associated with transportation system which comprise, chiller cost, fuel consumption, maintenance cost driver cost, and an average of these costs per kilometer. When all information regarding parameters of the supply chain and current transportation system of the company is collected against each route then it is summarized in the tabular form so the comparative study can easily be performed. This summarized information consists of the distance traveled by each vehicle under the given constraint of time and capacity. All the information is gathered from the navigation system and from the board of experts to have realistic data about distances, time, and other measures. Cost is calculated by the method of expenses calculation used by the transportation system of the company.

Figure 3: Sixty-two milk collection points around origin

Constraints

1. A vehicle of 12 ~14 GVW is considered to have a tanker capacity of 6200 liters. A total of 9 tankers with chillers are considered for this study. The carrying capacity of the fleet is 55,800 per shift, whereas the total capacity that must be collected is 46,527 liters.
2. One vehicle enters, and exactly one leaves each collection center
3. Vehicle must collect milk from allocated collection centers
4. Each collection center must be visited by vehicle once.
5. The maximum time allocated to each truck is 8 hours
6. Milk collected from each node must not exceed the capacity of the vehicle
7. The cost which is considered for this study is mentioned below;

Table 1: Cost Calculation

Serial no	Type of cost	Amount
1	Diesel cost	110 Rs/liter
2	Running cost	27.4 Rs/km
3	Maintenance cost	5.5 Rs/km
4	Chillers (consider 30 mint against 1 liter)	4 Rs
5	Driver and other (as general contact)	5 Rs/km
6	Over other	5.5 Rs/km
	Total cost	65.9/km

Work Done

In this section, the transportation route or company is optimized and redesigned using techniques of operation research and concepts of supply chain modeling. For this, a distance matrix is developed at first, which is based on data that has been previously collected; then by keeping in view the constraints stated by the company, the algorithm is prepared for optimization.

Matrix for distance

Reasonably widespread was used to analyze the real road distance of 62 milk collection centers. The location of each collection center around one fixed depot is selected using geographic navigation, and its latitude and longitude distances have been measured. Nine trucks were used to collect milk from these collection centers representing nine different routes. The merit of using geographic navigation is that real distance can be calculated, which can be further used to analyze actual data. Initially, data is entered in Tora software in a specific format of minimum spanning

tree Results are obtained. From the minimum spanning tree, the obtained solution is used as the initial basic feasible solution to make efficient and effective routes.

Optimization of the transportation route

Based on the matrix of distance, routes are optimized with the help of optimization tools such as the minimum spanning tree. Whereas 'D' indicates the number of nodes.

Table 2: Summary of current routes of transportation

Nodes (D)	Distance (km)	Cumulative (km)	Capacity (C) (liters)	Cumulative Capacity (CC) (liters)
D 1-54	13	13	567	567
D 54-55	14	27	998	1565
D 55-57	2	29	904	2469
D 57-61	21	50	901	3370
D 61-60	9	59	500	3870
D 60-2	33	92	904	4774
D 2-62	20	112	838	5612
Total distance traveled by truck 1 134 Km				acity occupied by 5612 Liters
D 1-48	30	30	984	984
D 48-59	42	72	750	1734
D 59-29	29	101	631	2365
D 29-4	18	119	698	3036
D 4-3	15	134	518	3581

D 3-40	33	167	915	4496
D 40-41	12	179	731	5227
D 41-45	50	229	750	5977

Total distance traveled by truck 2	Total
capacity occupied by truck 2	
269 km	5977
Liters	

D1-63	18			
		18	569	569
D 63-31	40	58	513	1082
D 31-53	38	96	533	1615
D 53-52	7	103	836	2451
D 52-5	40	143	977	3428
D 5-56	18	161	535	3963
D 56-30	30	191	831	4794
D 30-49	47	238	975	5769

Total distance travelled by truck 3	Total
capacity occupied by truck 3	
270 km	54977
Liters	

D 1-50		41 41 915 915		
D 50-51	16	57	731	1646
D 51-28	65	96	586	2232
D 28-7	17	103	915	3147
D 7-8	12	143	753	3900

D 8-38	48	161	537	4437	D 38-37	5	204	700	5137
D 37-36		9		213			831		5968

Total distance traveled by truck 3	Total capacity occupied by truck 3
239 km	5968Liters

D 1-50	41			
		41	915	915
D 50-51	16	57	731	1646
D 51-28	65	122	586	2232
D 28-7	17	139	915	3147
D 7-8	12	151	753	3900
D 8-38	48	199	537	4437
D 38-37	5	204	700	5137
D 37-36	9	213	831	5968

Total distance travelled by truck 4	Total capacity occupied by truck 4
239 km	5968 Liters

D 1-27	45			
		45	691	691
D 27-39	35	80	851	1542
D 39-42	16	96	835	2377
D 42-43	10	106	650	3027
D 43-46	42	148	871	3898
D 46-47	4	152	727	4625
D 47-19	13	165	730	5355

Total distance travelled by truck 5			Total capacity occupied by truck 5	
206 km			5355 Liters	
D 1-16	200	200	930	930
D 16-6	21 221	878 1808	D 6-9 7 228	783 2591
D 9-10	85	313	682	3273
D 10-15	8	321	906	4179
D 15-20	51	372	822	5001
D 20-18	48	420	721	5722

Total distance traveled by truck 6			Total capacity occupied by truck 6	
468 km			5722 Liters	
D 1-12	54	54	619	619
D 12-11	19	73	714	1333
D 11-13	10	83	884	2217
D 13-14	106	189	857	3074
D 14-44	19	208	687	3761
D 44-22	15	223	635	3396
D 22-26	86	309	787	5184
D 26-25	5	314	635	5818

Total distance travelled by truck 7			Total capacity occupied by truck 7	
360 km			5818 Liters	
D 1-24	38	38	691	691

D 24-32	5	43	838	1529
D 32-58	52	95	522	2051
D 58-33	66	161	510	2561
D 33-34	13	174	751	3312
D 34-35	28	202	973	4285
D 35-17	47	249	531	4816
D 17-21	15	264	973	5789
Total distance travelled by truck 8			Total capacity occupied by truck 8	
306 km				95789 Liters
D 1 -23	45	45	787	787
Total distance traveled by truck 9			Total capacity occupied by truck 9	
90 km				787 Liters

Table 3: Summary of optimized routes of transportation

Nodes (D)	nce (km)	tive Distance (km)	Capacity (C) (liters)	Cumulative Capacity (CC) (liters)
D 1-3	11	11	518	518
D 3-63	8	19	569	1087
D 63-61	8	27	901	1988
D 61-7	5	32	915	2903
D 7-42	61	93	835	3738
D 42-44	10	103	687	4425

D 44-62	56	159	838	5263
D 62-4	8	167	598	5861
Total distance traveled by truck 1			Total capacity occupied by truck 1	
		196 Km		5861 Liters
D 1-55	21	21	998	998
D 55-10	1	22	682	1680
D 10-13	9	31	884	2564
D 13-12	10	41	619	3183
D 12-11	9	50	714	3897
D 11-14	10	60	857	4754
D 14-51	9	69	731	5485
Total distance traveled by truck 2			Total capacity occupied by truck 8	
107 km				5485 Liters
D 1-23	45	45	787	787
D 23-25	8	53	635	1422
D 25-24	11	64	691	2114
D 24-5	3	67	977	3090
D 5-33	6	73	510	3600
D 33-35	7	80	973	4573
D 35-40	7	87	915	5488
Total distance travelled by truck 3			Total capacity occupied by truck 8	

		113 km		5488 Liters
D 1-43	37	37	650	650
D 43-18	66	103	721	1371
D 18-21	56	159	973	2344
D 21-22	15	174	635	2979
D 22-6	6	180	878	3857
D 6-9	11	191	783	4640
D 9-8	15	206	753	5393
D 8-17	33	239	531	5924
Total distance travelled by truck 4			Total capacity occupied by truck 4	
296 km			5924 Liters	
D 1-45	40	40	750	750
D 45-52	26	66	836	1586
D 52-57	7	73	904	2490
D 57-56	2	75	535	3024
D 56-53	7	82	533	3558
D 53-48	32	114	984	4542
D 48-59	13	127	750	5292
D 59-27	45	172	691	5983
Total distance traveled by truck 6		6	Total capacity occupied by truck 6	
216 km			5958 Liters	
D 1-2	11	11	904	904

D 2-31	14	25	513	1417
D 31-29	10	35	631	2048
D 29-16	31	66	930	2978
D 16-19	11	77	730	3708
D 19-15	6	83	906	4614
D 15- 20	11	94	822	5436
Total distance traveled by truck 7		149 km	Total capacity occupied by truck 7	5436 Liters
D 1-58	26	26	522	522
D 58-50	7	33	915	1437
D 50-38	3	36	537	1974
D 38-37	12	48	700	2674
D 37-39	5	53	851	3525
D 39-36	9	62	831	4356
D 36-41	7	69	731	5087
D 41-60	9	78	500	5587
Total distance traveled by truck 8		103 km	Total capacity occupied by truck 8	5587 Liters
D 1-49	32	32	975	975
Total distance traveled by truck 9		64 km Liters	Total capacity occupied by truck 9	975

Fleets assigned to each route

From the given constraint, it can be seen that nine trucks are available to collect milk from 62 milk collection centers. Route for each truck is developed by a company that is optimized to reduce their transportation cost, which has a great impact on the overall cost of logistics and overall profit of the company. It is the one factor that can create a big difference. Results are shown below table;

Table 4: Indicate distance traveled by each vehicle Route

	Current route (km)	Optimized Route (km)
For Truck 1	134	196
For Truck 2	269	107
For Truck 3	292	113
For Truck 4	239	296
For Truck 5	206	217
For Truck 6	379	216
For Truck 7	360	149
For Truck 8	288	103
For Truck 9	90	64
Total (km)	**2,257**	**1,461**

The total expenses of the existing transportation system of the company and optimized transportation route are shown below;

Table 5: Cost associated with the transportation system

Route	**Cost associated with current routes (Rs.)**	**Cost associated with optimized routes (Rs.)**
For Truck 1	8,831	12,916
For Truck 2	17,727	7,051

For Truck 3	19,243	7,446
For Truck 4	15,750	19,506
For Truck 5	13,575	14,300
For Truck 6	24,976	14,234
For Truck 7	23,724	9,819
For Truck 8	18,979	6,787
For Truck 9	5,931	4,218
Total (Rs)	**148,736**	**96,277**

Time to deliver from collection center to mega-collection hub:

Perishable items are transported every day depending upon their different nature of preservation. The quality of such products decreases with time. Due to short shelf life and high demand, direct transportation is used, which is very expensive, while cheap and sustainable transportation means large delivery timing. Keeping an inventory of perishable items for long is worse. The product must be within the minimum time from storage place to consumer. Loses of quality are very high due to changes in climate conditions. If milk is collected within a defined period, its quality will be categorized as A, otherwise B, C, and so on. There are several ways to avoid such losses, and one of the most feasible solutions is to develop an effective and efficient transportation system. The time written in the table is in hours. If the truck speed is 40 km/ hrs. on average, then it will take 0.025 hrs. /km (1.5min)

Table 6: Time comparison analysis for distance covered by each vehicle

Route	**Time covered during current route**	**Quality category in the current route**	**Time covered in** the **optimized route of the company**	**Quality Category in optimized route**
For Truck 1	3.34	Quality A	4.89	Quality A
For Truck 2	6.72	Quality A	2.67	Quality A
For Truck 3	7.29	Quality A	2.82	Quality A
For Truck 4	5.97	Quality A	7.39	Quality A
For Truck 5	5.14	Quality A	5.42	Quality A

For Truck 6	9.47	Quality B	5.39	Quality A
For Truck 7	8.99	Quality B	3.72	Quality A
For Truck 8	7.19	Quality A	2.57	Quality A
For Truck 9	2.24	Quality A	1.59	Quality A
Total (Hrs)	**56.35**		**36.46**	

Comparison of design

After summarizing, Current transportation system of a company and optimized transportation route of the company, it is put forward in a comparative study to analyze all parameters of transportation design, including distance, time, and cost.

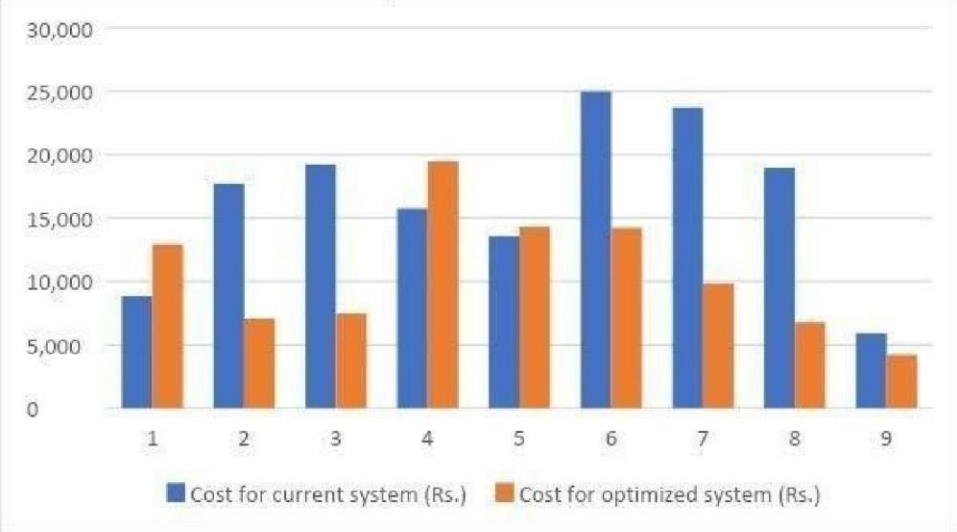

Figure **4:** Cost comparison for each truck

Figure 5: Distance comparison for each truck

Total cost of transportation system in existing route = 148,736 Rs. Total cost of transportation system after optimization = 96,279.9 Rs. Savings per day = 52,456 Rs, Savings per year = 19,146,440 Rs

Conclusion

The paper covered the importance of the proportion of transportation cost over logistics cost through an extensive review of dairy companies. A considerable cost is associated with the transportation system to transport milk effectively and efficiently. For this reason, it is crucial to look upon factors that constitute the majority of this cost. From the above transportation system, we can conclude that huge cost is associated with the transportation system and reduction in transportation cost will ultimately optimize the logistics system of a company. The Dairy Sector plays a vital role in the economy of the country, and even its demand is increasing day by day. In this way, we can say that improvement in transportation systems plays a role in the efficiency and performance of the logistics systems of a company. It means a powerful logistics system cannot be created without the establishment of an optimized link to the transportation system. On the other hand, the saved cost can be utilized to overcome other challenges and to bring technological advances in the logistics system of a company.

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