British Journal of Marketing Studies (BJMS)
Vol. 7, Issue 3, pp.27-43, June 2019
Published by European Centre for Research Training and Development UK (www.eajournals.org)

DISTRIBUTION SYSTEM OF ACI RICE SEEDS: AN AGRIBUSINESS MODEL IN BANGLADESH

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ABSTRACT: *The aim of this report is to investigate the current distribution system of ACI rice seed and propose an effective distribution model for delivering seeds. The study collected the demand and truck fare data from ACI seed and analyzed their current distribution system's shortcomings. After analyzing the process, the study found that distance saving matrix with vehicle scheduling method will be appropriate for the distribution of the rice seeds. The study shows how the method will be applied in distribution system and how it will make positive changes in their logistic system. After working with the data of a full season, the study gives a result of 43.62% decrease in distribution cost which will decrease the major operational cost as well. The result indicates that their current distribution system is ineffective and they have much scope to develop in their distribution sector. ACI seed is recommended to follow this distribution method to increase their operation efficiency.*

KEYWORDS: agribusiness model, ACI seed, distribution system model, Bangladesh

INTRODUCTION

Background of the study

Rice is the main food of Bangladesh and it contributes more than 80 percent to the total food supply [1]. About 75% of the total cropped land is covered by rice [2] and more than 60% of the total agriculture labor force is employed in rice production, processing, marketing and distribution [3]. Presently, the public and private/ NGO sectors are supplying only 40 percent quality seed against the total demand of the country. There is a high gap between the requirement and supply of quality rice seeds in Bangladesh. The contribution of public sector BADC and private sector seed companies supplying quality seed 25% and 15%, respectively. The rest 60% of the total national requirement of seed was fulfilled by the semi-formal seed and farmers own saved seeds, the quality of which was unknown or poor [4]. Any kind of mismanagement can greatly affect the rice production of our country.

The population of our country is growing and for this growing population our country needs proper food production. As rice is the main food, we need to give special emphasis on the production and distribution of rice. ACI is basically working with two types of rice seeds, they are BRRI 28 and BRRI 29. To ensure proper management of these rice seeds distribution, the study focuses on preparing a revised distribution model named vehicle routing problem for ACI seed Limited.

Distribution is an important part of logistics activities, according the vehicle type, distance, quantity and time requirements to delivery based on the set. In the decision-making process of the distribution, determining delivery routes are very important. As ACI seed not using any distribution model or following any location theory, the study aimed in preparing a quantitative

Print ISSN: 2053-4043(Print), Online ISSN: 2053-4051(Online)

model for distribution and a combination of qualitative supervision along with quantitative studies for other steps in the supply chain to make it more cost and time efficient. By means of well-handled distribution system, seeds could be sent to the right place at right time in order to satisfy customer's demands. It will bring efficacy, and also it will build a bridge between producers and consumers. Therefore, transportation is the base of efficiency and economy in business logistics and expands other functions of logistics system. In addition, a good transport system performing in logistics activities brings benefits not only to service quality but also to company competitiveness.

Justification of the study

The research emphasizes on establishing a transportation model for Rice seeds for ACI agribusiness; aiming that the study collected data from ACI Limited to analyze the current data pattern of distributing seeds. It was only limited to analyze the distribution pattern of two types of Hybrid rice, their major selling items. The study analyzes the current transportation procedures followed by the ACI team and ACI acknowledges that there are a number of adjustments that still need to be made. The progress in techniques and management principles in transportation will improves the delivery speed, service quality, operation costs, the usage of facilities and energy saving as transportation takes a crucial part in the manipulation of logistic. Reviewing the current condition, the paper identifies the sectors that can use the suggested transportation model to enhance the management system. This research divulges a set of recommendations for ACI limited as well as for the similar organizations who are working in this area to perform smoothly.

Statement of problem

ACI seed is operating a large supply chain network to produce and distribute rice seeds. The key element in a logistics chain is transportation system and transportation occupies one-third of the amount in the logistics costs and transportation systems influence the performance of logistics system hugely. ACI seed is not currently following any model for transportation and this report will provide a specific solution to reduce the cost and time by using an appropriate transportation model.

Scope of the study

The study is focusing on two types of rice seed produced and supplied to the farmers by ACI seed. The two types are BRRI 28 and BRRI 29. Currently ACI is contracting farmers to produce rice seeds and then they collect and process the seeds and send the seeds to the retailers and then farmers, the ultimate customers buy the processed seeds for them. ACI is trying to distribute quality seeds to the farmers so that they can generate plenty amount of rice. And ACI seed's values are- quality, transparency, innovation, fairness, continuous improvement and customer focus. To avail and maintain all these values they need change in their operational strategy. And one of the major operational parts is the transportation system as transportation is the base of efficiency and economy in business logistics. And this study focuses on the lacking of the distribution system. It will provide a guideline which will make the distribution system more time efficient and cost efficient. By means of well-handled transport system, seeds can be sent to the right place at right time in order to satisfy customers' demands. It will bring efficacy, and also it will build a bridge between producers and consumers. Therefore, transportation is the base of efficiency and economy in business logistics and expands other functions of logistics system. In addition, a good transport system performing in logistics activities brings benefits not only to service quality but also to company competitiveness.

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Limitations of the study

The supply chain of BRRI 28 and BRRI 29 consists of three steps for distribution. The first step is collecting the raw seeds from the farmers and gathering them in the local small warehouses and primary processing is done there. In the next step, the processed seeds are taken to the central warehouse at Rangpur from Lalmonirhaat, Pirgonj, Pirgachha, Thakurgaon and Kurigram. This upstream transportation is not revised by this paper due to time shortage though it is also a huge contributor in the operational cost. This study deals only with the downstream transportation from Rangpur central warehouse to seventeen depots.

The another limitation of this study was the collection of information. This report is based only on the demand data of the seeds in the season of 2013. The rice seed growing and distributing season consists of 4 months. They are August, September, October and November. ACI seeds managed to provide the demand and supply data of the whole season, they could not provide it month wise. So, this study worked with the total seasonal data and judgementally determined the month-wise demand and proposed the model according to that monthly demand data.

Objectives of the study

The primary objective of this study is to propose a structured distribution system for delivering rice seeds to the 17 depots. And the detailed objectives are-

- Increasing efficiency
- Minimizing distribution cost
- Decreasing lead time and lead time variability
- Effective use of resources

LITERATURE REVIEW

In the current literature review, it was tried to review all existing papers which are involved in saving algorithm for vehicle scheduling considering the minimization of total travel distance, travel time and distribution cost. First, the vehicle routing problem was first described by Dantzig and Ramser (1959) [5], who provided a solution method based, but one of the authors became known as the father of linear programming (Gass, 2003) [6]. Then Clarke and Wright (1964) [7] developed a heuristic solution method which became known as the savings method and the algorithm was widely used. It is also called the Clarke-Wright algorithm, after the authors, but in the early years it was also described as the Wright-Fletcher-Clarke algorithm [8] or the Fletcher-Clarke-Wright algorithm [9, 10]. Fletcher and Clarke had presented a paper at the 1963 conference of the Operational Research Society held in Nottingham. Surprisingly, their heuristic obtained a better result than Dantzig and Ramser for the illustrative example that they had used [11]. Dantzig and Ramser's approach had been to consider linking pairs of customers into a route that were close together, just considering the distance between them, but Clarke and Wright extended this, they take into account the reduction in distance obtained by linking two customers into a route, rather than serving them on separate routes. But this study followed the method suggested by Janat (2009) [12]. In his book he suggested that saving algorithm for vehicle scheduling can be used where a set of customers with known location and demand are to be supplied from a depot by delivery vehicles of known capacity subject to all customer demand being met, vehicle capacity not being exceeded and total trip length not exceeded. The routes begin and end at the depot. By means of this model, it can minimize the total sum of distances and costs related to the distribution.

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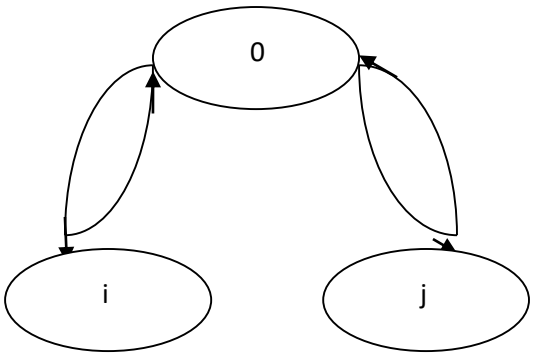
For this, the study needs to calculate the saving matrix first. The algorithm will require a cost matrix that contains information about the cost involved in travelling from warehouse to all depots. The saving matrix represents the saving that is realized when two nodes are consolidated in one route. As can be seen in figure 1(a) and (b), saving method starts with routes where each route serves just one node. Let us say we have two nodes that are served currently by two different routes. The distance for these two routes will be $2C_{oi} + 2C_{oj}$. If these two nodes are served by one route where the vehicle will go to depot i from the warehouse and visit depot j from node i and finally will return to depot 0, one cuts down the trip from the centre point to node j as well as the trip from node i to the center point, but will make an additional trip from point i to j. as we know that in a triangle the sum of two sides is always greater than the third side, the resulting savings will always be non-negative.

a) two independent routes



b) merged route

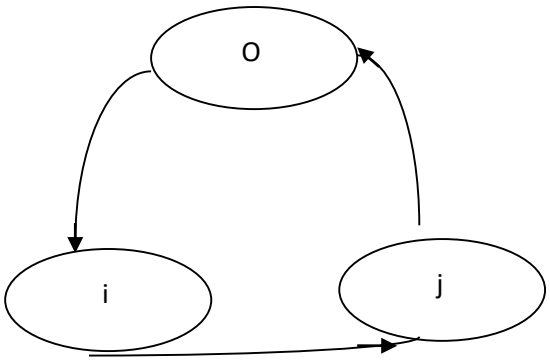


Figure 1. Present and proposed routing system

For calculating the distance saving matrix the equation is as follows-

$$\text{Savings } S_{ij} = C_{oj}+C_{io}-C_{ij}$$

For calculating the savings, we need the inter-distance between all depots. After that, we have to consider the distance which has the highest savings amongst all unassigned nodes. At the beginning of the algorithm all the nodes are in the list of unassigned nodes. After considering the highest distance, the method will consider the second highest distance and the process will continue in this way.

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After that, the study considered the demand data of the depots and the capacity of the transportation. If the demand is equal to the capacity, the cost saving method will not be applicable there. But if the demand is less or more than the vehicle capacity then the vehicle scheduling can be adjusted and the theory can be applied. At first, the vehicle will consider the depot situated at the location of highest saved distance, then the vehicle will consider the next depot situated at the second highest saved distance according to the matrix. Thus the distribution will continue and the number of distribution trip will be significantly reduced.

METHODOLOGY

In this paper, the research is trying to find out a distribution model which will help to reduce number of shipments. Because the higher the number of shipments, the higher will be the transportation cost. So, this study is focusing on reducing number of shipments preferring a full-truck load (FTL) shipment every time. With a less than full-truck load (LTL) shipment, the transport operator will have to run the vehicle at low capacity utilization which will increase the number of shipment.

Research Design

To prepare an appropriate distribution model the study mainly focused on quantitative approach rather than qualitative approach. As approximate historical data is available quantitative method can provide a better accuracy in distribution model.

Sample Design

The study did not collect the demand data of each year because it does not affect the accuracy of the study that much as the demand does not vary significantly from year to year. So, this study collected the most recent data available of the season of year 2013 as sample.

Data Collection

The study collected monthly demand data of BRRI 28 and BRRI 29 rice seeds from secondary source of ACI seeds. The study also collected the distribution cost or truck fare from central warehouse of Rangpur to 17 depots country wide. For preparing the distance saving matrix, the study also collected the distance data from Rangpur to 17 depots.

Analysis Method

After analyzing the data, the study concluded that, saving matrix with vehicle scheduling method can provide a better solution for distributing the rice seeds. So the study followed the method and the whole analysis was performed in Microsoft excel software. The full analysis in excel is added in the appendix part.

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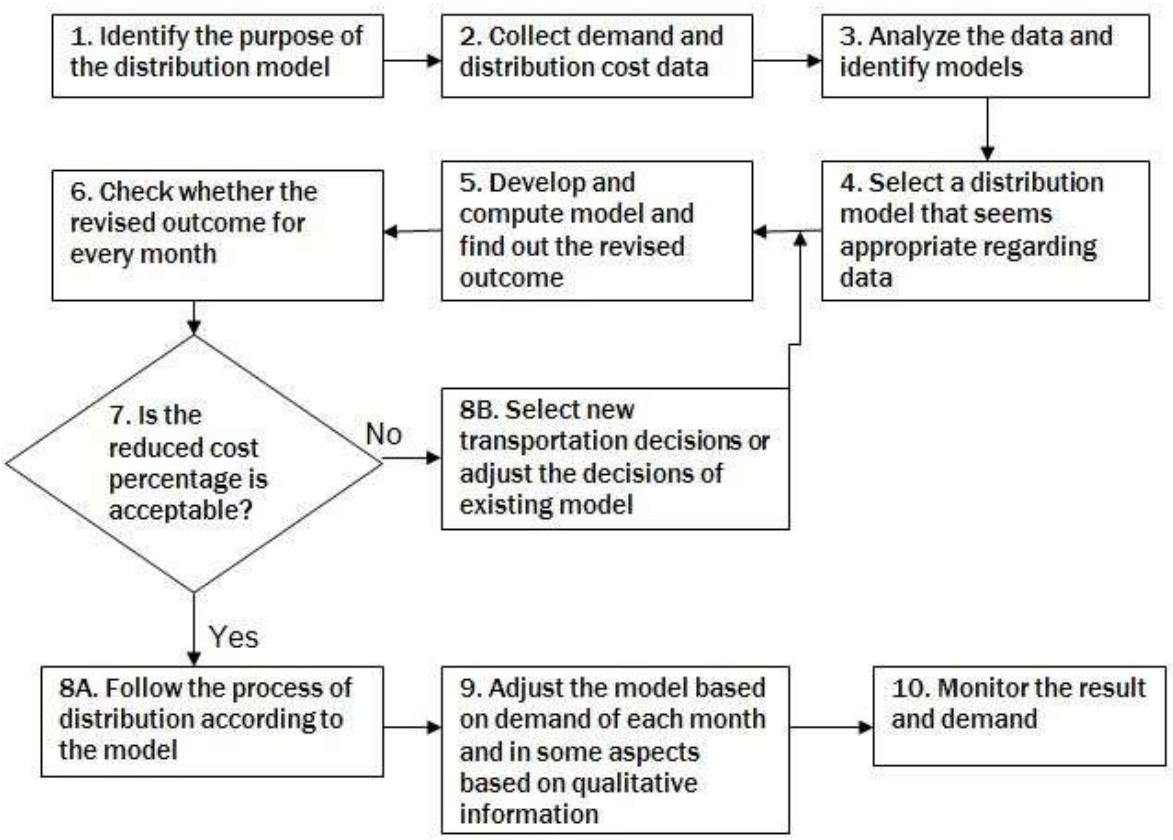

Figure 2. Model Selection Process

Analysis

The Present Scenario

The whole supply chain basically consists of six major steps and this research works with the fifth step, distribution in depots. The fifth step is one of the major cost contributors because this distribution is handled only from one central warehouse to countrywide. The countrywide distribution costs a major amount as the depots are distant from the warehouse.

Figure 3. The total supply chain

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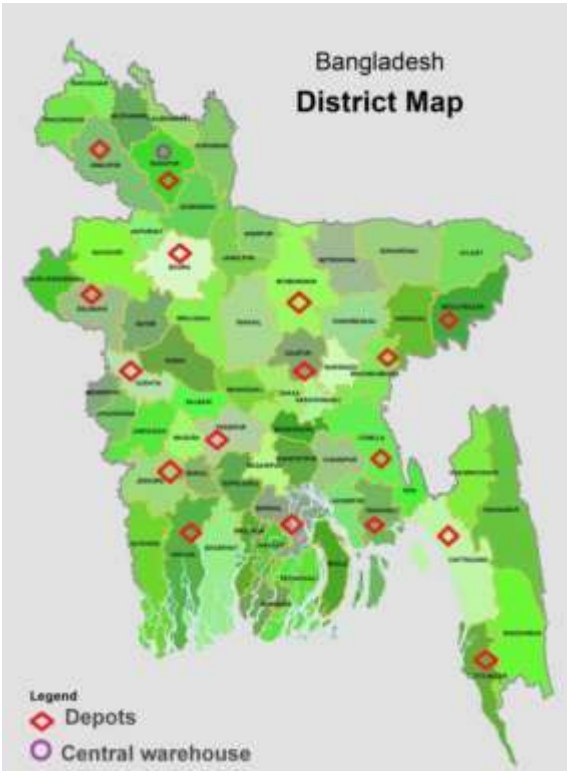

Figure 4. Location of the warehouse and depots

The study has collected secondary demand data of rice harvesting season of 2013 (From August, 2013 to November, 2013). It has analyzed the different demand pattern in different month and tried to design a distribution system with minimum shipments. The demand (mentioned in kilograms) for a season is presented in table 1.

Table 1. Monthwise demand in different depos

		AUGUST															
	Dinajpur	Rangpur	Bogra	Rajshahi	Kushtia	Jessore	Faridpur	Khulna	Barisal	Noakhali	Mymensi	Gazipur	Moulviba	Brahmani	Comilla	Chittagon	Cox's Baz	Total
DEMAND	6762	4728	16917.2	25608.8	640	6690.8	4882	4786	2063	4480	13462	5594	7166	1800	10861.4	504	413	117358.2
		SEPTEMBER															
	Dinajpur	Rangpur	Bogra	Rajshahi	Kushtia	Jessore	Faridpur	Khulna	Barisal	Noakhali	Mymensi	Gazipur	Moulviba	Brahmani	Comilla	Chittagon	Cox's Baz	Total
DEMAND	13524	9456	33834.4	51217.6	1280	13381.6	9764	9572	4126	8960	26924	11188	14332	3600	21722.8	1008	826	234716.4
		OCTOBER															
	Dinajpur	Rangpur	Bogra	Rajshahi	Kushtia	Jessore	Faridpur	Khulna	Barisal	Noakhali	Mymensi	Gazipur	Moulviba	Brahmani	Comilla	Chittagon	Cox's Baz	Total
DEMAND	40572	28368	101503.2	153652.8	3840	40144.8	29292	28716	12378	26880	80772	33564	42996	10800	65168.4	3024	2478	704149.2
		NOVEMBER															
	Dinajpur	Rangpur	Bogra	Rajshahi	Kushtia	Jessore	Faridpur	Khulna	Barisal	Noakhali	Mymensi	Gazipur	Moulviba	Brahmani	Comilla	Chittagon	Cox's Baz	Total
DEMAND	6762	4728	16917.2	25608.8	640	6690.8	4882	4786	2063	4480	13462	5594	7166	1800	10861.4	504	413	117358.2

For conveniently and more properly making this model, the study also collected the distribution cost from warehouse to depots. The distribution cost is as follows-

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	Distribution cost (Taka)
Dinajpur	6000
Rangpur	2500
Bogra	5000
Rajshahi	8000
Kushtia	15000
Jessore	15000
Faridpur	18000
Khulna	15000
Barisal	18000
Noakhali	19000
Mymensing	17000
Gazipur	13000
Moulovibazar	18000
Brahmanbaria	17000
Comilla	20000
Chittagong	20000
Coxs Bazar	25000

With this distribution cost, ACI seed is now distributing their rice seeds to the depots according to the demand. But they are not using any specific method or model. They are sending trucks to every depot and the trucks are carrying rice seeds along with other items which can hamper the quality of the seeds. Moreover, in this strategy trucks are not fully loaded every time. So the transportation assets are not used properly and it causes increasing number of shipments. For example, the demand in August of Comilla depot is 10860 kg. If they send a truck just to deliver the seeds in Comilla, the truck will be less than full-truck load (LTL), as the capacity of the truck is 15 ton or 15000 kg. The truck will need (15000-10860) = 4140 kg for a full truck load. Now, if we consider the demand and distribution cost to calculate the total distribution cost of 4 depots (Comilla, Noakhali, Chittagong and Coxs-Bazar), the cost will be –

	Demand	**Distribution cost (Taka)**
1. Comilla	10860	20000
2. Noakhali	4480	19000
3. Chittagong	504	20000
4. Coxs Bazar	413	25000
	Total	**84000**

For distributing to 4 depots the truck is travelling 4 times, returning to the warehouse 4 times and travelling 2094 kilometers. And the most important thing, the truck is not fully loaded every time which is causing time and money loss. If ACI seeds use this conventional model, the total cost for transportation in August, September, October and November will be 312500, 412500, 598000 and 312500 tk approximately.

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Proposed Distribution System

For calculating the savings, we need the inter-distance between al depots. And the inter-distance chart is shown below –

Table 2. Inter-distance between depots [13] (Bangladesh, Roads and Highways Department, 2007)

	Dinajpur	Rajshahi	Bogra	Kushtia	Jessore	Faridpur	Khulna	Barisal	Noakhali	Mymensingh	Gazipur	Moulovibazar	Brahmanbaria	Comilla	Chittagong	Coxs Bazar	Rangpur
Dinajpur	0																
Rajshahi	205	0															
Bogra	141	114	0														
Kushtia	283	122	144	0													
Jessore	374	213	235	92	0												
Faridpur	378	217	239	96	96	0											
Khulna	434	272	295	151	59	155	0										
Barisal	505	344	366	22	168	131	109	0									
Noakhali	494	412	353	297	257	206	246	196	0								
Mymensingh	320	238	178	234	291	203	302	291	278	0							
Gazipur	310	228	169	184	216	128	217	206	193	93	0						
Moulovibazar	509	427	368	362	362	300	378	367	258	240	208	0					
Brahmanbaria	416	334	374	268	269	206	285	273	143	147	114	116	0				
Comilla	432	350	291	279	256	193	272	202	67	216	130	196	81	0			
Chittagong	578	496	437	425	402	339	366	317	134	362	276	342	227	151	0		
Coxs Bazar	726	644	585	573	550	487	514	465	282	510	425	490	375	300	160	0	
Rangpur	78	219	107	249	340	345	400	471	460	286	276	475	382	398	544	692	0

For example, if we want to calculate the saving distance between, Rangpur, Chittagong and Coxs Bazar, the equation will be-

$$Savings_{Chittagong,coxsbazar} = C_{rangpur,chittagong} + C_{rangpur,coxsbazar} - C_{chittagong,coxsbazar}$$

$$Savings_{Chittagong,coxsbazar} = 544+692-160$$

$$Savings_{Chittagong,coxsbazar} = 1076 \text{ km}$$

Table 3. Distance saving matrix

Distance Saving Matrix																	
	Dinajpur	Rajshahi	Bogra	Kushtia	Jessore	Faridpur	Khulna	Barisal	Noakhali	Mymensingh	Gazipur	Moulovibazar	Brahmanbaria	Comilla	Chittagong	Coxs Bazar	Rangpur
Dinajpur	0																
Rajshahi	92	0															
Bogra	44	212	0														
Kushtia	44	346	212	0													
Jessore	44	346	212	497	0												
Faridpur	45	347	213	498	589	0											
Khulna	44	347	212	498	681	590	0										
Barisal	44	346	212	698	643	685	762	0									
Noakhali	44	267	214	412	543	599	614	735	0								
Mymensi	44	267	215	301	335	428	384	466	468	0							
Gazipur	44	267	214	341	400	493	459	541	543	469	0						
Moulovib	44	267	214	362	453	520	497	579	677	521	543	0					
Brahmanl	44	267	115	363	453	521	404	580	699	521	544	741	0				
Comilla	44	267	214	368	482	550	526	667	791	468	544	677	699	0			
Chittagor	44	267	214	368	482	550	578	698	870	468	544	677	699	791	0		
Coxs Baz	44	267	214	368	482	550	578	698	870	468	543	677	699	790	1076	0	
Rangpur	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	0

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We have to consider the distance which has the highest savings amongst all unassigned nodes. At the beginning of the algorithm all the nodes are in the list of unassigned nodes. Here, the highest savings is 1076 km, after considering this distance the method will consider second highest distance and the process will continue in this way.

Now the study will consider the demand data of 17 depots. If the demanded amount of any depot is around 15000 kg, a single truck will deliver the rice seeds. Cost saving method will not be applicable on this type of case. But if the demand is less than 15000 kg, the distribution will follow the cost saving matrix and a truck will cover up the demand of the depots situated in the same zone according to the saving matrix. For example, the demand of August in Coxs Bazar is only 413 kg. so according to the matrix the highest saved distance is 1076 km for Chittagong and Coxs Bazar. So the truck will also deliver the demanded amount in Chittagong also, but the demand in Chittagong is only 504 kg. So the truck can still accommodate (15000-413-504)= 14083 kg. now, it will again consider the next highest saved distance and the depots in Noakhali and Comilla will be considered according to the matrix. So the distribution will be like this-

Table 4. Distribution according to proposed system (1st route)

August distribution (Full truck)	
1. Comilla	9603
2. Noakhali	4480
3. Chiittagong	504
4. Coxs Bazar	413
Total	15000

The total demand in Comilla is 10861 kg, in the first trip to distribute in the first route the truck can accommodate 15000kg , so to 9603 kg is delivered in the first trip and the rest of the amount will be distributed in the second trip according to the next highest distance. The next distribution will be like this-

Table 5. Distribution according to proposed system (2nd route)

August distribution (Full truck)	
1. Moulovibazar	7166
2. Brahmanbaria	1800
3. Comilla	1258
4. Gazipur	4776
Total	15000

If they follow this vehicle scheduling system, the number of trip will be significantly reduced. And reduction in trip will automatically lower the distribution cost. Now, the distribution cost from Rangpur to 17 depots is known but if a truck covers more than one depot, the transportation cost needs to be calculated to know how effective this model is. To calculate the transportation cost, this model has used regression analysis to determine the fixed and variable cost. How the variable cost changes with the distance and what is the approximate fixed cost, is determined by the regression analysis regarding truck fare and distance. The regression analysis (The regression analysis was performed with 95% confidence interval and the value of multiple R was 0.94) shows that the fixed cost is around 8000 tk and the variable cost is around 24 tk. So the cost determination equation will be like this-

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8000+24x

Where, x is the distance. The distance will be multiplied by the variable cost and thus the total cost for distribution will be determined. For example, after following the distance saving matrix and vehicle scheduling the reduced distance is 759 km for the first trip of August and the cost will be according to the equation –

8000+(24*759)

=8000+18216

=26216 tk

Without this method the truck will need to travel almost 2094 km and the cost is 84000 tk for delivering in comilla, noakhali, Chittagong and coxs bazaar. After following this method the change in distribution cost is very significant. Before applying this system the distribution cost and after the application the scenario of each month will be approximately-

Figure 10. Cost saving scenario of a full season

August		September		October		November	
Total present cost:	312500 tk	Total present cost:	412500 tk	Total present cost:	598000 tk	Total present cost:	312500 tk
Total reduced cost	140416 tk	Total reduced cost	248132 tk	Total reduced cost	451524 tk	Total reduced cost	140416 tk
Reduced cost:	172084 tk	Reduced cost:	164368 tk	Reduced cost:	146476 tk	Reduced cost:	172084 tk
Cost reduction rate:	55.07%	Cost reduction rate:	39.85%	Cost reduction rate:	24.49%	Cost reduction rate:	55.07%

The average cost reduction rate for a season is =

cost reduction rate of (August+September+October+November)

4

=(550669+3984679+2459431+550669)/4

=43.62% cost saving in distribution.

Findings

The distribution system is not structured at all and causing unnecessary expenses. Without any model, the vehicle needed 17 trips in the month of August whereas if they use this proposed model they will only need 8 trips to fulfill the demand in August. The proposed month-wise distribution is shown below-

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Table 6. The distribution matrix of August

		1st route	2nd route	3rd route	4th route	5th route	6th route	7th route	8th route
1	Coxs Bazar	413							
2	Chittagong	504							
3	Noakhali	4480							
4	Comilla	9603	1258						
5	Brahmnbaria		1800						
6	Moulvibazar		7166						
7	Gazipur		4776	818					
8	Mymensingh			13462					
9	Barisal				2063				
10	Faridpur				4882				
11	Khulna				4786				
12	Jessore				3269	3421			
13	Kushtia					640			
14	Rajshahi					10608	15000		
15	Bogra							15000	1917
16	Rangpur								4728
17	Dinajpur								6762
	Total Supply (kg)	15000	15000	14280	15000	14669	15000	15000	13407
	Num of Trucks	1	1	1	1	1	1	1	1

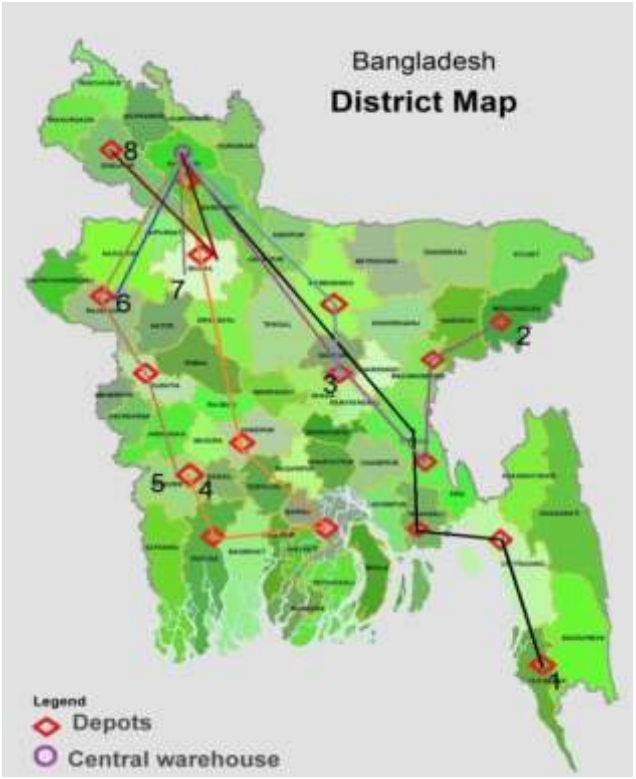

Figure 5. The distribution routes of August (Routes are mentioned in number)

Without any model, the vehicle needed approximately 22 trips in the month of September whereas if they use this proposed model they will only need 16 trips to fulfill the demand in September.

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Table 7. The distribution matrix of September

		1st route	2nd route	3rd route	4th route	5th route	6th route	7th route	8th route	9th route	10th route	11th route	12th route	13th route
1	Coxs Bazar	826												
2	Chittagong	1008												
3	Noakhali	8960												
4	Comilla	4206	15000	2517										
5	Brahmnbaria			3600										
6	Moulvibazar			8883			15000							
7	Gazipur				2305									
8	Mymensingh				11294	15000								
9	Barisal							4126						
10	Faridpur							1302	8462					
11	Khulna							9572						
12	Jessore								6538	6844				
13	Kushtia									1280				
14	Rajshahi									6218	45000			
15	Bogra											30000	3834	
16	Rangpur												9456	
17	Dinajpur													13524
	Total Supply (kg)	15000	15000	15000	13599	15000	15000	15000	15000	14342	45000	30000	13290	13524
	Num of trucks	1	1	1	1	1	1	1	1	1	3	2	1	1

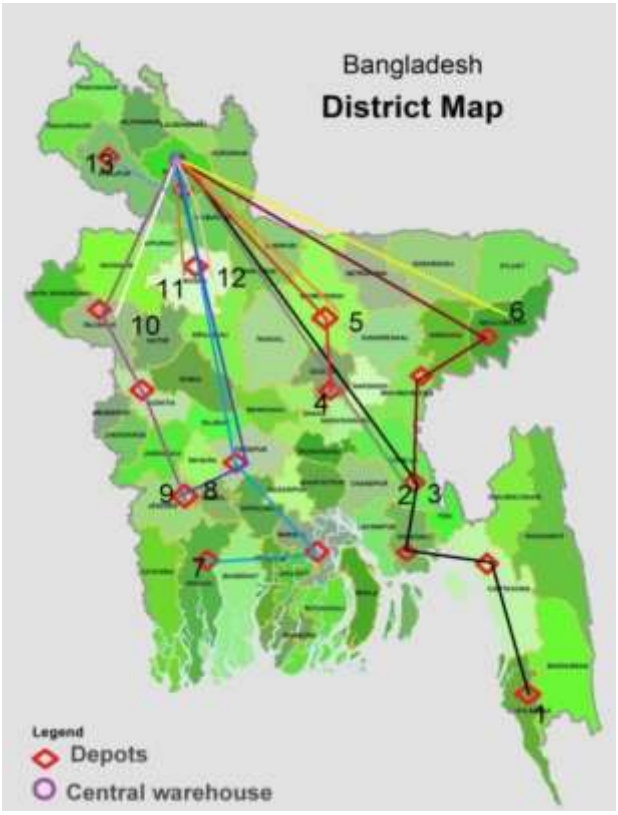

Figure 6. The distribution routes of September (Routes are mentioned in number)

Without any model, the vehicle needed 46 trips in the month of October whereas if they use this proposed model they will only need 38 trips to fulfill the demand in October

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Table 8. The distribution matrix of October

		1st route	2nd route	3rd route	4th route	5th route	6th route	7th route	8th route	9th route	10th route	11th route	12th route	13th route	14th route	15th route	16th route	17th route	18th route	19th route
1	Coxs Bazar	2478																		
2	Chittagong	3024																		
3	Noakhali	9498	15000		2382															
4	Comilla			60000	5168															
5	Brahmnbaria				7450		3350													
6	Moulvibazar					30000	12996													
7	Gazipur																			
8	Mymensingh																			
9	Barisal							12378												
10	Faridpur							2622	15000				11670							
11	Khulna									15000	13716									
12	Jessore										1284	30000	3330	5531						
13	Kushtia													3840						
14	Rajshahi													3853	150000					
15	Bogra													1976		90000	9527			
16	Rangpur																6473	15000		5895
17	Dinajpur																		30000	10572
	Total Supply (kg)	15000	15000	60000	15000	15000	16346	15000	15000	14342	15000	30000	15000	15000	150000	90000	16000	15000	30000	16467
	Num of trucks	1	1	4	1	1	1	1	1	1	1	2	1	1	10	6	1	1	2	1

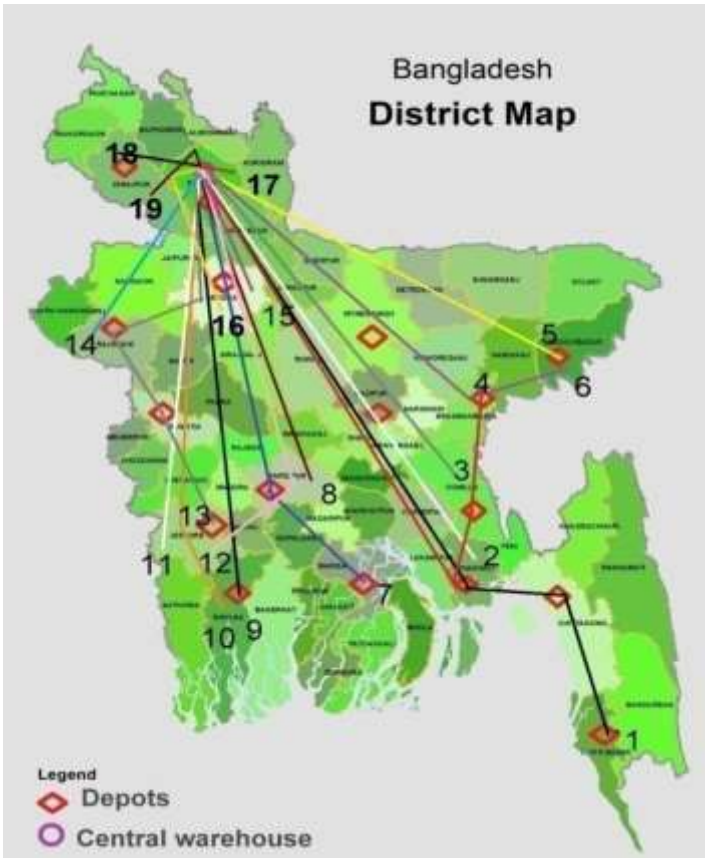

Figure 7. The distribution routes of October (Routes are mentioned in number)

Print ISSN: 2053-4043(Print), Online ISSN: 2053-4051(Online)

Without any model, the vehicle needed 17 trips in the month of November whereas if they use this proposed model they will only need 8 trips to fulfill the demand in November.

Table 9. The distribution matrix of November

		1st route	2nd route	3rd route	4th route	5th route	6th route	7th route	8th route
1	Coxs Bazar	413							
2	Chittagong	504							
3	Noakhali	4480							
4	Comilla	9603	1258						
5	Brahmnbaria		1800						
6	Moulvibazar		7166						
7	Gazipur		4776	818					
8	Mymensingh			13462					
9	Barisal				2063				
10	Faridpur				4882				
11	Khulna				4786				
12	Jessore				3269	3421			
13	Kushtia					640			
14	Rajshahi					10608	15000		
15	Bogra							15000	1917
16	Rangpur								4728
17	Dinajpur								6762
	Total Supply (kg)	15000	15000	14280	15000	14669	15000	15000	13407
	Num of Trucks	1	1	1	1	1	1	1	1

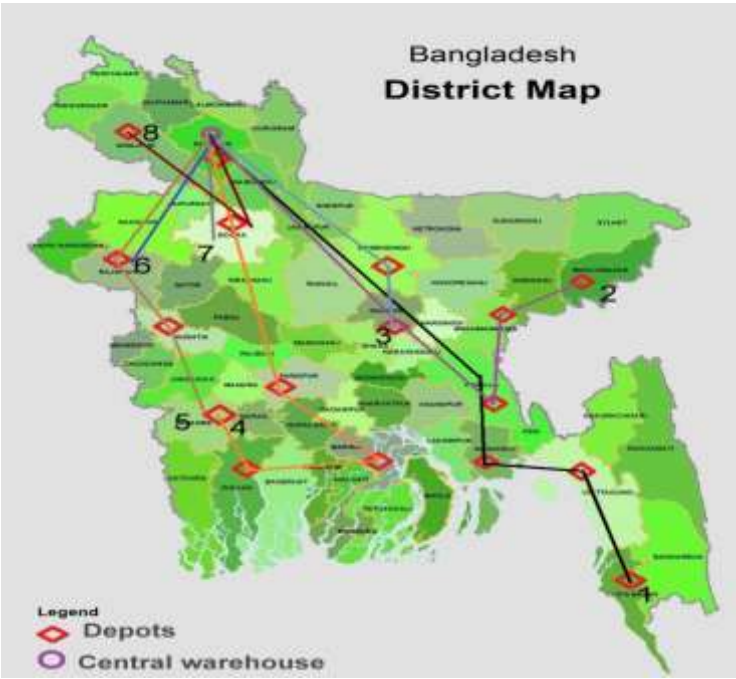

Figure 8. The distribution routes of November (Routes are mentioned in number)

ACI seed makes profit from selling seeds and selling includes distribution in different parts of Bangladesh. And this distribution contributes almost one-third of their total operational cost. So, if they use this model in the described manner they can reduce approximately 43.62% cost from their present distribution, which will save a huge cost and increase the operational performance. Apart from this cost reduction by saving distance, it will also save the labor cost for loading and

Print ISSN: 2053-4043(Print), Online ISSN: 2053-4051(Online)

unloading seeds to the truck. because the number of trip will be decreased and the truck will deliver more than one depot if the space in truck is left. So, while loading last in first out method will be used and the number of loadong and unloading will decrease which will lessen the manpower cost and time as well.

Suggestions

Proper distribution system is one of the major part of the operational process. If the distribution system is not structured the whole operation will be ineffective as distribution is a major contributor to cost. After analyzing the information from the distribution model following suggestions are encouraged to enhance the performance-

- It is recommended to use this quantitative model along with some qualitative decisions to increase the performance.
- The management should update the demand values periodically to adjust the vehicle routing.

Conclusions

The vehicle routing problem is a well-known combinatorial optimization problem. It could integrate the limited resources of logistics companies to avoid unreasonable investment and waste and achieve the efficient distribution of a logistics system. Here, by using this method, the flexibility afforded by the use of merging routes may yield further reductions in total cost and vehicle utilization.

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