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Logistics Cost Structure for Mangosteen Farmers in Thailand

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Abstract

Mangosteen is a major Thai export produce which brings economic benefits to farmers. The objectives of this paper are to study the mangosteen supply chain in eastern Thailand and analyze the logistics cost structure for mangosteen farmers. The results show that the highest logistics cost consists of material handling such as post-harvest, grading, and handling, followed by transportation, procurement, customer communications, and inventory, respectively. In addition, we found that the logistics cost structure varies by the size of farms; also, the yield of mangosteens increases as the size of the farm increases. To reduce the logistics cost and increase the efficiency of logistics operations, mangosteen farmers should reduce non value-added activities and increase the utilization of resources during production, harvest, postharvest, grading, packing, storage and delivery. In addition, the integration of farmers and collaboration among farmers and collectors should be encouraged.

Keywords: Logistics engineering; Cost, Mangosteen, Supply chain

1. Introduction

Mangosteens are one of the major fresh produce products exported from Thailand to many countries such as China, Taiwan, Japan, etc. At present, there is a problem with inequality of supply and demand. This indicates that there is a limitation in the logistics and supply chain of mangosteens in Thailand. Mangosteen production is seasonal and fragile; in each region, fresh mangosteens can be marketed for only for a few months each year. Fortunately, mangosteens are grown in two parts of Thailand, the south and the east. Hence, they can be distributed over a longer period of time, because mangosteens from the east are harvested before those from the south.

The logistics management is difficult because of the perishability and fragility of mangosteens. The stakeholders in the supply chain must be careful during the harvesting, grading, handling, and transporting to consumers. This increases the logistics cost to the stakeholders. If the upstream stakeholders handle mangosteens properly but the downstream ones do not, then the quality will deteriorate quickly before delivery to consumers. Another problem is that the price of mangosteens fluctuates due to several factors such as supply, demand, selling season, quality, etc. The price of premium-grade mangosteens can be up to ten times that of the lower grade. This encourages farmers to produce the premium grade. However they are very difficult to produce, for reasons which include climate variables, disease, insects, labor shortage, insufficient funding, and inadequate harvesting technology. There is wastage during harvest and postharvest as well. Factors such as climate, disease and insects are difficult to control. Hence, the

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present focus is on the improvements that could be made to logistics management, such as by reducing waste, which would bring additional benefits to stakeholders, especially farmers.

2. Literature Review

Supply chain management has recently become a popular topic. The principles can be implemented in several industries, including agriculture. The stakeholders in the supply chain should be virtually integrated by establishing coordination, collaboration and sharing information throughout the whole supply chain so that the total system-wide costs can be minimized while the service level is satisfied [1][2][3].

Some recent research can be applied directly to farmers, such as studies of: analysis of key factors for a farmers choice of crop [4]; production costs of small-, medium- and large-size rice farmers in Bangladesh [5]; the relationship between farm size and performance in U.S. dairy farms [6]; producers and the changing production and marketing environment, to help farmers compete in the long run [7]; the integration among farmers and other parties in the same supply chain [8][9]; the role of contract farming in Latin America [10]; value addition and value creation to the rice supply chain [11]; and the improvement of production efficiency [12]. Weinberger and Lumpkin [13] stated that horticultural research and development should be encouraged to aid producers, especially in terms of genetic improvements, safe production systems, commercial seed production, postharvest facilities, and farming in an urban or peri-urban environment. Genova et al. [14] studied postharvest vegetable losses in Southeast Asia. Boselie et al. [15] investigated five cases of fresh produce supply chains in African and Asian supermarkets or for export markets in Europe. They analyzed the problems faced by small producers, as well as their competitive advantages. They found that small producers have difficulty meeting the requirement of supermarkets, and generally have inadequate investment; however, they tend to produce good quality produce and have a higher level of commitment to the crop because it directly affects their livelihood.

The demand management process in agri-food supply chains can be improved through collaboration across the supply chain. Increased collaboration, information sharing and joint planning between manufacturers and retailers helps retail food supply management become more efficient [16] [17].

Costs can be calculated in many ways. Activity-based costing (ABC) systems have been developed to improve the costing system, and claim to be more accurate than traditional costing methods [18] [19] [20] [21] [22]. Trienekens et al. [23] studied the fresh vegetable chain in Thailand, as well as the shipment of fresh fruit from South Africa and Ghana to the Netherlands. Ruben et al. [24] analyzed the transaction cost of the vegetable procurement system in Asian supermarkets by comparing case studies in Bangkok, Thailand, and Nanjing, China. Comparisons are presented of two major types of suppliers for TOPS supermarket in Bangkok: local wholesalers and preferred suppliers. They concluded that in the case of TOPS supermarket there are five aspects involved in the transition of wholesale procurement toward a preferred supplier arrangement: fixed investments, variable costs, economies of scale, governance costs, and opportunistic behavior. For fixed investments aspects, they considered quality and freshness, lead time, and out of stock and yield loss. The variable costs depend on the number of suppliers and distribution cost. Governance costs are contractual arrangements, information and search of partners, screening and monitoring of the quality control system, negotiation and enforcement. The opportunistic behaviors are asset specificity and risk. A preferred supplier has the benefits of economies of scale, high quality and freshness, low lead time, low out of stock and yield loss, low number of suppliers, low distribution cost, contractual arrangements, quality control systems, and low negotiation and risk factors; whereas the drawbacks include potential rejection of products, financial penalties, and high asset specificity. TOPS converted its regular suppliers into value-added suppliers by adding such activities as quality control, cutting, trimming and packing.

Furthermore, Rong et al. [25] analyzed the design and operation of a food distribution system to maintain optimal quality of fresh food throughout the supply chain, using a mixed-integer linear programming model. Their model considered quality degradation, temperature control, shelf life, and transportation lead times.

Several recent research reports are directly applicable to mangosteen farmers. Jaritngam [26] investigated a method of checking for defects in mangosteens. Rattanatraipob [27] studied methods to extend mangosteen shelf life. Other researchers who have studied the benefits of farmers groups and cooperatives are Kladpuang [9] and Bamrungcheep [8]. Focusing on the marketing and distribution of mangosteens, the Kenan Institute Asia [28] studied the potential for central market settlement in Chantaburi, and a distribution system for domestic and international markets. In addition, a survey of the mangosteen supply chain in Indonesia was carried out by Dimyati

and Muharam [29]. Currently, the Royal Thai government has several strategies to assist the agricultural sector, one of which is the development of a marketing and logistics system for fresh produce and other agricultural products.

The objectives of our study are to study the mangosteen supply chain and logistics operations, such as the transportation and handling system of fresh mangosteen from harvest to delivery to the consumers, and to analyze the logistics costs of farmers and collectors. We then propose guidelines to reduce these logistics costs to help ensure the profitability and sustainable development of the stakeholders in the supply chain.

3. Methodology

1. Develop a questionnaire related to logistics operations and cost.
2. Collect data by interviewing farmers in the east of Thailand (Rayong, Chantaburi and Trat). A convenient sampling method was used.
3. Draw the supply chain of mangosteen.
4. Compute logistics costs per kilogram per farmer according to Table 1.
5. Analyze logistics cost according the proportion of each type of logistics cost.
6. Categorize the farm size according to the number of mangosteen plants in the farm. Then, analyzing the logistics cost. Then, calculate the confident interval of logistics costs and proportions based on t-statistics.
7. Propose guidelines to reduce logistics cost.

Table 1. Activities in each type of logistics cost for farmers

Logistics Cost	Details
1. Procurement	Transportation cost of purchasing supplies such as fertilizer, pesticides and equipment; communication cost between suppliers and farmers
2. Material handling	Harvesting cost, handling cost, grading and depreciation cost of materials and handling equipment, and loss of harvesting
3. Transportation	Gas, depreciation of vehicles, maintenance of vehicles, driver salaries, and losses during delivery
4. Inventory	Opportunity cost of inventory of supplies
5. Customer communications	Communications cost between farmers and customers

4. Results

4.1. Mangosteen Supply Chain

From the survey, we can draw the mangosteen supply chain, as shown in Figure 1. Note that the existing supply chain may include other channels as well. The major stakeholders of the mangosteen supply chain are:

1. Farmers: Farmers acquire the necessary supplies from suppliers, and hire laborers from local or other areas to grow mangosteens. It takes several years for mangosteen farmers to produce harvestable quantities of fruit. Currently, most farmers use chemical fertilizers and pesticides. However the number of farmers using organic fertilizers is increasing due to several factors, such as the high price of chemical fertilizers and customer requirements. The government supports group activities and cooperation among farmers, but there is a lack of local leadership in some small villages.
2. Groups of farmers: In some villages, small-sized farmers jointly conduct agricultural and marketing activities on the basis of self and mutual assistance among the members. These groups can be farmers groups, cooperatives, or community enterprises.
3. Collectors: Collectors gather the fruits from one or more farmers and distribute them to their customers. Collectors either pick fruit directly from farms or wait for farmers to deliver to their warehouses. Their activities also include grading, packing, and delivering to customers.

4. Wholesalers and retailers: Wholesalers buy large quantities of mangosteens from farmers and distribute the fruit to retailers. Retailers are the merchants in markets, supermarkets or hypermarkets who sell mangosteens to consumers.
5. Manufacturers: Such enterprises process fresh mangosteens into products such as frozen mangosteens, juices, jams, cosmetics, snacks, etc. Some manufacturers are also exporters.
6. Exporters: Exporters export fresh mangosteens or their products to international markets.
7. Government: The government has a role in supporting farmers and groups of farmers by providing expertise, funding and technology. In addition, the government has instituted an expanded international marketing campaign.

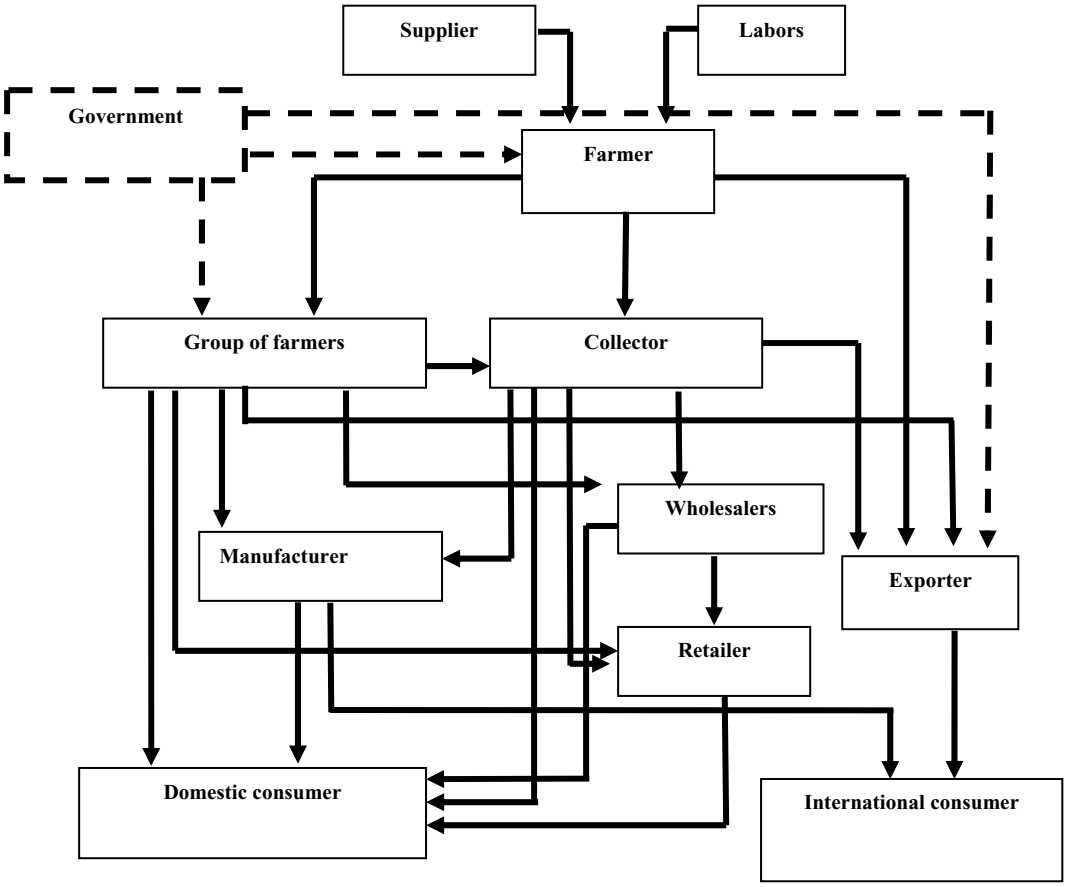

Fig. 1. Mangosteen supply chain

4.2. Logistics Cost Analysis

Logistics activities of mangosteen farmers can be categorized into five parts, as shown in Table 1. The logistics cost of all activities are collected and computed accordingly. For farmers, the logistics cost per kg of mangosteens is the annual expense divided by the quantity of mangosteens produced in that year. However, this can vary from farm to farm, according to practices and economies of scale due to the size of the farm. Hence we instead calculated the proportion of the logistics cost for each category.

At present, the farmer population in eastern Thailand numbers many thousands. For the purposes of this study we randomly selected 30 farms. Of these, however, only 19 farms had complete information. The confidence interval of the farmers logistics cost proportion, assuming normal distribution, was calculated and reported by using t statistics at a 95% confidence level ($t_{0.025},18 = 2.101$). The results show that the proportion of the logistics cost for

farmers in eastern Thailand is between the upper and lower bounds (Table 2) and the logistics cost structure of farmers categorized by activity is shown in Figure 2.

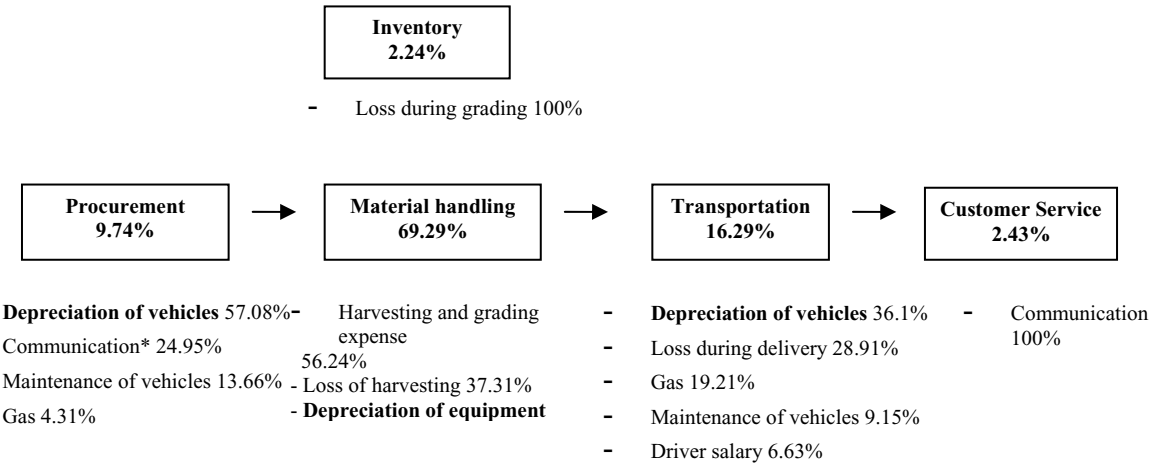

Fig. 2. Logistics cost structure of farmers categorized by activity

Table 2. Average and variance of logistics cost and its structure based on activities of mangosteen

	Logistics Cost			Logistics Cost Proportion (%)		
Logistics Activities	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
1. Procurement	**0.73**	**0.92**	**1.25**	**9.74**	**7.35**	**0.75**
- Depreciation of vehicles	0.47	0.77	1.64	5.56	6.15	1.11
- Communication*	0.13	0.14	1.06	2.43	2.51	1.03
- Maintenance of vehicles	0.09	0.13	1.43	1.33	1.43	1.08
- Gas	0.04	0.07	1.98	0.42	0.63	1.50
2. Material Handling	**4.42**	**2.51**	**0.57**	**69.29**	**19.01**	**0.27**
- Harvesting and grading	2.10	2.54	1.21	25.85	27.19	1.05
- Loss of harvesting**	2.04	0.86	0.42	38.97	22.32	0.57
- Depreciation of equipment	0.28	0.31	1.12	4.47	4.84	1.08
3. Transportation	**1.21**	**1.26**	**1.04**	**16.29**	**11.84**	**0.73**
- Depreciation of vehicles	0.48	0.77	1.60	5.88	6.34	1.08
- Loss during delivery	0.37	0.74	1.99	4.71	9.71	2.06
- Gas	0.20	0.29	1.44	3.13	3.12	1.00
- Maintenance of vehicles	0.10	0.13	1.33	1.49	1.48	0.99
- Driver salary	0.06	0.23	3.66	1.08	4.07	3.77
4. Inventory	**0.13**	**0.54**	**4.16**	**2.24**	**9.53**	**4.25**
- Opportunity cost of	0.13	0.54	4.16	2.24	9.53	4.25
5. Communication and	**0.13**	**0.14**	**1.06**	**2.43**	**2.51**	**1.03**
- Communication*	0.13	0.14	1.06	2.43	2.51	1.03
Total (Baht/kg)	**6.63**	**3.61**	**0.54**	**100.00**		

Note: *The communication cost (telephone bill) is divided by two.

**The price of mangosteen is estimated from the average selling price.

Our analysis is based on the average proportion of the logistics cost. We found that the individual logistics cost of farmers is more variable than the individual structure of the logistics cost of farmers, as shown in Table 3. This implies that most farmers have a similar pattern of expenses in logistics activities. The result show that the major logistics cost of farmers is material handling cost, at 69.29% of the total logistics cost. The second-highest logistics cost is for transportation cost, at 16.29%. Procurement cost amounts to 9.74%, whereas the communications and customer service and inventory costs are 2.43% and 2.24%, respectively. Although the depreciation of vehicles and equipment and loss during harvest and delivery are ignored, the major logistics cost is still material handling. On the

other hand, the transportation cost and procurement costs are about the same. This shows that if the farmers own the vehicles or equipment, then the transportation cost and material handling cost will be increased. Next, we analyze whether the size of the farms affects the logistics cost structure.

Most of the farmers grow several types of fruit.The number of mangosteen plants is also different on each farm. Then, we categorize the types of farms, according to the number of mangosteen stems per farm, into three types: large, medium and small farms, as shown in Table 4. Due to the variety of material handling equipment and vehicles belonging to an individual farmer, we propose two methods to compute the logistics cost, as follows:

1. Including the depreciation of equipment in material handling activities and loss of harvesting and delivery in the logistics cost.
2. Excluding the depreciation of equipment in material handling activities and loss of harvesting and delivery in the logistics cost.

Table 3. Logistics cost and its structure interval based on activities of mangosteen farmers

	Logistics Cost			**Logistics Cost Proportion (%)**		
Logistics Activities	**Mean**	**LB**	**UB**	**Mean**	**LB**	**UB**
1. Procurement	0.73	0.29	1.17	9.74	9.70	9.77
- Depreciation of vehicles	0.47	0.10	0.84	5.56	5.53	5.58
- Communication*	0.13	0.07	0.20	2.43	2.42	2.44
- Maintenance of vehicles	0.09	0.03	0.15	1.33	1.32	1.33
- Gas	0.04	0.00	0.07	0.42	0.42	0.43
2. Material Handling	4.42	3.21	5.63	69.29	69.20	69.38
- Harvesting and grading expenses	2.10	0.88	3.32	25.85	25.72	25.98
- Loss of harvesting**	2.04	1.63	2.45	38.97	38.86	39.07
- Depreciation of equipment	0.28	0.13	0.43	4.47	4.45	4.50
3. Transportation	1.21	0.61	1.82	16.29	16.24	16.35
- Depreciation of vehicles	0.48	0.11	0.85	5.88	5.85	5.91
- Loss during delivery	0.37	0.02	0.72	4.71	4.66	4.75
- Gas	0.20	0.06	0.34	3.13	3.11	3.14
- Maintenance of vehicles	0.10	0.03	0.16	1.49	1.49	1.50
- Driver salary	0.06	0.00	0.17	1.08	1.06	1.10
4. Inventory	0.13	0.00	0.39	2.24	0.00	2.29
- Opportunity cost of inventory	0.13	0.00	0.39	2.24	0.00	2.29
5. Communication and customer	0.13	0.07	0.20	2.43	2.42	2.44
- Communication*	0.13	0.07	0.20	2.43	2.42	2.44
Total (Baht/kg)	6.63	4.89	8.37	100.00		

Note: *The communication cost (telephone bill) is divided by two.

**The price of mangosteen is estimated from the average selling price.

Table 4. Categories of farms according to the number of plants

Category of farm	Number of mangosteen plants	Number of farms	Average yield (kg per stem)
Small	< 201	5	13.2
Medium	201-999	11	43.31
Large	> 999	3	47.35

Table 4. shows that the average yield of mangosteens increases according to the size of farm. This implies that large-sized farms are more productive. However, there is little difference in average yield between medium-sized and large-sized farms. In fact, two out of three large-sized farms are dedicated exclusively to mangosteen farming, and one of these is an organic farm. Such factors may affect the yield as well. Further research should explore whether dedicated and/or organic farming does indeed affect the yield. In addition, the government should help small-sized farms increase their yield by providing them with production assistance and updated information on harvest and post-harvest technology.

In considering the relationship of logistics cost and the size of farms, as shown in Table 5, if depreciation and loss is taken into account in the logistics cost, we found that small-sized and large-sized farms have high logistics cost, whereas the logistics cost of medium-sized farms is the least. To show the relationship of the proportion of logistics cost and the size of farms, about half of the total logistics cost of small-sized farms is related to material handling, whereas procurement and transportation costs are about the same (17.57 and 20.7%, respectively). On the other hand, for medium-sized farms about 75% of the total logistics cost is material handling, followed by transportation and procurement, respectively. In large-sized farms, material handling accounts for about half of the total logistics cost, whereas transportation cost is about one-third. This implies that the lower difference between material handling and transportation costs compared to other sizes of farms is due to vehicle usage. In addition, some large-sized farms have the cash to buy large quantities of supplies and then will use them throughout the year, so the inventory cost is higher than for other types of farms.

Table 5 Logistics cost proportion of farmers according to logistics activities and the size of farms

Logistics Activities	**Average of logistics cost proportion of each size of farm**							
	First method*				**Second method****			
	Small	**Medium**	**Large**	**Total**	**Small**	**Medium**	**Large**	**Total**
1. Procurement	17.57	8.16	1.93	9.74	16.47	6.21	3.56	8.49
2. Material handling	57.02	75.86	49.71	69.29	66.78	81.92	71.23	76.25
3. Transportation	20.7	14.02	33.78	16.29	8.63	8.01	8.62	8.27
4. Inventory	0	0.03	14.08	2.24	0	0.14	15.21	2.48
5. Customer communications	4.7	1.93	0.50	2.43	8.13	3.72	1.39	4.51
Total logistics cost (Baht/kg)	**7.64**	**5.93**	**7.52**	**6.63**	**3.14**	**2.71**	**3.34**	**2.92**

* Including depreciation and loss

** Excluding depreciation and loss

When depreciation and loss costs are excluded from the logistics cost, the transportation cost is reduced dramatically; however, the main cost for all types of farms is still material handling. When considering the cost versus the type of farm, we found that the procurement cost and customer communication cost are reduced when the size of the farm is larger. On the other hand, for larger farms the inventory cost is larger. The material handling cost of medium-sized farms is highest, compared to small- and large-size farms. Medium-sized farms outsource labor for harvesting, grading and packing the produce, but do not have the advantage of economy of scale that large-sized farms have; whereas small-sized farms perform most of their handling activities using their own family labor.

5. Discussions

We found that large-sized farms are more productive because the farmers generally have more knowledge and experience, and have the advantage of economies of scale. However, there is little difference in average yield between medium-sized and large-sized farms. In addition, medium-sized farms have the lowest logistics cost. This implies that the large-sized farmer invests more in material handling equipment, labor and vehicles in order to achieve high productivity, whereas the medium-sized farmer invests less but is able to maintain high productivity, so that the average logistics cost per product is less.

In terms of the relationship of logistics cost and the size of farms, as shown in Table 4, if depreciation and loss is taken into account in the logistics cost, we found that small-sized and large-sized farms have higher logistics costs, whereas the logistics cost of medium-sized farms is the least. Farmers main logistics cost is from material handling activities: harvest, postharvest, and grading. Since most farmers hire outside labor to perform these activities, the labor cost accounts for the highest portion of the material handling cost. In addition, the value of loss of harvesting is the second highest portion. It is difficult to reduce the labor cost due to lack of readily available labor, but the loss of harvesting can be avoided by using efficient harvesting technology. Transportation cost is composed of fuel cost, maintenance cost, depreciation cost, driver salaries and the value of losses during delivery. Depreciation and the value of loss during delivery account for the main proportion of these transportation costs. Farmers can reduce their losses during delivery by using more appropriate containers or packaging. There is no temperature-controlled supply

chain, or cold chain, in small and medium-sized farms due to insufficient economies of scale and inadequate investment. The highest portion of procurement cost is depreciation of vehicles. Customer communication cost for farmers amounts to very little because they generally use cell phones for only a short time, and most customers are repeat customers. The inventory cost of farmers is also relatively insignificant because most farmers do not have sufficient funds readily available to buy a large quantity of supplies. Usually, small-scale farmers buy supplies using one-year credit terms from their local suppliers; however, we did not factor the interest paid on such loans into our calculation.

After categorizing farms according to the number of mangosteen stems in a farm, we found that large-sized farms obtain increased benefits or economies of scale through savings in material handling, transportation, procurement and inventory costs. If the farmers own the vehicles and other sophisticated material handling equipment, then their logistics cost will be high. Thus, to reduce the logistics cost farmers should use their vehicles and equipment efficiently. Otherwise, they should elect to outsource the transportation.

In summary, the government should give farmers additional support by providing expertise and technology regarding production (harvest and postharvest), grading, packing, processing, transportation systems, storage and collection of mangosteens. In addition, the agricultural database should be more accurate and integrated so that the stakeholders can benefit from using this information for production planning and marketing.

6. Conclusions

There are many stakeholders involved in the mangosteen supply chain: suppliers, farmers, collectors, traders, manufacturers, exporters and consumers. We have studied the logistics cost for farmers to analyze the cost structure and monitor the efficiency of supply chain performance. However, logistics cost varies from person to person, as well as by the size of farms. The yield of mangosteens increases along with the size of the farm. The proportion of logistics cost has been computed to present the major activities of farmers. In fact, about two-thirds of farmers logistics cost is material handling cost; hence farmers can reduce costs by increasing the efficiency of material handling. To reduce waste from logistics activities, advances in harvest and postharvest technology should be communicated to farmers. Losses occurring during transportation could be reduced by using appropriate containers. Currently, the total costs for farmers are much higher than the logistics cost due to the increasing costs of raw materials, such as fertilizers and insecticides, while the price of mangosteens is varied. Farmers could also reduce costs by using organic fertilizers and insecticides to increase productivity. Future research could identify other factors that influence yield, such as dedicated and organic farming methods.

7. Copyright

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