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The application of Supply Chain Operations Reference (SCOR) model: Herb supply chain in Dong Bang Village, Thailand

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Abstract

During the year 2021, the COVID-19 crisis caused the demand for *Andrographis paniculata* (Fa thalai chon) herbs to increase. But the group of Dong Bang Village farmers could not send it to customers in time and lost the opportunity to sell their products. The supply chain operations reference or SCOR model is used to diagnose supply chain management. A study on supply chain performance amongst the farmers of Dong Bang Village is lacking. Therefore, this research aims to examine the herb supply chain and determine the SCOR performance metric for analysing the issue for the farmers. The initial study involves how the herb supply chain works. Next, a questionnaire is generated and used to collect information from all the farmers in Dong Bang Village. Following this, the SCOR performance metrics are determined by using the information from the questionnaires. Finally, guidance for improvement is proposed. According to the study, the herb supply chain consists of fertilizers and seed suppliers, herb farmers, herb drying plants, Chaopraya Abhaiphubejhr Hospital, the Thai traditional medical clinic, and customers. The SCOR performance metrics determined are reliability, responsiveness, agility, cost, and asset management efficiency. Three indicators show areas for improvement. The responsiveness measure shows the issue that farmers take 9–10 months to fulfill customer orders. The measurement of agility shows that changing the output volumes requires a long lead time. The measurement of costs is high, particularly when it comes to the cost of seeds. Subsequently, guidelines are proposed to improve efficiencies.

Keywords: SCOR model, Herb supply chain, SCOR performance metrics

1. Introduction

Thailand has a climate suitable for the growth of various plants, especially medicinal plants. There are hundreds of thousands of species, both naturally occurring and from cultivation. Currently, herb plants are classified among the economic plants that foreign countries are looking for ways to invest in, selecting Thai herbs to extract drugs for the treatment of certain diseases. According to a survey of the herbal industry group in the year 2011, the Federation of Thai Industries found 1,007 herbal medicine factories in Thailand, of which only 28 had received the Pharmaceutical Inspection Cooperation Schemes (PIC/S) GMP standard for drug manufacturers testing, which is the standard used in European countries. Few entrepreneurs see the importance of using herbs obtained from organic farming as raw materials. Dong Bang Village, located in Tambon Dong Khi Lek, Amphoe Mueang, Prachinburi Province, Thailand, has received the organic farming certification standard from the Organic Agriculture Certification Thailand or ACT. Currently, however, there are only 8 farmers left due to the complexity of taking proper care of the farms. Organic farms must meet many criteria, so some farmers who are more familiar with the use of chemicals are unable to convert to organic planting. In addition, the farmers of Dong Bang Village have also encountered a problem of increased competition, because there are other places that can grow herbs of equal quality. The main customer for the farmers of Dong Bang Village is Chaopraya Abhaiphubejhr Hospital. During the COVID-19 crisis, the demand for herbs, especially *Andrographis paniculata* (Fa thalai chon), has increased. However, the hospital is unable to produce enough to meet the market demand due to insufficient raw materials. It is possible that if the farmers of Dong Bang Village do not adjust, this will allow their customers to buy raw materials from other providers.

Therefore, the objectives of this research are 1) to examine the herb supply chain and 2) to determine the SCOR performance metric for analysing the issues facing the farmers.

2. Literature review

The supply chain operations reference model (SCOR) is a management tool used to address, improve, and communicate supply chain management decisions within a company and with the suppliers and customers of the company [1]. The SCOR model maximizes supply chain visibility, including efficiency, measurable and actionable outcomes when the visibility strategy of the supply chain is aligned with the model [2]. SCOR is organized around five management processes (Plan, Source, Make, Deliver, and Return) [3-8]. The performance attributes consist of supply chain delivery reliability, supply chain responsiveness, supply chain agility, supply chain

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costs, and supply chain asset management efficiency [5, 9-12]. The ‘Plan’ and ‘Source’ decisions are more important for customer-facing supply chain performance (reliability, response, and flexibility), and the ‘Make’ decisions positively affect internal performance metrics (costs and assets) [13]. There are many pieces of research in the field of applying the SCOR model (Table 1).

Table 1 Examples of applying the SCOR model.

Author(s)	Topic	Implementation
Praharsi et al. [12]	Supply chain performance for traditional shipbuilding industry in Indonesia.	Applied the SCOR model and metrics to identify the critical issues to improve in the industry.
Hwang et al. [14]	Performance evaluation of SCOR sourcing process: case study of Taiwan’s TFT-LCD industry	Proposed the supply chain of the thin film transistor-liquid crystal display (TFT-LCD) industry.
Yilmaz and Bititci [15]	Performance measurement in the value chain: manufacturing v. tourism	Compared the performance measurement of manufacturing and tourism industries from a value chain perspective.
Huang et al. [16]	Efficiency evaluation of key ports along the 21st-Century Maritime Silk Road based on the DEA–SCOR model	Proposed the DEA–supply chain operations reference (SCOR) model to be used as the basis to analyse the port operating efficiency of ship inward–outward and stacking yard.
Rosyidah et al. [17]	Measurement of key performance indicator green supply chain management (GSCM) in palm industry with green SCOR model	Presented use of the green SCOR model to measure the key performance indicator Green Supply Chain Management (GSCM) in palm industry.
Ricardianto et al. [18]	Supply chain management evaluation in the oil and natural gas industry using SCOR model	Evaluated supply chain management on fuel oil to optimize improvement strategies that can be applied to ConocoPhillips companies in Indonesia.
Krawglom et al. [19]	Logistics and supply chain management of herbal goods for community enterprise: case study of Don Tum District, Nakhon Pathom Province	Measured the efficiency of the logistics and supply chain management of herbal goods in Don Tum, Nakhon Pathom community enterprise.
Meilizar et al. [20]	Design of models for coconut oil supply chain system performance measurement	Developed model of performance measurement on a supply chain system in coconut oil agro-industry with SCOR model as initial formula.

3. Methodology

The methodology is shown in Figure 1.

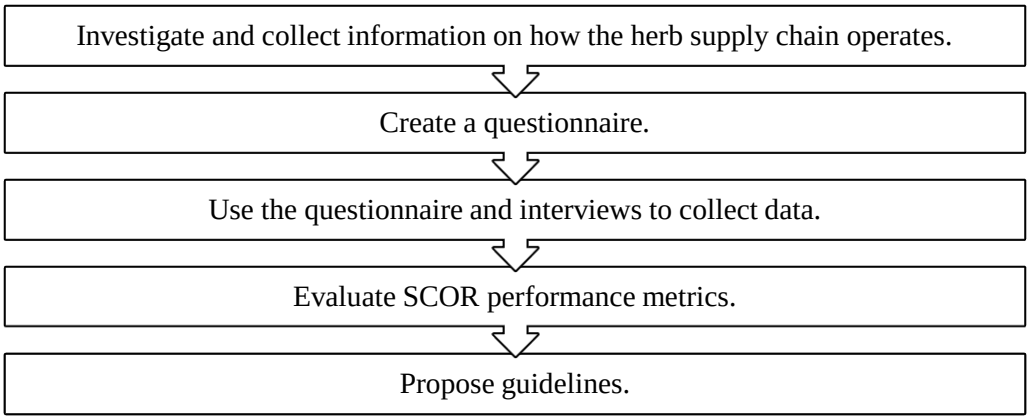

Figure 1 Methodology

3.1 Investigate and collect information on how the herb supply chain operates

The theories and concepts in supply chain management and related research, including an overview of the group of herb farmers in Dong Bang Village, are studied. Information on the various organizations in the supply chain of the Dong Bang Village herb farmers group is collected.

3.2 Create a questionnaire

A questionnaire is created for data collection, consisting of 2 parts: general information about the farmers and details of the herbs grown. General information includes name-surname, age, and total cultivated area (area rented or owned). The details of the herbs include the types and quantity of herbs grown by the farmers, the area used, the harvest time, the costs of planting per square meter, and the selling price per kilogram.

3.3 Use the questionnaire and interviews to collect data

In this step, the questionnaires are used to gather information from all farmers. In addition, direct interviews with farmers are conducted, with questions about the implementation of the SCOR model (planning, source, make, deliver, and return). Moreover, there are also questions about the ability to adjust in case the order is changed, as well as delivery errors including problems and obstacles to the cultivation of herbs.

3.4 Evaluate the SCOR performance metrics

The SCOR performance metrics are determined by using the information from the questionnaires and interviews. This research has five metrics: reliability, responsiveness, agility, cost, and asset management efficiency.

3.5 Propose guidelines

After identifying the problems, guidelines for improving the efficiency are proposed.

4. Result and discussion

4.1 Herb supply chain in Dong Bang Village, Thailand

The herb supply chain is shown in Figure 2.

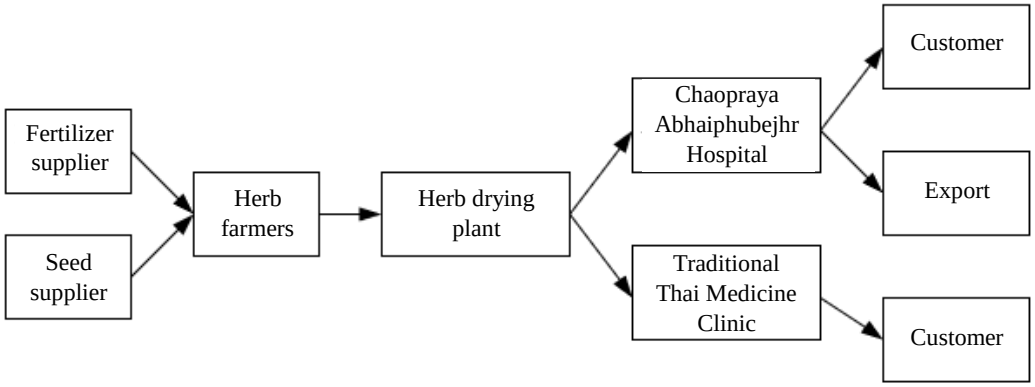

Figure 2 The herb supply chain in Dong Bang Village, Thailand.

From the study, there are 8 members in the group of herb farmers in Dong Bang Village. Table 2 shows the types of herbs grown by the group.

Table 2 Herbs grown in Dong Bang Village

Name	Scientific name
Beijing Grass	*Murdannia loriformis*
Fa thalai chon	*Andrographis paniculata*
Ya nuat maeo	*Orthosiphon aristatus* (Blume) Miq.
Butterfly pea	*Clitoria ternatea* Linn.
Philippine violet	*Barleria lupulina* Lindl.
Bitter cucumber	*Momordica charantia* Linn.

Source: [21, 22]

All of the farmers have an MOU with Chaopraya Abhaiphubejhr Hospital, so each production amount depends on the order from Chaopraya Abhaiphubejhr Hospital. The farmers plan to sell each type of herb together as a group by dividing the planting and selling according to the number of members. For example, when sending 1,000 kilograms of *Andrographis paniculata* (Fa thalai chon), all 8 members are collectively responsible for producing this quantity. This is a way to help each other and share their income. The farmers will produce their seeds by collecting seeds from the original medicinal plants and sponsoring several seeds from Chaopraya Abhaiphubejhr Hospital. They do not use chemicals to grow the herbs because they are to be grown organically. Therefore, the fertilizers and composts used by the farmers are organic and free of chemical contaminants, and no pesticides are used. The farmers

started planting herbs in 1997. The age of the farmers is in the range of 40–62 years and they have 10–20 years of experience in growing herbs; some of the farmers inherited from their parents' generation and therefore have little experience. All the planting areas are owned by the farmers themselves. From October–November each year, the marketing department will have a planning meeting about what herbs the hospital will use and how much. Then the farmers will start to plant. There are 2–3 harvests per year. When the herbs are collected, they are washed and cut, then dried using solar energy and heat treatment. Then, the dried herbs are packed in bags and weighed. The farmers will collect dried herbs from each family according to the orders received. If there are any herbs left, these will be distributed to the Thai traditional medical clinic. Chaopraya Abhaiphubejhr Hospital will send a pickup truck to pick up the dried herbs, then process them to produce various products. The products are distributed at hospitals, drugstores, and general department stores. Moreover, the products are also sold through online channels via the hospital website and exported abroad.

4.2 SCOR model

The SCOR model of the herb supply chain is shown in Figure 3.

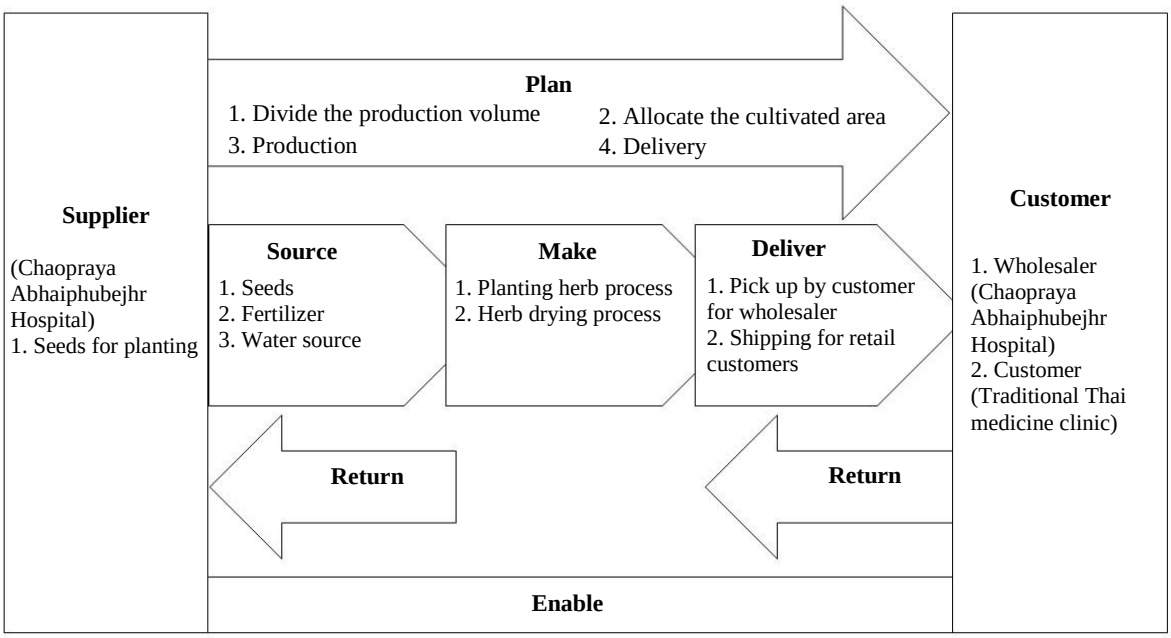

Figure 3 SCOR model of the herb supply chain

Figure 3 is separated into 3 parts: suppliers, SCOR model processes, and customers. Chaopraya Abhaiphubejhr Hospital is the supplier of this model. The customers can be divided into 2 types: wholesalers and retailers. Most of the products are sent to Chaopraya Abhaiphubejhr Hospital, which is the wholesaler. However, if there are any products remaining, they will be sold to the traditional Thai medicine clinic.

The SCOR model consists of 5 processes:

1) *Plan* is a process that involves defining the requirements and taking actions to achieve the supply chain objectives.
   - The amount of each herb to be planted in each production cycle is planned. It takes about 2–3 months per cycle to get a sufficient quantity to deliver to customers.
   - The area to be used for the cultivation of each herb is planned.
   - The production is planned according to customer orders. Moreover, the hiring of workers is also planned.
   - Delivery will be planned when the required quantity is produced according to the customer request.

2) *Source* is the process of purchasing and procuring raw materials. These include seeds, fertilizers, and water sources. The seeds used by farmers can be divided into the following proportions: 70% from individual farmers procuring and purchasing their seeds, 20% from collecting seeds from herb seedlings, and 10% from Chaopraya Abhaiphubejhr Hospital. The farmers use organic fertilizers to grow herbs and use shallow wells to water them, drilling to find water springs and using a water pump to pump up the water.

3) *Make* is a process that involves changing the raw materials that are available for sale. There are 2 main processes: planting the herbs and drying them. The herb planting process takes about 80–90 days in each production cycle. In the harvesting process, farmers will collect fresh herbs, wash them with water, and let them drain. After that, the herbs are cut and dried using solar energy. Then, in the herb drying process, farmers heat the herbs in a dryer. After that, the dried herbs are packed in bags and weighed.

4) *Deliver* is the process of delivering goods to customers. For wholesalers, Chaopraya Abhaiphubejhr Hospital will pick up herbs in pickup trucks and 6-wheeled vehicles. The customer is responsible for the transportation costs. For retail sales, farmers will distribute herbs that are surplus to the wholesale order by selling at the traditional Thai medicine clinic.

5) *Return* is a process that involves receiving products that are returned from customers for any reason. From the farmer interviews, it was found that product returns in fact never happen. The farmers inspect the quality every time, including general inspections such as the number of herbs, packing, and contaminants. In addition, there are also random checks by hospital staff to check the quality and any contaminants in herbs. In addition, the farmers have never returned any raw materials to the suppliers.

The SCOR metrics are diagnostic metrics. SCOR recognises three levels of pre-defined metrics. In this research, the focus is only on level 1 based on the five indicators. First, the reliability metric indicates the performance of the supply chain in delivery and can be measured by the orders fulfilled. Second, the responsiveness metric can be measured by the order fulfillment cycle time, i.e., how quickly the farmers respond to orders from Chaopraya Abhaiphubejhr Hospital. Third, agility is the adaptability of a supply chain in responding to marketplace changes. Fourth are the costs associated with operating the supply chain. The last indicator, asset management efficiency, is the effectiveness of an organization in managing its assets to support demand satisfaction. The first three target values were obtained from a brainstorming session between the farmers and key customers. The other two were obtained from brainstorming among the farmers in the group. The target levels of the metrics are shown in Table 3.

Table 3 Target levels

Metrics	Target level
1. Reliability	95%
2. Responsiveness	< 6 months
3. Agility	< 60 days
4. Cost	< 5 Baht/m^2
5. Asset management efficiency	> 10%

4.3 SCOR performance metrics

The results of the SCOR performance metrics based on the five indicators are as follows:

4.3.1 Reliability

A fulfilled order should have the correct product and quantity, on-time delivery, and the correct condition and packaging. From the study, it was found that farmers were able to deliver products to customers under the correct conditions. The packaging is in good condition, and the quantity is complete and on time. Based on these data, the reliability is equal to 100%. As a result, the reliability indicator is not an issue.

4.3.2 Responsiveness

When farmers receive orders from the hospital, they will divide the delivery of herbs to the hospital into 3 cycles. Because of this, farmers have limited cultivation areas. In one cycle of planting herbs, it takes 80–90 days or about 2–3 months after collecting the herbs. The process of drying and packing products for delivery to the hospital in Round 1 and planting new herbs and delivering them to the hospital in Round 2 and 3, respectively. Therefore, the responsiveness measure shows an issue that the farmers take 9–10 months to fulfill customer orders.

4.3.3 Agility

In this research, agility is measured by its flexibility in terms of quantity. In 2021, with the coronavirus (COVID-19) outbreak, *Andrographis paniculata* (Fa thalai chon) was in great demand, as a result of which there was a shortage of this herb in the market, which fuelled increasing demand from customers. The reason for the problem was that herb farmers cannot predict or know the exact needs of their customers. Although the orders for *Andrographis paniculata* increased, the farmers had limited space to plant. They could only start planting *Andrographis paniculata* once the original harvest was completed at the end of up to 90 days. This meant there was a problem with flexibility.

4.3.4 Cost

This study focuses only on the herb growers of Dong Bang Village. Their costs (per production cycle) can be divided into 4 main parts; seed, fertilizer, labour, and drying costs, as shown in Table 4.

Table 4 Detail of each cost

Cost	Baht/m^2	%
1. Seed	4.39	55.61
2. Fertilizer	1.73	21.94
3. Labour	1.74	22.07
4. Drying	0.03	0.38
Total	**7.89**	**100.00**

Table 4 shows that more than 50% of the cost is for seed, while the cost of drying was the lowest proportion. The total cost was quite high, so consideration should be given to which elements can be reduced.

4.3.5 Asset management efficiency

In this research, the asset turnover rate is used to show the asset management efficiency. The calculation is shown in Equation (1).

$$Turnover\ rate = \frac{Net\ sales}{Fixed\ assets\ value} x100 \quad (1)$$

The asset turnover rate shows how farmers use their assets to generate income. In this research, fixed assets were calculated from the value of the land used for growing herbs. The land appraisal price of Prachinburi Province is 375 Baht/m^2. According to Table 5, the asset index has not encountered any problems.

Table 5 Details for determining the turnover rate

Title	Value
Cultivated area (m^2)	39,200
Fixed assets value (Baht)	14,700,000
Net sales (Baht/year)	1,620,900
Turnover rate (%)	11.02

4.4 Guidelines for improvement

4.4.1 Responsiveness

Due to the limited cultivation area, the guidelines for resolving responsiveness problems should use the ABC principle to allocate the area for cultivation. The planting area is divided according to the number of orders. For example, the hospital ordered 300 kilograms of Fa thalai chon, 100 kilograms of Ya nuat maeo and 50 kilograms of Beijing Grass, and then used the ABC principle for classification. Zone A will use 70% of the plantation area to plant Fa thalai chon. To get a yield of 300 kilograms, the farmer would have to take strict precautions to keep it productive and not to damage it so as to avoid insufficient production to fulfill the order requested. Zone B will use 25% of the plantation area to plant Ya nuat maeo, for which there is a more moderate number of orders. The farmers should be moderately controlled and careful. Zone C will use 5% of the plantation area for Beijing Grass, this being the smallest order. This solution has the advantage that it requires no investment. However, information about the amounts ordered must be taken into account to determine how to divide the zone according to the ABC principle. In addition, to increase the area cultivated, the new generation should be invited to join the group of planters, highlighting the revenues that will be received.

4.4.2 Agility

The way to improve agility is for the farmers and Chaopraya Abhaiphubejhr Hospital, which is the main customer, to exchange information on the planting and sales of herbal medicines that can be used for planning the next planting cycle. The advantages of sharing sales data are that the farmers are able to prepare the raw materials for the hospitals in time. If farmers exchange planting information, the hospital will understand the situation and be able to find solutions in time. In addition, farmers should apply the principles of safety stock and forecasting principles. Using this method, farmers can ensure the herbs are delivered to the hospital on demand. However, this method requires the collection of historical data and calculations that may be complicated because of the farmers' lack of knowledge.

4.4.3 Cost

To deal with the seed cost problem, farmers should reduce the proportion of seed purchases and increase the use of their own collected seeds. In addition, they should select seeds from reliable sources and with a high percentage of growth. Fertilizer costs can be decreased by farmers mixing the soil and using their own fertilizer. Meanwhile, labour costs can be reduced by using smart farm systems, such as automatic plant watering when humidity is reduced. Automatic plant watering systems consist of a soil moisture sensor, pump, pump controller, drip irrigation kit, connecting pipe and Arduino.

However, reducing costs by adopting a smart farm system requires an initial investment. Therefore, it is necessary to calculate the payback period and the rate of return.

Subsequently, draft guidelines were presented to the farmers for their consideration and verification. The farmers thought the draft guidelines presented were interesting and feasible. Therefore, the details of the guidelines will be studied in future research.

4.5 Discussion

Praharsi et al. [12] found that the lowest performance metric value in the traditional shipbuilding industry is the cost of goods. Meilizar et al.'s [20] observations identified twelve variables: raw material inventory accuracy, internal relationships, planning employee reliability, time to produce a product, source fill rate, mean lateness of delivery, percentage of correct quantities delivered, percentage of correct delivery quality, delivery by committed date, order fulfillment lead time, make time, and response time. The results show that the values of all the variables are still less than the company target. Krawglom et al. [19] found a reliability problem, where the return rate was 8.30%. Meanwhile, in this research, the lowest performance metric values were responsiveness, agility, and cost. However, each product has different characteristics, which means there are differences in determining the indicators used for measuring the performance of the supply chain. Nevertheless, the results from this study were consistent with those of Praharsi et al. [12] and Ricardianto et al. [18]. The SCOR performance metric can help identify opportunities for improvement.

However, this research is limited because it is still only the first phase of the research focusing on the measurement of SCOR performance and identifying problems. Therefore, there are still no detailed proposals for solving the problems, and this study offers only draft guidelines.

5. Conclusions

Five metrics are determined in this study. For three of them problems are identified, namely, responsiveness, agility, and cost. The group of herb farmers in Dong Bang Village takes up to 9–10 months to grow and then deliver to customers to complete their orders. This shows that there is a problem with the responsiveness. In addition, as concerns the agility metric, when the quantity of herbs needs to change, the farmers are unable to adjust the planting as needed. It takes time to harvest the old herbs first before planting can be

started again. Moreover, the cost metric found that the cost of cultivation was quite high. When costs were broken down, it was found that the seed costs were the highest. In light of these findings, guidelines for improvement were proposed. To improve the responsiveness, the ABC analysis for optimal allocation of the area for cultivation is proposed. Sharing of information on the planting and sales of herbal medicines that can be used for planning is recommended for improving agility. For cost reduction, expenditure on seeds can be reduced by farmers purchasing fewer seeds and increasing the collection of seeds from their own herb seedlings.

In future research, detailed guidance will also be proposed on corrective actions for smart farms, in terms of both equipment and investment.

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