Conceptual Framework of Performance Improvement in Coffee Production Using Integrated Lean Technique

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Abstract

Coffee is one of the most popular beverages in the world. This study examined and proposed improving coffee production performance involving farmers, factories, and entrepreneurs by using lean concepts and smart farming. Collecting data from site visits, observation, and interviews, value stream mapping (VSM) was employed to recognize and classify activities in the coffee supply chain. Eliminate, Combine, Rearrange, and Simplify (ECRS) techniques were proposed to enhance supply chain performance. Those can help in improving and increasing the profitability of the Thai coffee supply chain. This work focuses on the function of productivity improvement implementation in coffee production. The effects of productivity improvement implementation will be analyzed using a case study. In the future, farmers and factories can gain several benefits and become more reactive to the customer's needs.

Keywords

Coffee production; Performance improvement; Value stream mapping; ECRS technique; Smart Farming

1. Introduction

Coffee is an important economic crop and product that creates significant value for the food industry worldwide. In terms of economy, it is a vital commodity that contributes to considerable income on domestic and worldwide scales for producing countries. Recently, it has been found that the production cost of coffee from harvesting coffee cherries to obtaining green coffee beans in Thailand is relatively high, compared to coffee made in neighboring countries due to high labor costs. Consequently, this issue should be addressed so that Thai coffee production can be improved and the cost can be reduced.

This research aims to analyze activities and increase the efficiency of coffee production in northern Thailand. This coffee production framework includes the producers (farmers), factories, and entrepreneurs. The production of coffee will be sketched through Value Stream Mapping (VSM), after which the ECRS technique will be used to evaluate the production cost before and after improvement using appropriate indicators in our knowledge. Those tools are considered to be relatively new for agricultural supply chain studies. The application to coffee has not yet been extensively conducted. Therefore, a successful improvement of coffee production can be proposed and

focused. According to the methods and supply chain management described, the entrepreneurs can operate their sustainable business in the future.

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Supply chain management is an efficient method in integrated management to build value-added products and services. A combination of several activity relationships and collaboration led to improved competitiveness and sustainability (Handfield and Nichols, 1999; Sopadang et al. 2012). In the same way, the supply chain is composed of organization activities from upstream to downstream, not only manufacturers and service but also related to the response of the customer needs.

Therefore, the SCM can be applied to solve the organization problem in supply chain management of the production process from distribution network configuration, for instance, production facility, distribution center, warehouse and customer, distribution strategy. SCM can improve the production process from raw material to finished products to deliver to their customers (Yaibuathet et al. 2008) and trends of mass demand with the concept of smart logistics and led to cost reduction and right of the good quality product (Dallasega et al. 2019; Dallasega et al. 2020; Santiteerakul et al. 2020). One of the tools to improve the production process is Value Stream Mapping (VSM) and ECRS technique.

VSM remains one of the most popular tools for identifying and categorizing activities in the supply chain, which classify activities in the supply chain into three main types of activities: Value Added (VA), Non-Value Added (NVA), and Necessary-Non- Value Added (NNVA) activities (Wattanutchariya et al. 2016).

The theory of VSM is a tool for identifying and categorizing the efficiency of production in the industry. It has been studied and was used to assess the overall production process. This was done to find waste in the production process, as well as to improve the overall efficiency of the process of production (Womack et al. 1990; Jones and Womack 2002; Hines and Rich 1997; Somboon and Yaibuathet 2018; Srisuk and Yaibuathet 2020). VSM was used to improve agricultural products' production process (Thitijaroenpong 2009; Hossain and Masud 2012; Karim and Biswas 2016; Tansuchat et al. 2017; Predana et al. 2018; Wattanutchariya and Kuaites 2018; Janthawong et al. 2016). Wattanutchariya et al. (2016) applied the technique of VSM for identifying and analyzing the Thai parboiled rice supply chain. The findings showed that the supply chain could be decreased from 34 to 12 activities (reduction of 32.35%), leading to an increase in the efficiency of the Thai parboiled rice supply chain. Moreover, Lam et al. (2015) used to recognize risks at various steps in order to certify supply chain performance in the Hong Kong rice supply chain. Thitijaroenpong (2009) assessed the canned corn supply chain's operation efficiency by using VSM to groups of activities from seed procurement to transportation for exporting. VSM improved the production process and offered a significant reduction of WIP inventory (91.28%), TCT (3.44%), TLT (80.4%), on-time delivery (100%), and manpower (51.61%) in coffee production (Tarapituxwong 2015).

ECRS is a simple and straightforward approach to identify waste and implementation in improving the production process. ECRS consists of four core principles, including Eliminate (eliminate unnecessary work), Combine (combine operations), Rearrange (rearrange the sequence of operations), and Simplify (simplify the necessary operations). ECRS was used in manufacturing to improve production line efficiency by reducing time in the production process and reducing cost (Auanvichit 2010; Ongkunaruk and Wongsatit 2014; Srisuk and Tippayawong 2020). For example, Ongkunaruk and Wongsatit (2014) applied ECRS to analyze the time of the pre-cooking process at a frozen chicken firm and recommend enhancing productivity by incorporating ECRS and line balancing concepts. Furthermore, Chueprasert and Ongkunaruk (2015) also applied ECRS to enhance the productivity and efficiency in a production line of pasteurized milk. Korsanan et al. (2008) used the ECRS technique to solve problems in the sleeve production line and applied the ECRS technique to solve work problems, which resulted in improved work efficiency. For, Srisuk and Tippayawong (2020) used the VSM and ECRS technique to identify and improve a raw material picking process in warehouse initiates. Besides, Auanvichit (2010) studied the sportswear factory focusing on the production line improvement using work improvement techniques, ECRS, consisting of eliminating jobs, combining jobs, and re-arranging jobs. The results of work improvement were found that productivity was increased and the operation efficiency was enhanced. Also, ECRS was applied to a line balancing concept to reduce the total internal transportation distance and numbers of operators in the canned fruits production line (Makprang et al. 2012).

However, previous studies showed that VSM was mainly used to analyze the companies with a definite production line scope. This tool is considered to be relatively new for agricultural production. Application to coffee production

is relatively novel. Therefore, in this work, performance improvement of coffee cherry production is proposed. The VSM and ECRS techniques are the potential tools for productivity improvement in coffee production and efficiency improvement in production procedures and instructions, which affect the required production process and reduce cost and time in the organization.

2. Methodology

The conceptual framework of this study is based on the explanation of lean process improvement (LPI) to eliminate waste in the manufacturing process to a minimum and achieve a maximized rate of the continuous production process in order to achieve a level of business excellence. From the conceptual framework of production process improvement, the activities of the coffee production and efficiency of performance improvement using VSM and ECRS techniques are proposed. The research framework of the coffee production process is shown in Figure 1. This study of development and improvement can be divided into two phases as follows;

2.1 Collecting the coffee supply chain data

This research focused on the analysis and performance improvement of coffee cherry production. The scopes included a process from upstream to downstream (coffee cherry harvest, coffee processing, and end customer). Data will be collected by methods of interviews, site visits, and questionnaires. Fifteen farmers, one production factory, and one entrepreneur involved in a coffee production business are interviewed as this case study.

2.2 Identifying and analyzing the activity of coffee production by the lean technique

The collected data consist of harvest coffee cherry processes, transportation, activities in the production process, and time in each process will be analyzed for identifying and categorizing the production process using VSM. The overall activities in the coffee production process are identified as VA (Value Added), NVA (Non – Value Added), and NNVA (Necessary Non – Value Added) by monitoring of time of each activity.

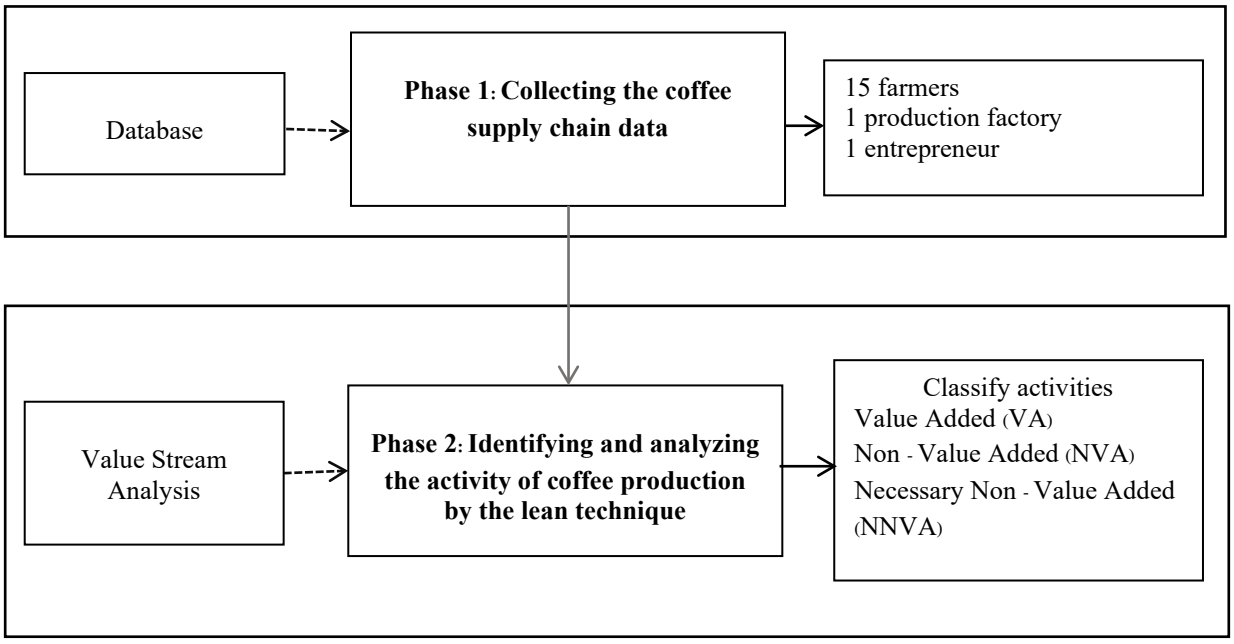

Figure 1. The research framework methodology of the coffee production process

3. Results & Discussions

The production process of coffee cherries from farmland to coffee processing factory is demonstrated in Figure 2. At the primary stage of coffee cherries, the farmers are harvested from farmland till green bean coffee processing. After the harvesting, the coffee cherries will be directly sent to green bean coffee production and followed by transporting the finished goods to the coffee processing factory or the end customer.

Figure 2 shows the current state value stream mapping of the coffee production process. The VSM method is applied for production process analysis, aiming to create the current state and future state of coffee production to improve the performance.

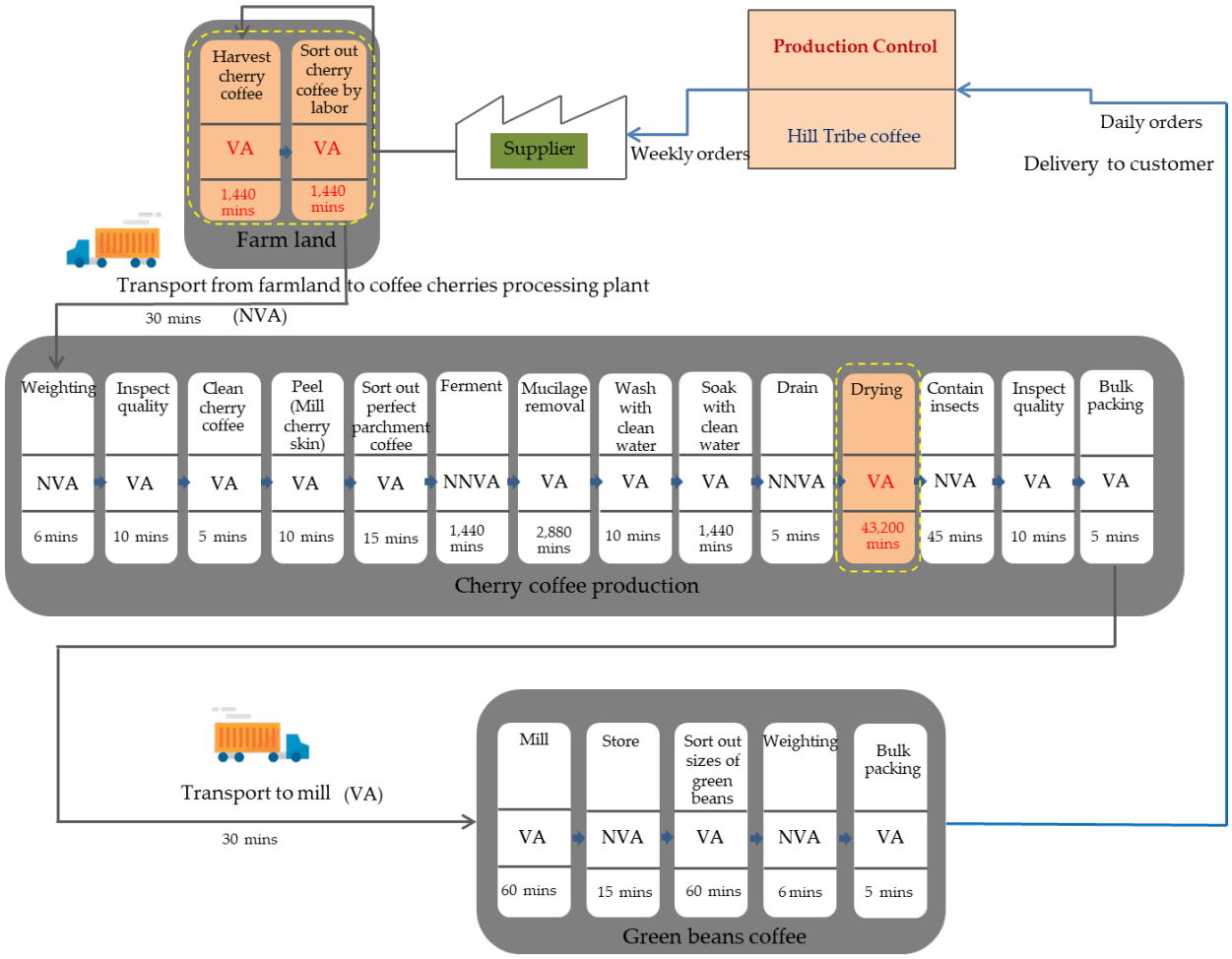

Figure 2. The current state value stream mapping of the cherry coffee production process

From literature reviews, interviewing, site visiting, and questionnaires, the current VSM of the coffee cherries production process can be identified with 23 activities from coffee cherries harvest on the farm to balk packing in the northern coffee roasting plant. The main problems in the coffee production process were identified as incoming raw material and lack of quality coffee cherries and green beans coffee.

(i) Incoming raw materials are from the harvest and sort out coffee cherries activity by labor - All coffee cherries of every shade are harvested and mixed together, which makes a lack of quality. The problem encountered in this process is that the suppliers do not separate coffee cherries before delivering them to the processing plant. For this reason, it difficult to control product quality in production processes. Thus, if the entrepreneurs have a plan for the incoming process of raw material are systematical. Moreover, a time schedule for collecting and transporting raw

materials is necessary and vital. If the entrepreneur arranges the time schedule of each supplier clearly, coffee cherries can be traced back and investigated into the origin.

(ii) Lack of quality coffee cherries from harvest activity - Currently, the coffee company has been sorting the cherries' shade by hand before delivering them into the production process. Different shades of cherries affect the quality and production costs. In the current situation, labor shortages and high labor costs are severe problems for farmers in Thailand, especially during the harvest season. High costs of production affect the capacity and benefit of coffee production. To solve the severe problem, the improvement of coffee cherries sorting and the cost of labor using a mechanical point of view is introduced in this study.

The color sorter can be separated into three shades include red, green, and yellow color. The coffee cherries with red color have high quality and characteristic. They are suitable for coffee roasting, while green and yellow colors are identified as defects and low-quality coffee cherries. The defective coffee cherries are a by-product. For example, they can be used for other purposes, for example, the cosmetics production industry (Koo et al. 2007) and functional coffee foods (Cano-Marquina et al. 2013). Furthermore, the color sorter can reduce the time and cost of coffee production. (Pearson 2009; Zhong et al. 2014; Jie et al., 2011; Chaitanya et al. 2019; Sopadang et al. 2007).

The entrepreneur or farmers may apply dryer machines instead of conventional in natural process. The dryer machine can control the quality standard of green coffee beans coffee production. Also, it can reduce the risk of contamination from insects as well as reduce the moisture content of raw material, Etc. (Wankhade et al. 2013). Moreover, reducing time and labor costs in the production process for increasing profit in the long term (Tippayawong et al. 2008; 2009; Pintana et al. 2016; 2017; Thanompongchart et al. 2016; 2017; Amelia et al. 2019).

According to the problems mentioned above, in the future, we will create a framework of coffee production to improve the performance of the production process in order to reduce costs and to produce high-quality coffee, which consists of four steps as follows;

Step 1: After creating the framework of the coffee production process, additional data collected from farms, factories, and entrepreneurs will be investigated and analyzed.

Step 2: In the coffee production process, the questionnaire was used for data collection to explore and solve the problems.

Step 3: After problem detection, defect reduction will be identified, and an alternative solution should be given.

Step 4: In coffee processing, machine technology, from operating, maintaining, repairing, or inspecting machines to designing and creating programs, can be used to solve the problem and enhance the efficiency of the process, including cost analyzing time reduction and high-quality production.

4. Conclusions and Suggestions for Future Works

This study focused on the small farms and companies because they are high numbers of the coffee process unit and the backbone of economic growth in Thailand. They still lack knowledge and skill in farming management. So, this study emphasizes farm management and investigates the high efficiency of the manufacturing process from upstream to downstream as a case study. Moreover, this case study results can apply to a large scale of production, which are a few players in Thailand for the typical distributors.

In order to improve the efficiency of the coffee production process, the problems of low-quality raw materials of coffee cherries in the incoming process and uncertainly of coffee cherries quality. The suppliers were proposed and solved this issue. The time schedule of raw materials in the incoming process was introduced and the traceability of every step. This process was applied using the technique of VSM and ECRS techniques from the harvesting until the processing. The overall activities in the coffee production process will be identified as VA, NVA, and NNVA by VSM. Then the current state mapping of the coffee production process will be created. After that, the ECRS technique will be used to improve the quality and efficiency of the production process.

Finally, the color sorter will be applied to the production process to categorize the shades of coffee cherries (red, green, yellow) led to a high value-added specialty coffee with high quality. Moreover, a special drying machine with several sensors for detecting and temperature controlling should be applied to the process to increase efficiency and save time, energy, and cost.

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