Lean Production on Chili Pepper Supply Chain Using Value Stream Mapping

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Abstract. In the globalization economic development, most of industries have been developing strategies to improve efficiency in their production processes. Meanwhile, chili pepper supply chain is still not aware about efficiency and effectiveness in its management. Most actors in chili pepper supply chain face several obstacles, i.e. losses, waste products, and inefficiency in delivery time. This research is focused on the development of chili pepper supply chain performance using Value Stream Mapping (VSM) analysis and aims to create a new key system to develop efficiency and effectiveness. VSM is used as an instrument to enhance comparative advantage in wildly industries. VSM in chili pepper involves operation system such as 6S, Volkswagen production system, visual workplace, quick changeover system, and Hiejunka Kanban system. Those techniques are applied to reduce waste in chili pepper supply chain. The research result shows that chili pepper supply chain should explore the implementation of VSM.

Keywords: Lean Production, Supply Chain Management, Value Stream Mapping

Introduction

Agricultural sector in developing countries faces several challenges in today's global industry competition. Logistics and supply chain in agricultural sector become the greatest challenge due to the characteristics of product, supply, distribution process, and market. Agricultural products are perishable, have a short life, and deteriorating significantly over time (Blackburn & Scudder, 2009). One of the valuable agricultural products is chili pepper commodity that has a complex and dynamic system, which is now at risk of volume and quality products uncertainty because of the lack of production management system. This product also experiences the lack of technology improvement due to the low funding since agricultural productions are dominated by small-scale farmers (Dolan, Humphrey & Harris-Pascal, 1999). Moreover, most farmers do not linkage their productions with market thus resulting in price fluctuation; they do not have access information about consumer requirement/demand and do not know about time production and distribution based on market needs (Opara, 2002; LaLonde & Pohlen, 1996).

Chilli pepper is one of the strategic commodities in Central Java which tends to influence inflation both in regional and/or national economic situation. Furthermore, Indonesia's food logistics system is still not optimal because logistics costs are still high, ranging from 20% to 25% of Gross Domestic Product (GDP). Specifically, logistics cost in horticultural supply chain are ranging from 20% to 30% of sold products costs. The high cost of chili pepper logistics is caused by inefficient logistics system that occurs in food supply chain. Causes of inefficiency in chili pepper logistics system include improper post-harvest handling, food logistics infrastructure (such as packing house, cold chains, transport modes, etc.), rural road damage, the absence of agricultural logistics services in rural areas, limited of actors' knowledge on agricultural logistics management, and the absence of an institutional framework specifically

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concerned with agricultural logistics system. Those risks are affected price fluctuation and become crucial problems in the development of logistics and supply chain management.

Price stability, specifically in chili pepper supply chain, becomes one of the key success factors in the development of food safety. In addition, price stability contributes to inflation as an indicator of national economic situation. An effective production system could help business gain competitive advantage and improve value added with the result that producer could gain stable price (Lewis, 2000). Efficiency of production system would reduce or at least minimize the risk in production, eliminate waste, and things which closely linked to the production costs (Russell & Taylor III, 2003). Moreover, continuity, efficiency, and affectivities of production system and stable price of agricultural products have prompted many agricultural actors to adopt new production approaches (Kruska, Reid, Thornton, Henninger & Kristjanson, 2003). Catching up on current situation needs appropriate approach to develop efficiency and effectiveness in agricultural logistics and supply chain management (Puvanasvaran, Megat, Hong & Razali, 2009).

Lean production or lean manufacturing (in industry) becomes truly a global affair, in which economic globalization have made several impact changes over recent decades. Lean production is a comprehensive design of factory operations and production process which is oriented and emphasizes on continual improvement, total system efficiency, and value-adding action (Behrouzi & Wong, 2011). The aim of lean production is to design production process which minimize waste in supply chain system and invent more values for consumers (Womack & Jones, 2003). According to Bhasin & Burcher, (2006), 10 percent of the United Kingdom organizations have implemented lean production effectively. Lean production becomes an important role to improve competitive advantage and value adding in industrial production (Worley & Doolen, 2006).

Lean production is core analytical tools that have been widely applied in manufacturing industry with 5 techniques (5's) of general visual management, cellular manufacturing, value adding, total productive maintenance, kitting department, and pull production. In agricultural sector, lean assessment includes land, labor, machinery, building, variable inputs, time, financial performance, degree of value creation, and improvement of competitive advantages as well as value adding. In line with the issue, food chain in the United Kingdom has applied lean concept for agri food chain by implementing value stream mapping, value chain analysis, and benchmarking to study the potential way in delivering beneficial agricultural products (Defra, 2006).

The first industry to apply lean production is Toyota production system that has designed four principles of lean, which are: <u>value</u>, to determine value as demanded and defined by the ultimate consumer; <u>value stream</u>, it illustrates or maps all pattern, information activities, and describes specific physical production activities involved in producing and delivering the products or services with values identified. This principle also identifies non-value adding activities that should be removed and involves detailed supply chain activities. *Flow,* this principle becomes the remaining value-adding process which flows without holding-up towards demand. The last principle is *pull,* that is to produce only what is pulled (demanded) by consumers and try to remove as much inventory stocks as possible (Womack & Jones, 2003).

In this research, Value Stream Mapping (VSM) is used to explicate the general production process, to analyze the production efficiency, and to find waste in production system (Womack et al., 1990; Jones et al., 2002; Hines & Rich, 1997). It is believed that the implementation of lean production approach in the system with uncertainty characteristics would make it more robust, effective, and efficient. In developing chili pepper supply chain, we build research stream on lean production with a robust, effective, and efficient value stream mapping approach. In this research, Value stream mapping (VSM) is used as a technique for illustrating and analyzing the logic of a production process. According to Rother & Shook, (2003) VSM is all the processes (both value added, and non-value added) which affected the big picture and reform the whole activities usually relate to lean production, and precisely, the area of lean methods implementation.

A value stream map is mapping the graphical major subject and information flows in transforming raw materials into finished product that a customer is willing to pay for. In the context of this research, the stream consists of farmers who produce chili pepper,

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and farmers group/farmers' association who focus on post-harvest, distribution, and marketing processes. The goal of chili pepper supply chain management is finding the best, effective and efficient system with lean production approach (Womack & Jones, 1997).

The improvement of effectiveness and efficiency in supply chain management is considered an important element of lean production, i.e. bottleneck removing, cellular manufacturing, competitive benchmarking, cycle time reductions, cross-functional workforce, Kanban/pull system as a technique to eliminate queues and increase workstation, planning and scheduling strategy, self-directed work programs, preventive management, continuous flow products, process of capability measurement, lot size equipment, JIT (Just in Time), HRM (Human Resources Management), quality management, and operation performance (Shah & Ward, 2003). According to Banomyong, Palamara, Burrow & Messer (2007), there are four key success factors to implement supply chain system that would gain efficient costs, continuity, safety, and responsive as value-adding improvement, i.e. infrastructure, institutional framework, services provider, and logistics actors. As it can be seen, lean production is built with various elements represented the multi-dimensional combination based on exploration to combine individual practice in a multiplicative function (Flynn, Schroeder & Sakakibara, 1995; Cua, McKone, & Schroeder, 2001).

Concerning value optimization, lean production can be used as a systematic approach in maximizing the value through minimizing the waste and flowing the product or service according to customers' demand (Locher, 2008). In lean production, waste occurs when products are not being made. Based on that, there are seven generally accepted wastes in production process: overproduction that is regarded as the most serious waste tends to lead to expensive costs and storage times. Overproduction also leads to expensive work-in-progress stocks which resulted in physical dislocation of operations as the consequence of poor communication. The second element is waiting, which occurs both in production and workers. The third element is transport, where the inefficiency in moving/delivering goods tends to lead to expensive costs and time wasting. Next is inappropriate processing which occurs in the grossly complex situations of production. The fifth is Unnecessary inventory, that tends to enhancing lead time and space, discouraging communication, increasing storage costs, and lowering the industry competitiveness. The sixth is unnecessary motion, that tends to lead to poor productivity and quality problems. The last one is defects or the bottom-line waste, which occurs in ultimate poor management (Hines & Rich, 1997; Bicheno, 2004; Pheng & Shang, 2011; Ohno, 1988; Rother & Shook, 1999).

Based on its characteristics, the goal of this research is to explore the empirical implementation of lean production concept to reduce waste that considering robust, effective, and efficient in chili pepper supply chain management. The novelty of this research is the discussion of lean production for managing chili pepper supply chain which would becomes more effective, efficient and robust. The study will be based on operational coordination and analytical framework to tackling logistics problems that occur in chili pepper supply chain. Lean production in agricultural supply chain management performance could give robust, effective, and efficient supply chain system in accordance with the characteristics of agricultural in Indonesia which has complex and dynamic system. The novelty of this research, in addition to the above one, is to gain value-added and competitive advantage that resulting in stable price.

Research Method

To implement lean production, VSM is used as an instrument. The model built in this study is based on chili pepper supply chain system in Magelang District, Central Java Province, Indonesia. Magelang is the second largest production center of chili pepper in Central Java and has potential environment in the development of agricultural logistics management. Research method used is a case study to collect the qualitative and quantitative data and exploring the complex issues (Baxter & Jack, 2008). In this stage, the technique of in-depth interview, field observation, literature studies, and document analysis were implementing to gain in-depth understanding of the development of chili pepper supply chain management. 15 informants were interviewed to get data and information related daily activities and time in chili pepper supply chain.

The model was built restricted to the

scope of production activities, harvest and post-harvest activities, distribution, and marketing process in chili pepper supply chain. Value stream mapping is a tool to identify and eliminate waste, streamline work processes, make lead time short, reduce the costs (in whole logistics flows), and increase quality and quantity of products (Martin & Osterling, 2014). Value stream mapping identically follows by several steps to design and implement lean in value stream. The first step is to draw current state map consisting of data and information on the shop floor. Data and information in current state map is basic to develop future state map, and it needs deep understanding to develop lean principles in the future state. Process of data that should be recognized in current step mapping is customer demand, cycle time (C/T), Process time (P/T), Changeover time (C/O), number of operations (Op.), capital (cap.), available time, uptime or downtime, quality or defect rate (Q), number of product variations, batch size, and inventory level.

Likewise, drawing future state ideas will often point out at the importance of current state information that has been largely overlooked. Future state map will redesign the process according to lean principles (Rother & Shook, 2003). Designing future state map should pay attention to several handy principles and methods that can be applied, i.e.; move towards continuous flow, that is to make most efficient mode of can with continuous production without inventory or waiting between operations; rebalancing the process, that is to minimize waiting time and aims to fill up the Takt with the result of operations equal to work content (Ohno, 1988). Changing the batch size that has pros and cons of batch production; changing the batch size means it needs to increase total productions capacity that experienced the changeover. Leveling out production (Heijunka) is applied when there are large differences in cycle time between products and make the process uneven and jerky. Reducing changeover time: Changeover is problematic and becomes a very common target for improvement. SMED (Single Minute Exchange of Die) method is commonly used to reduce changeover. Improve quality; the obvious goal for any process is to reduce number of defect. For a simple case, it is possible to use '5 why', meanwhile a complex case requires a cause-and-effect chart (known as *Ishikawa chart*). Putting it all together is a stage to illustrate all changes in a new value stream process that will be used in the future.

Current State Map of Chili Pepper Supply Chain

Process of case study analysis provided competitive operating data throughout the dissimilar sequence of events. The study focuses on the process of production, post-harvest handling, and delivery process of chili pepper in order to lowering waste, developing stable price, and exploring the key parties involved in chili pepper supply chain. In this stage, all the processes take more time during each step of the process and resulting in the highest production costs and waste of time.

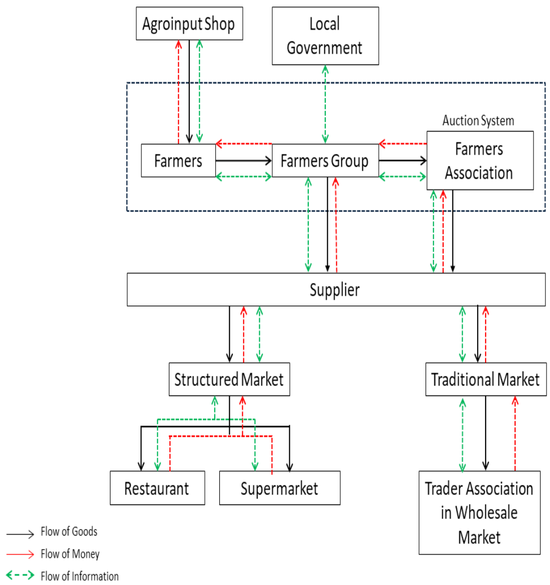

Figure 1. Chili Pepper Supply Chain Characteristics

Based on figure 1, chili pepper supply chain characteristics involved multiple actors: farmers as producer, farmers group in charge of collecting products after harvest, and farmers association responsible to do post-harvest and marketing with auction system. Supplier is an actor who plays a role as trader and supplies products to multi-markets, i.e. traditional market and modern market (restaurant, supermarket, and trade association in wholesale market). Meanwhile, local government is responsible to support and assist farmers group in production process development and agro-input shop as the provider of agro-input (seeds, fertilizer

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and pesticides).

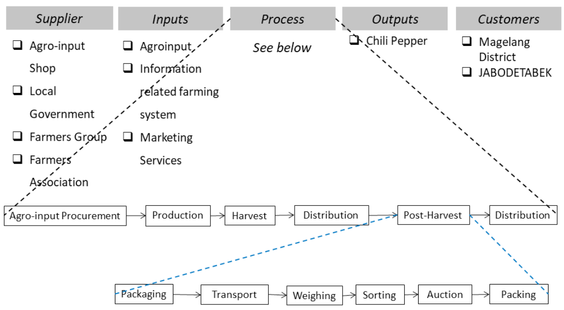

Figure 2. SIPOC Mapping in Production Process of Chili Pepper Value Stream

As it is explained in figure 1, farmers association is using auction system to sell chili pepper. Nevertheless in figure 2, the price still fluctuates, and farmers do not get value-added and competitive advantage because in the production process (from farming activities until post-harvest handling and distribution) there are no proper value added, such as the maintained product quality from field to market, develop marketing contract with stable price, etc. Farmers group and farmers associations do not do post-harvest handling and only do sorting, weighting, and packaging (using sack). In this process, all actors lacked the implementation of quality control (specifically after harvest) which led to waste, inefficiency process, and inflicted unstable quality, quantity, and continuity of production. All the processes is shown in SIPOC (Supplier, Inputs, Process, Output, Customers) diagram below.

Business process of chili pepper value stream has several processes described in schematic picture in figure 3. After went through production processes, products are transferred to farmers group and saved in loading dock for 5 hours without placing any value adding because it was wasting of time and costs as well as decreasing quality of product in the process of value stream. Then, products are delivered to farmers association where they do sorting and weighting before they start auctioning.

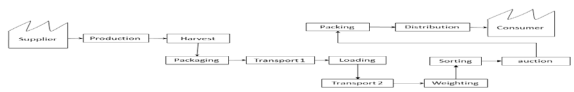

Figure 3. Schematic Picture of Chili Pepper Value Stream

According to consumer demand, farmers group and association can produce 5.2-ton chili pepper per 2 day or 936 ton per years. The physical flow in chili pepper value stream shows that chili pepper value stream wasted more time in completing the activity and thus influenced the costs. In chili pepper value stream, all activities depend on estimations.

PERT (Program Evaluation and Review Technique) Analysis is used to estimate the time spend on each activity of chili pepper value stream.

Table 1
PERT Analysis in Chili Pepper Value Stream Process

No	Activities	Activity Type	Expected Time (t_e) (Hour)	Sigma	Activity Value
1	Seed Procurement	Operation	210.00	38.00	VA
2	Land Processing	Operation	58.33	5.00	NNVA
3	Basic Fertilization	Inspection	2.67	0.67	VA
4	Planting	Operation	5.33	1.33	VA
5	Cultivation	Operation	450.00	16.67	VA
6	Pest and Diseases Protection	Inspection	76.67	23.33	VA
7	Harvest	Operation	4.67	1.00	VA
8	Packaging	Operation	0.51	0.15	VA
9	Transport 1	Transportation	1.00	0.17	VA
10	Loading	Warehouse	5.17	0.50	NVA
11	Transport 2	Transportation	0.51	0.15	VA
12	Weighting	Operation	0.28	0.06	NNVA

No	Activities	Activity Type	Expected Time (t_e) (Hour)	Sigma	Activity Value
13	Sorting	Inspection	4.42	0.42	VA
14	Auction	Operation	1.08	0.25	NVA
15	Packing	Operation	1.14	0.31	VA

Supply Chain

No	Activities	Activity Type	Expected Time (t_e) (Hour)	Sigma	Activity Value
16	Distribution	Transportation	9.33	2.33	VA

Based on the table 1, chili pepper value chain uses no machines in production process (include cultivation, harvest and post-harvest process) and make it difficult to improve the quality, quantity and continuity of chili pepper production. Moreover, moving chili pepper from plantation to the warehouse is onerous due to the fact that there is no adequate transportation mode, which means it takes a very large amount of time and causes shrinkage to quantity and quality of products. VSM should show non-value adding activities (NVA), maintain the pull-off process, and lead time. Those processes indicate that chili pepper value stream is having a lack of continuity in legal action stream.

Regarding information flow in figure 4, when customers and middleman (as supplier for traditional market) or supplier (supplier for modern market) need products, they would come to the warehouse or make order by phone through auction process. Production department do not manage inventory stock due to the uncertain products quantity in farmers' association warehouse. Moreover, there are also some technology limitations in post-harvest process and restricted products quantity with the target of 15.6 kg/week of production cycle.

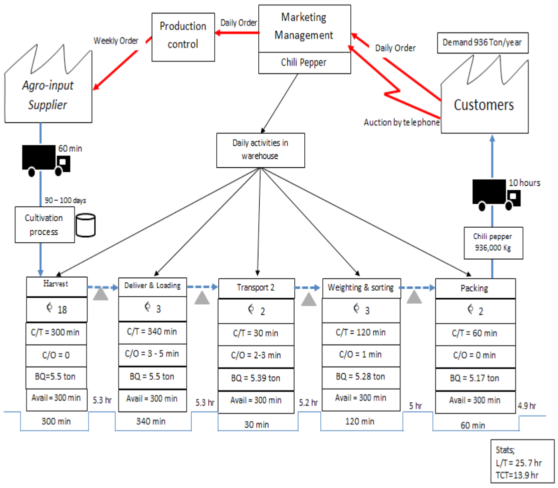

Figure 4. Current State Map of Chili Pepper

The coordination of production process is controlled by farmers group without integration with market demand. The TCT (Time Compression Technologies) in the current state of chili pepper value stream takes about 13.9 hours (13 hours 9 minutes), which associated with 25.7 hours of TLT (Total Labor Time). Most of the process is lengthy with necessary and unnecessary waiting time periods. The advancement system focuses on redesigning the production process to reduce lengthy process by implicating some techniques.

Table 2
Analysis of Activities Classification and Average Time of Current State Chili Pepper Production

Activities	Time (hour)	Percentage
VA	766.25	92.20%
NVA	59.70	7.18%
NNVA	5.17	0.62%
TOTAL	**831.11**	**100.00%**

Most of activities in chili pepper production are activating the value as shown in table 2. Improvement of operational efficiency is not only minimizing the cycle time (CT) of the NVA and NNVA activities, but also reducing the TCT of production. It used to set approaches for tracing the operational progress according to predetermined goals through lean matric analysis including inventory levels, TCT, TLT, manpower, enhance technology, and on-time delivery rates illustrated in the future state map.

Future State Mapping

Basic data to build future state map obtained from current state map and taken as an approach to improve the efficiency of chili pepper production process by analyzing several processes in the future state map, i.e.

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customer demand, production flow, leveling production, and planning.

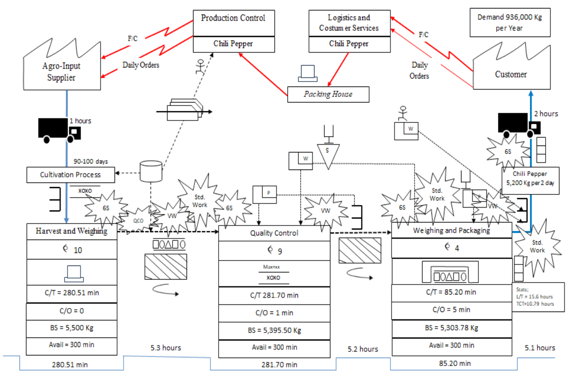

Figure 5. Future State Map of Chili Pepper Supply Chain

Customers demand equal to 5.2 ton per 2 day and Takt Time is marked 3.46 second, while the pitch is 2.88 minutes. Moreover, the estimation of efficiency process is about 54.08% of total lead time which adding value to product, whereas 45.92% of time wasted in inventory stage (waiting). Needless to say, there should be synchronization in all operations and remove waste in inventory. Based on fluctuation of chili production and volatility of customer demand, chili pepper supply chain needs to implement production scheduling and get market demand information as solutions to manage production capacity per day.

To prevent any uncertainty in production capacity by fulfilling customer demand per day requires constant service levels and buffer/safety stock. The implementation of new system as refinement process to meet consumer demand change is probably resulted in inventory subtraction which affected wastes. Accordingly, the 6s system of Seiri (Sort), Seiton (Set in Order), Seiso (Shine or Sweeping), Seiketsu (Standardize), Shitsuke (Sustain), and Safety is used to eliminate the time waste and cost in customer delivery process. To meet customer demand per day, farmer association should process (do post-harvest handling) for 25.05 kg per minutes.

According to production process, chili pepper supply chain manages the continuous stock of product line balanced with merging operations, utilization, and employees' skills by using the concept of distributed administration in each step. The system is expected to reduce waste time in every stage of the process. Figure 5 shows there are seven actions being used to add up cycle time that less than takt time. Waste time can be reduced by handing over structured market distribution methods to shipment activity. Machines can substitute labor (and lowering the labor cost) in the process of checking, sorting, and grading products. The chili pepper production process can be improved by involving the three work cells, which are:

Work cell 1 is a combination of harvesting and weighing activities which degrade wastes in respecting flow, inventory, and waiting process. It would create work cell cycle time equal to 280.51 minutes. The new key task scheme determines what action to do by applying the 6s system, the Kanban, and Volkswagen production system to diminish obstacles affecting the continuous stream process.

Work cell 2 is a composite of activities consisting of inspection, sorting and grading processes of regular labor intensive. The cycle time is 281.70 minutes and can decrease waste time. Controlling the new system, chili pepper supply chain should apply FIFO (First In First Out) system to pull material flow and achieve continuous process stream for the next activities using 6s system to supervise and organize the work field. Moreover, Volkswagen production system is used to synchronous the process based on the structure of house (foundation which specify the constancy of the four pillars; tact, flow, pull, and perfection).

Work cell 3 is simplifying efficient product delivery for customers and supplier of both modern and traditional market by rectifying the interoperability of weighing and packing through assigning them in the same stage and organizing the process using 6s system. Thus, waiting time can be minimized by operationing the u-shape cell in reaction to the new tact of chili pepper supply chain. The warehouse services are added to supervise number of finished products to stave off overproduction. The operational process implements the Kanban system in customer delivery by diminishing inventory waste.

Heijunka (also known as level-loading/production-leveling/production-smoothing) is addressing unevenness in workload (*mura)* by leveling holding capacity and mix over time. Heijunka can reduce lead time, inventory, and physical worker in addition to psychological stress that could burden the company with fluctuation workloads. Moreover, withdrawal Kanban has been adjusted to indicate number of chili pepper order from the market or to reckon the weighing and packing the finished products to be distributed. Withdrawal Kanban can manage the amount of customer demand. If the stock is based on reorder point, the manager will order Kanban production through production team (farmers and/ or farmers group) by specifying only the safety stock commensurate the number of customers' need per day.

Refinement of production system in the future state map involves production process which focusing on cultivation flow, using withdrawal and kanban production systems to take control of production speed to the most efficient way to satisfy customer needs. Due to output fluctuation, a conceptual production system is needed in order to manage a process of continuous flow and the draft of safety stock to stave off demand changeability. Correspond to the goals of action plan as mentioned above, the lead time in production process is lessened gradually from 25.7 hours to 15.6 hours, as planned in the future state of value stream map. Moreover, the estimation of efficiency process for about 69.17% of the total lead time is adding value to the product and about 30.83% of the time is wasted on waiting in inventory. It means that the process in the future state map can reduce non-value adding process that caused wasted on waiting in inventory.

Improving chili pepper supply chain should apply pull factor to get an efficient and effective development of chili pepper supply chain. Pull factor system could reduce wasted inventory products. Applying pull factor system means the production activities are done based on customer and market's needs. According to pull factor system, there should be an implementation of management and integrated production system (cropping pattern, planting scheduling, harvesting scheduling, crop rotation scheduling, applying GAP (Good Agriculture Practice), and SOP (Standard Operation Procedure)), post-harvest handling (applying GHP (Good handling Practice), HACCP (Hazard Analysis and Critical Control Points) and SOP (Standard Operation Procedure)) as well as products distribution process based on market needs.

Improving pull factor in chili pepper supply chain with lean six sigma approach would reduce waste (waste inventory and obsolete product). Pull factor tends to be applied for dynamic market needs, and the price fluctuation based on market needs could reduce non-value adding and data Point of Sale (POS) involved in chili pepper supply chain and reduces lead time as well.

Lean production may offer opportunities for farmers in developing countries to upgrade level of competitiveness by reducing waste and developing the quality of products. This study develops production process to support farmers in the improvement of competitive advantages through enhancing the manufacturing process by applying value stream map. As for the chili pepper manufacturing process, the test of using lean concept to control the flow of production process is an obligation of understanding for the stakeholders concerning their responsible in each stage, and for them to understand how the production process affect the flow process (Andayani et.al., 2016; Hakim & Perdana, 2017).

Notwithstanding, the case study of chili pepper supply chain can adjust the application of lean production by comparing the results of current state map learn with the future state map learn. It is found that the prominent side of developing the production process is significant reduction of WIP (Work in Process) inventory (84.16%), TCT can be decreased to 22.95%, and lean can reduce TLT from 25.7 hours to 15.6 hours. Moreover, on-time delivery is significantly reduced to 100% and manpower of 52.35%.

Conclusion

The production system can be improved by reducing LT (Lead Time) agreeing to the target goals and could affect the reduction of certain classify of wastes, including unnecessary inventory area, unnecessary waiting and movement, along with the improvement of continuous flow of production process. To maximize the operational process in chili pepper supply chain, farmer should cooperate with farmers group and farmer association to implement lean production process improvement through several elements of 6s system (include sort, Set in Order, Shine or Sweeping, Standardize, Sustain, and Safety), Volkswagen production system (applying tact, flow, pull, perfection based on foundation), visual workplace, Kanban, Heijunka, quick changeover system, and merging and removing loading process as the effort to increase efficiency, effectiveness, and competitive advantage. A long cooperativeness of supply chain actors is

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the key to maintain continuity of production process as well as to increase bargaining position and value of products.

There are still some issues to be considered in further improving the process of lean production in chili pepper supply chain. Development of lean production in chili pepper supply chain need integration action from all stakeholders involved in production process (both in upstream to downstream process). Based on agricultural supply chain study in Indonesia, implementation of lean production should develop logistics services provider which can help farmers and farmer group in the process of post-harvest handling, distribution and marketing process. Moreover, distributed governance/administration plays a part in developing integration production based on multiple markets and multi-actors in the development of chili pepper supply chain to achieve a robust, effective, and efficient production.

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