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# Improving Cocoa Production Through Lean: A Case Study of the Ghanaian Cocoa Industry

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# IMPROVING COCOA PRODUCTION THROUGH LEAN:
# A CASE STUDY OF THE GHANAIAN COCOA INDUSTRY

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IMPROVING COCOA PRODUCTION THROUGH LEAN:
A CASE STUDY OF THE GHANAIAN COCOA INDUSTRY

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Date

I dedicate this thesis to my parents, Kwasi Boateng and Florence Denkyira, and to my sisters, Ama Nyantah Boateng and Ama Kissiwah Boateng for their undying love. I could not have asked for a better family. I also dedicate it to my best friend, confidante, and God's own gift to me, Ese Blessing Aghenta.

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Cocoa has been useful in several ways, especially to countries that produce it and consumers all over the world. Its benefits range from improving economies to satisfying millions all over the world who desire one cocoa product or the other. The production of cocoa however is not without its own attendant problems. Aging tree stock, spread of diseases, and production capacity problems are, but a few of many challenges that seed gardens that produce cocoa face. This study investigated the pollination process on selected seed gardens in Ghana, the second largest world producer of cocoa.

The purpose of this study was to investigate the artificial pollination process of cocoa on seed gardens in Ghana, and explore ways by which the Lean principle of Value Stream Mapping could be applied in improving the process. The process of pollination was observed on eighteen seed gardens, and a current value stream map depicting the existing process developed to give an indication of the current state of affairs. Subsequently, a future value stream map based on the current map was developed to show aspects of the process that could be improved to enhance the operations of the seed gardens.

The future value stream map revealed that operational procedures relating to cleaning and preparation of trees, choosing male and female trees for pollination,

harvesting of pollen, and manually pollinating practices presented various avenues for improving the pollination process and hence seed production output.

## Introduction

Cocoa has immensely contributed to the economy of the West African country of Ghana over the years, especially in exports. For example, cocoa beans and products accounted for 28.1 percent of total exports (Bank of Ghana, 2012) and has consistently accounted for almost half of agricultural exports (Breisinger, Diao, Kolavalli, & Thurlow, 2008). Breisinger et al (2008) further estimated that cocoa is poised to remain Ghana's most important cash crop and is expected to contribute about 44 percent of exports by 2015. According to the International Cocoa Organization (2012), cocoa production from Ghana in the 2009/2010 season accounted for about 17.5 percent of global production, second to Cote D'Ivoire, which produced 34 percent.

The contribution of cocoa to the Ghanaian economy is immense, since it benefits the central government, and a good number of Ghanaian cocoa farmers. For instance, in October 2012, the Minister of Finance and Economic Planning who doubled as the chairperson of the Producer Price Review Committee indicated that producer price of cocoa had seen an increment from GHC 205 to GHC 212 per bag for the 2012/2013 cocoa season. This increment was in spite of the fact that there had been a drop in the prices of cocoa worldwide from USD 3,000 to USD 2,300 in October 2012 (ISSER, 2012).

The Ghana Cocoa Board (COCOBOD) regulates the cocoa industry in Ghana, with a primary mandate of enabling production, processing, and marketing of cocoa as efficiently and effectively as possible (Ghana Cocoa Board, 2012). The Quality Control Company, the Cocoa Research Institute of Ghana, the Cocoa Marketing Company, and the Seed Production Unit are some of the various divisions that operate complementarily under the umbrella body of COCOBOD. For example, the Seed Production Unit is responsible for multiplication and distribution of improved cocoa planting materials to farmers. Based on research and development by the Cocoa Research Institute of Ghana (CRIG), the SPU usually recommends the use of hybrid coca pods and materials (Ghana Cocoa Board, 2012). Cocoa production sometimes experiences setbacks due to factors related to government schemes, environment, yield and stock features of trees (Dand, 1999). In setting up farms; therefore, it is necessary to strive to increase yields in order to help cut unit costs.

**Problem Statement**

From a supply perspective, Ghana's emergence as a leading producer of cocoa saw a rise until the late 1960s, and early 1970s, when production started to go down (Kolavalli & Vigneri, 2011). This decline was because of smuggling of as much as 20 percent of Ghana's harvest cocoa into Ivory Coast (Bulir, 2002), along with aging tree stock and spread of disease. In spite of Ivory Coast being the world's leading producer of cocoa, it is widely believed that cocoa from Ghana is of a higher quality than Ivorian cocoa (USDA, 2012). Data from Ghana's Central Bank (Bank of Ghana) indicated that export receipts of cocoa beans and products for the first quarter of 2011 amounted to $859.4 million (61 percent of total export earnings) relative to $682.5 million for 2010, which was 48.8 percent (USDA, 2012). In 2010 alone, Ghana exported a record value of $95.6 million in cocoa beans, and a remarkable improvement on the $55.2 million the country exported in 2009. This was in addition to an increment of 62.8 percent in cocoa butter and paste exports, which was primarily due to the quality of cocoa that the processing industries in Ghana produced (USDA, 2012).

With regard to demand, European countries accounted for 16 out of the top 20 countries that consume chocolate. Americans consumed a total of three billion pounds of chocolate (representing $13.1 billion in sales) in 2001(World Atlas of Chocolate, Simon Fraser University, 2012). According to the ICCO (2010), although both world production and demand of cocoa continue to show erratic upward increases, the contrast between seasons of production surplus and seasons of significant production deficit indicate that demand will continue to exceed supply. The craving for cocoa products both locally and internationally further gives an indication of the need to achieve higher production levels as far as cocoa production is concerned.

The Seed Production Unit of the COCOBOD is largely responsible for annual production of cocoa beans in Ghana, since it supplies pods and seedling to farmers. The unit engages in the multiplication and distribution of cocoa materials to farmers through activities on their seed gardens. Annual estimates for the SPU stands at 4.5 million hybrid pods, although it is suggested that there is a potential producing capacity of 6.8 million hybrid pods (Asare, Afari-Sefa, Gyamfi, Okafor, & Mva Mva, 2010).

Projections by the International Cocoa Organization (ICCO) indicated that Ghana's annual cocoa output for the 2012/2013 season would be 850,000 metric tons (ICCO, 2012). This would be far less (about 150,000 metric tons) than the government's projection of 1,000,000 metric tons. The SPU, like any production unit, employs a number of activities in its production, and the inability of the unit to produce at the potential estimates suggests a certain deficiency in the processes of the unit.

## Significance of the Research

The research findings of this study will be significant to the SPU in the sense that it investigated whether the application of principles of Lean will have any effect on the annual production levels of cocoa. This involved investigating the possible application of the Lean technique of Value Stream Mapping in the artificial pollination process of the SPU and the possible effects of implementing VSM on annual production levels.

## Purpose of the Research

This study primarily sought to investigate the activities of the SPU and most importantly the process of artificial pollination of the cocoa pods on the various seed gardens. In addition, the study investigated how the pollination process could be improved using the Lean technique of Value Stream Mapping (VSM).

## Hypothesis

$H_0$1: Implementing the Lean technique of Value Stream Mapping on the artificial pollination process will not show opportunities that can result in an increase in annual cocoa production.

$H_1$1: Implementing the Lean technique of Value Stream Mapping on the artificial pollination process will show opportunities that can result in an increase in annual cocoa production.

## Assumptions

The following assumptions were made in the conduct of this study:

1. The information obtained from the SPU gardens was accurate.
2. The use of both current and proposed future VSMs were appropriate as techniques for investigating production output levels.

### Limitations

1. Time constraints did not allow for observation of all pollination processes on all the gardens.
2. Weather conditions did not permit observations on all gardens simultaneously and within the same period.

### Delimitations

Delimitations set for the completion of the study were as follows:

1. The study did not cover all the seed gardens under the Seed Production Unit.
2. Production data used from previous years was not more than five years old.

### Definition of Terms

For operational purposes, the following definitions of terms applied in this study:

1. *BoG*: Bank of Ghana.
2. *Cocoa Bean:* Seed of the cocoa bean; ground roasted beans are source of chocolate.
3. *Cocoa Pod:* Vessel that contains the seeds of the cocoa.
4. *COCOBOD:* Ghana Cocoa Board.
5. *CRIG:* Cocoa Research Institute of Ghana
6. *USDA:* United States Department of Agriculture
7. *GoG:* Government of Ghana

8. *Ghana cedi (GHC)*: Currency of Ghana (GHC 2.6 = USD 1.00 as at February 2014).
9. *GoG*: Government of Ghana
10. *ICCO* (*International Cocoa Organization)*: A global organization composed of both cocoa producing and cocoa consuming member countries.
11. *ISSER (Institute of Statistical, Social and Economic Research):* A research institute with a mandate to conduct research in the social sciences in order to generate solutions for national development.
12. *SPU*: Seed Production Unit.
13. *VSM*: Value Stream Mapping

## Review of Literature

This review was in four parts. The first part discussed the history of cocoa in Ghana, its contribution to its economy and the role of the Seed Production Unit (SPU). A section for related Lean studies discussed the history of Lean Manufacturing and Value Stream Mapping as a Lean technique respectively. The final part of the literature review summarized the parts discussed previously.

### History/Contribution of Cocoa in Ghana and the role of the Seed Production Unit

Cocoa is believed, historically to have been discovered in the Ulua Valley of present day Honduras as a fermented alcoholic drink sometime between 1400 BC and 1100 BC (Maugh, 2007). It subsequently made its way to Mexico where it was integrated into the culture of the Aztecs, who thought the “god of air” brought them the tree. By the 17th century, cocoa had spread to territories in Central America, and then eventually to Brazil in the 18th century. It made its way from Brazil to Sao Tome in 1882 and around 1854 eventually got to the island of Fernando Po in West Africa (Sundiata, 1974).

A Ghanaian blacksmith by the name of Tetteh Quashie, who was a laborer on a cocoa plantation in Fernando Po is widely believed to have brought cocoa to Ghana (Hill, 1963). This was; however, preceded by Basel (Presbyterian) Missionaries who, working under the auspices of the Danish government, first introduced cocoa to Ghana in 1857. Unfortunately, the missionaries gave up the whole idea of cocoa farming since the seedlings they planted died year after year due to attack from beetles and worms. Only a few of the plants survived. Quarshie; however, had success with his nursery, with cocoa production thriving in Ghana thereafter. The first export of 80 pounds was in 1891 and by

1910/1911 Ghana was the world's leading producer with total exports of 40,000 tons per year (Howes, 1946).

In 1947, the government of Ghana established the Ghana Cocoa Board (COCOBOD), as a regulator body for the development of the industry. This was in recognition of the contribution of cocoa to the country's economic development (Ghana Cocoa Board, 2012). Presently, six out of ten of the administrative regions in the country, namely Ashanti, Brong Ahafo, Eastern, Volta, Central and Western regions, are the cocoa growing areas (Figure 1 shows Ghana with dots in the cocoa growing areas).


*Figure 1. Map of Ghana with dots in the cocoa growing areas (Adapted from CDD-Hewlett Data Center, 2013)*

The introduction of cocoa into Ghana and its subsequent production on a commercial scale has contributed immensely to the country's economy. It has remained the number one cash crop, as well as the highest agricultural crop foreign exchange earner, for the country. The Government of Ghana (GoG) fully controls the industry and has monopsony over the purchase and monopoly over the export of cocoa beans. The Ghana Cocoa Board (COCOBOD), established by the GoG, monitors and regulates operations of the industry. The Board does this by facilitating the production, processing, and marketing of quality cocoa in an efficient and cost effective manner. The COCOBOD operates under the aegis of the Ministry of Finance, and oversees and controls the export and internal marketing of cocoa beans. COCOBOD registers and licenses private sector companies who undertake the internal purchasing of beans from producers (Ghana Cocoa Board, 2012).

According to Asante-Poku and Angelucci (2013), the prevailing cost structure in the value chain of cocoa in Ghana results in farmers receiving disincentives which are a result of levies and taxes on exports, the cumbersome regulating framework, and high transportation costs. They however suggested that in spite of these disincentives, production in most years have increased because of easy accessibility to seeds and technical assistance, and the institution of an input subsidy program by the government. Furthermore, they suggested that policies such as reduction in the monopoly structure, especially concerning exports, lessening the level of power among purchasers, and reviewing costs relating to quality control and treatment before exports will greatly reduce the disincentives to farmers.

In 2011, Ghana's Central Bank stated that export receipts for the first quarter amounted to $859.4 million. This represented 61 percent of all export earnings as compared to $682.5 million (or 48.8 percent) in 2010. In terms of trade exports, Ghana exported 526,761 metric tons of cocoa beans in the season 2009/2010, up from 485,785 in 2008/2009 (Bank of Ghana, 2012). Export of cocoa beans also account for 40 per cent of the country's foreign exchange earnings and provide the second largest source of export dollars (USDA, 2012).

Mhango (2010) suggested that Ghana's economic growth experienced a slow down by about 4.7 percent in 2009 due to a subdued growth in non-agricultural sectors such as industry and services. Broadening the agricultural sectors scope to include the cocoa industry, forestry and logging, as well as fishing indicated that it generated more than a third of national output. Ghana has undertaken reforms in recent years to ensure that farmers get a larger portion of international prices for their produce and also to prevent smuggling and incentivize productivity gains. Mhango (2010) further suggested that in spite of the expansion in cocoa production, the agriculture sector's contribution has seen a decrease since 1993, when it generated 41% of Ghana's gross domestic product (GDP), to 37% in 2008. In spite of occasional fluctuations in prices for international cocoa trade, the capacity of the cocoa industry for growth, coupled with expectations of higher commodity prices and an increase in global trade makes a case for producing countries to undertake constant reforms, especially concerning production. This will ultimately provide opportunities for increased export earnings in the industry.

When Quashie arrived in Ghana, he established a cocoa nursery in Mampong-Akwapim (Eastern Region) and when his crop matured, sold the pods and seedlings to local farmers (Hill, 1963). Howes (1946) stated that Quarshie's trees that he initially established are believed to be the parent trees of the cocoa industry in Ghana, as cocoa farming thereafter spread to the Ashanti, Brong Ahafo, Central, and Western Regions. The Seed Production Unit (SPU) is a unit of COCOBOD responsible for the multiplication of improved cocoa planting materials to farmers. The unit, created in 2001, evolved from the merging of what was formerly a cocoa services division with the

Ministry of Food and Agriculture. Another reason for creating the unit was problems of low productivity that had plagued farmers. Some of these problems were attributable to factors such as tree stock being predominated by low yielding varieties and old trees suffering from disease and pest infections. In addition, extension services for farmers were increasingly becoming ineffective resulting in low levels of farm maintenance and standard practice (World Cocoa Foundation, 2012).

The SPU, among other things, provides a means of replacing cocoa trees with new high yielding, early bearing, and disease/pest resistant ones. The SPU uses findings from the Cocoa Research Institute of Ghana (CRIG) to multiply and make available to farmers improved cocoa plants that are developed from breeding programs of hybrid pods and seedlings. These seedlings are high all-year-round-yielding, early bearing, sturdy and disease resistant. The unit currently operates twenty-six seed gardens, of which twenty-three are active, and produces an average of about 4.5 million hybrid pods per annum (Asare et al., 2010).

Cocoa bean production reached a record high of 1,004,190 metric tons in the 2010/2011 season, up from 650,940 in 2009/2010 according to COCOBOD. COCOBOD determines cropping and purchasing period for cocoa beans, and the main crop season is from October to February/March, with the smaller/light mid-crop season from April/May to September. The Board has, in recent years, introduced longer crop seasons for the main crop (October to May) and reduced light crop season (June to September), primarily to maximize foreign exchange earnings through greater main crop yields (Ghana Cocoa

Board, 2012). Figure 1 shows the history of cocoa bean production in metric tons since 2005.

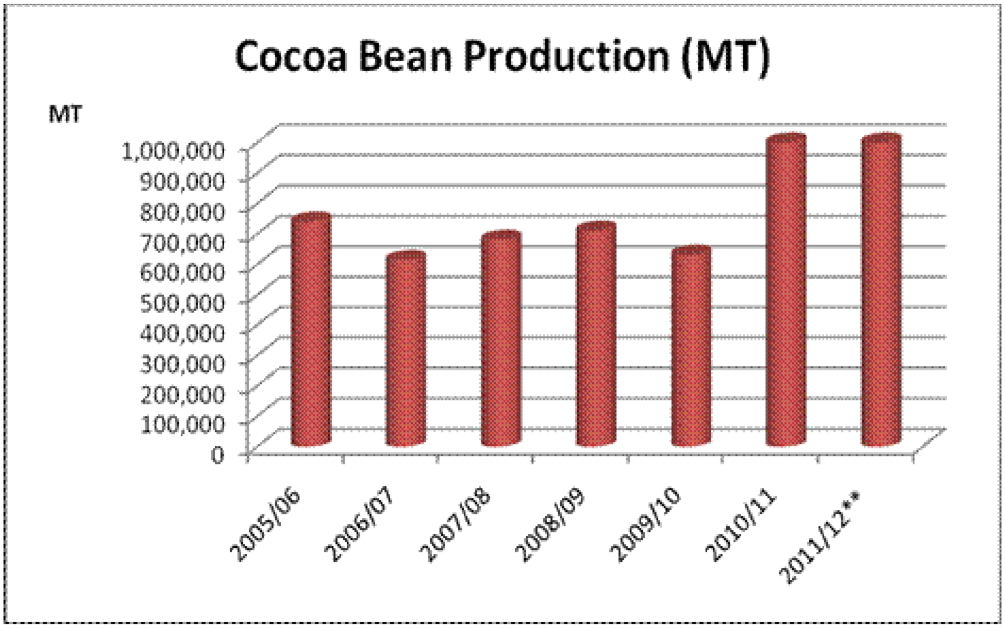



*Figure 2. Ghana Cocoa Bean Production. Source: Ghana Cocoa Board, **Post Projections*

**History of Lean Manufacturing**

Hines, Holweg, and Rich (2004) stated that Lean thinking began on the shop floors of Japanese manufacturers, especially at the Toyota Motor Corporation, as a result of innovations that had to be introduced in response to resource scarcity and high competition in Japan for automobiles. Lean operations focused on eliminating waste while improving efficiency of process or product flows. Hines et al. (2004) further stated that a lot of the early work at Toyota was under the leadership of Taiichi Ohno, with the systems, methods, and techniques relating to Lean applied to car engine manufacturing, vehicle assembly, and later to the supply chain.

Hines et al. (2004) indicated that for a long time the principles espoused by Lean were limited largely to Japanese manufacturers. In fact, until Womack, Jones, and Roos (1990) pointed out the differences between Toyota and other carmakers in their book *The Machine that Changed the World*, Western manufacturing companies had not started addressing their mind to those Lean principles espoused by the Lean philosophy. Womack et al. (1990) coined the term “lean production” (or “lean manufacturing”) in their book and pointed out that problems in manufacturing and technologies were universal in nature and Lean as a philosophy could be transferred to Western manufacturing entities.

The implementation of Lean in the early stages focused more on the tools of Lean with very little focus on the human aspect relative to high-performance work. According to Womack and Jones (1996), from the early 1990s there was a gradual broadening of the focus of Lean to encompass identifying what customers valued, how to manage value stream, as well as developing more and efficient flow production. Furthermore, the mid 1990s saw the evolution of the value stream concept to consider not only manufacturing, but customer needs and raw material sources, and invariably provided the nexus between Lean and supply chain (Hines & Rich, 1997; Rother & Shook, 1998).

**Related Studies**

Lean sometimes comes with a cost and may not always present a win-win situation. Therefore, it is important that its application is always put in proper perspective. In a study to assess how a computer firm in the United States implemented Lean production in their international value chain, Levy (1997) made some rather interesting findings. The author studied the effects of Lean production on the firm by comparing the effects of domestic and international sourcing of printed circuit boards (PCBs), an important component required in computer production. The comparison considered completed systems that company produced in California and intended for the United States market with similar systems produced in facilities in Singapore and subsequently sent to the United States. Furthermore, the study compared the effects of sourcing of bare PCBs from suppliers in the United States vis-à-vis suppliers in Japan and Singapore, while consideration of factors such as geographic distance, international operations, social, as well as cultural differences. Levy (1997) stated that Lean production typically requires a fast flow of goods and information, which sometimes proves costly and difficult to achieve. Because of this, international supply chains tend to have lead times that are longer as well as higher inventory levels relative to domestic supply chains. Consequently, longer supply chains have attendant problems that may include poor sales forecasting and delays in dealing with technical issues. The author suggested that even though aspects of Lean production such as reduction of defects and ensuring low levels of inventory enabled the company to have a stable supply chain, it was crucial for managers to understand fully the impacts of disruptions on supply chains that are scattered globally in order not to lose sight of their associated costs.

Agriculture is one such area that has seen the application of some Lean principles because of the evolution of Lean to encompass sectors other than manufacturing. Sofokleous (2007) investigated how a fresh pineapple production company implemented Lean strategies to improve processes including packaging, and transportation. The author examined the implementation of Lean techniques including Value Stream Mapping in identifying bottlenecks as well as kaizen events (events that target continuous improvement towards excellence) that the company could carry out. Furthermore, the study investigated how the storage room of the company could utilize 5S (Sort, Straighten, Shine, Standardize, and Sustain) in its organization as well as analyzing costs for potential savings and benefits. The author proposed methods of redesigning the company's work area in order to create a better process flow. Options such as the use of dolleys, pallets, and hand trucks provided avenues for the reduction of cycle time and the number of workers in the facility needed to transport crates from one point to the other. This further helped to reduce the required man-hours in addition to saving company costs.

Sofokleous (2007) utilized 5S methods including visual aids in training workers to keep storage rooms tidier and more accessible for their own use. The utilization of 5S served as a kaizen event since the researcher constituted a team to ensure continually that improvements such as updates to visual aids, equipment, and stocked items were implemented in the work area to help eliminate waste. In addition, after the kaizen event, the team documented the process to create a standard and provide precedence for workers in other shifts. Overall, the study indicated that Lean methods could be implemented in areas other than manufacturing with a great degree of success.

A major problem facing the development of agriculture in Africa is the lack of efficient seed production systems (Guei, Barra, & Silue, 2011). This is primarily because of farmers, especially those in remote areas to have access to quality seeds of adapted varieties. In a study to assess the success of methodologies geared at enhancing the sustainability of quality seed production and supply, Guei et al. (2011) investigated how smallholder seed enterprises could strengthen their capacities for rice, sorghum, maize, and millet seed production. The study involved mobilizing and training groups of farmers in technical aspects of seed production such as organization of farmers into autonomous seed producer groups, selection of seed production sites, crop management, and weed control and crop protection. The focus of this training was to build the groups as business units to enhance the multiplication and supply of varieties of maize, sorghum, and millet. The study concluded that seed production required quite an amount of financial and technical support, especially in the beginning stages and therefore it was crucial to sensitize and train seed producers' organizations while building alliances among all partners, producers, and local research and development agencies.

**Value Stream Mapping (VSM) as a Lean Technique**

Irani and Zhou (2011) suggested that the combination of all the processes engaged in by manufacturers, suppliers, and distributors to ensure an efficient and cost effective delivery of products to customers constitute Value Stream Mapping. They further stated that VSM helps in understanding the flow of material and information, as well as create a visual perspective for assessing both value adding and non-value adding steps in a process.

According to Rother and Shook (1999), VSMs employ the technique of using symbols in showing the movement of inventory and information. Furthermore, Hines and Rich (1997) underscored VSM as a useful method that enterprises yearning to become

Lean could adopt. In addition to their traditional uses, VSMs have also been combined with other Lean approaches to improve supply chains, as demonstrated by Hines (1999) and Brunt (2000), who used VSMs across entire supply chains.

As manufacturing and businesses become more complex, researchers continue to develop newer value stream tools, and have developed many tools and techniques for different purposes to reduce or eliminate waste. For instance, Emiliani and Stec (2004) utilized VSMs in describing business leaders' competencies, even as Singh and Sharma (2009) suggested that VSMs have seen tremendous application in new sectors, while being proposed in more areas. In spite of the fact that VSM has seen widespread use in manufacturing, it continues to see applications in service-related areas such performance measuring and leadership.

**Construction of Value Stream Maps**

According to Hines and Rich (1997), Value Stream Mapping is essentially a process activity mapping that uses the following approach: studying the flow of processes, identification of waste, consideration of how to arrange processes in an efficient sequence, consideration of a better flow pattern, and a consideration of the necessity of all stages in the process. The authors further suggested that any changes to processes should target avoidance of the seven wastes commonly accepted by the Toyota Production System (TPS) namely, overproduction, waiting, transport, inappropriate processing, unnecessary inventory, unnecessary motion, and defects.

Value Stream Mapping makes use of symbols to show a visual representation of processes (Figure 3 shows examples of symbols used for Value Stream Mapping).

According to Rother and Shook (1999), although Value Stream Mapping symbols have many variations and are not standardized, they usually fall into three categories; Material Flow, Information Flow, and General Icons. These symbols are used in combination with other appropriate symbols in developing both current and future state VSMs.

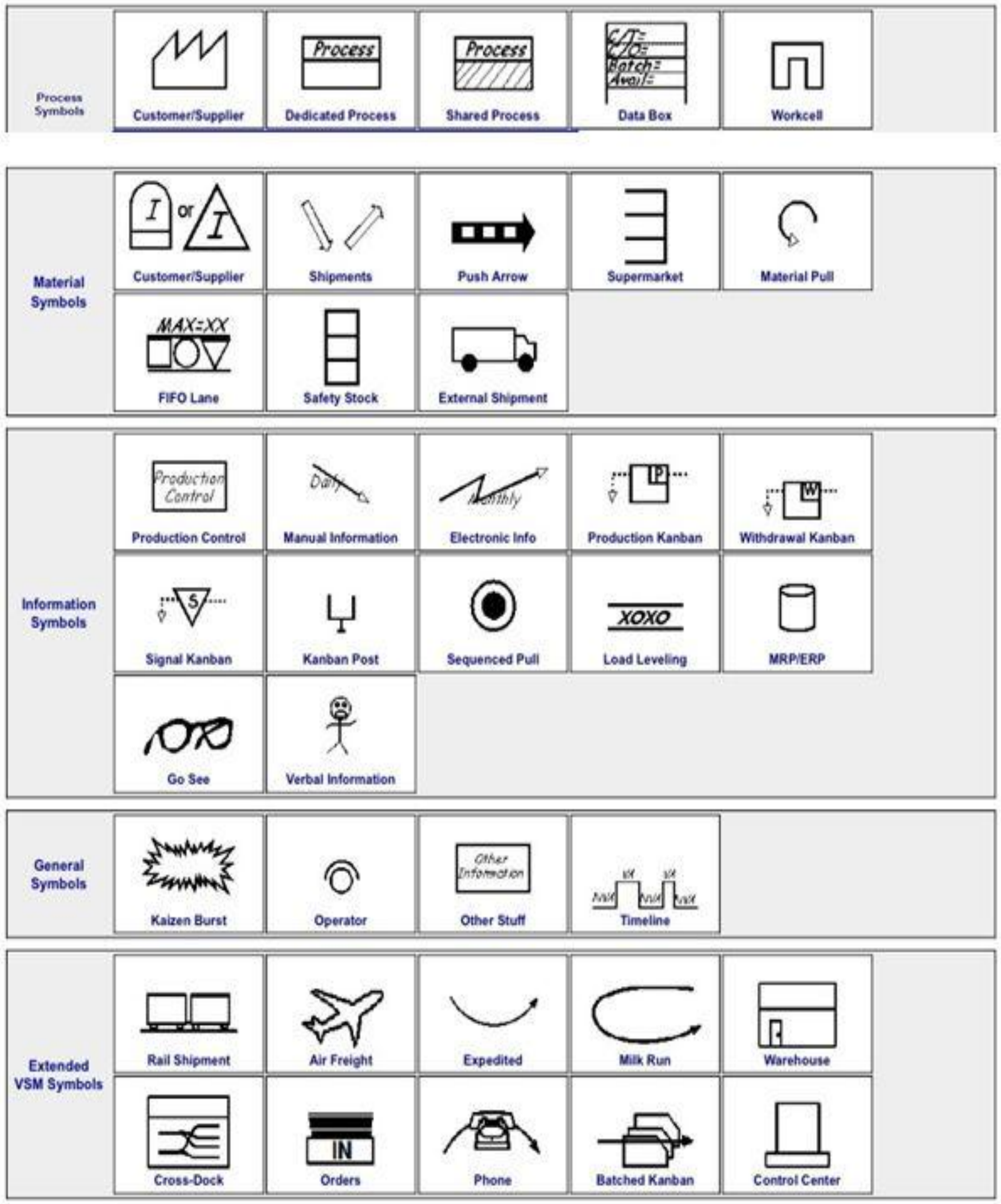



*Figure 3. Examples of Value Stream Mapping Symbols (Strategos-International, 2014)*

Current VSMs show the present state of a process, while future VSMs are created to show the state of the process after improvements have been made (Figures 4 & 5 show examples of current and future VSMs). According to Rother and Shook (1999), it is important to analyze the current condition of a production system in order to develop a future state. In order to create current VSMs, an individual or team first collects current-state information such as process time, inventory, materials, and customer requirements about a process in order to have a correct understanding of the process. The current state is then subjected to critique and suggestions made in order to identify areas that could be improved. Thereafter, the current state VSM is used as a reference point to create a future state VSM incorporated with useful suggestions from the critique of the current state VSM.

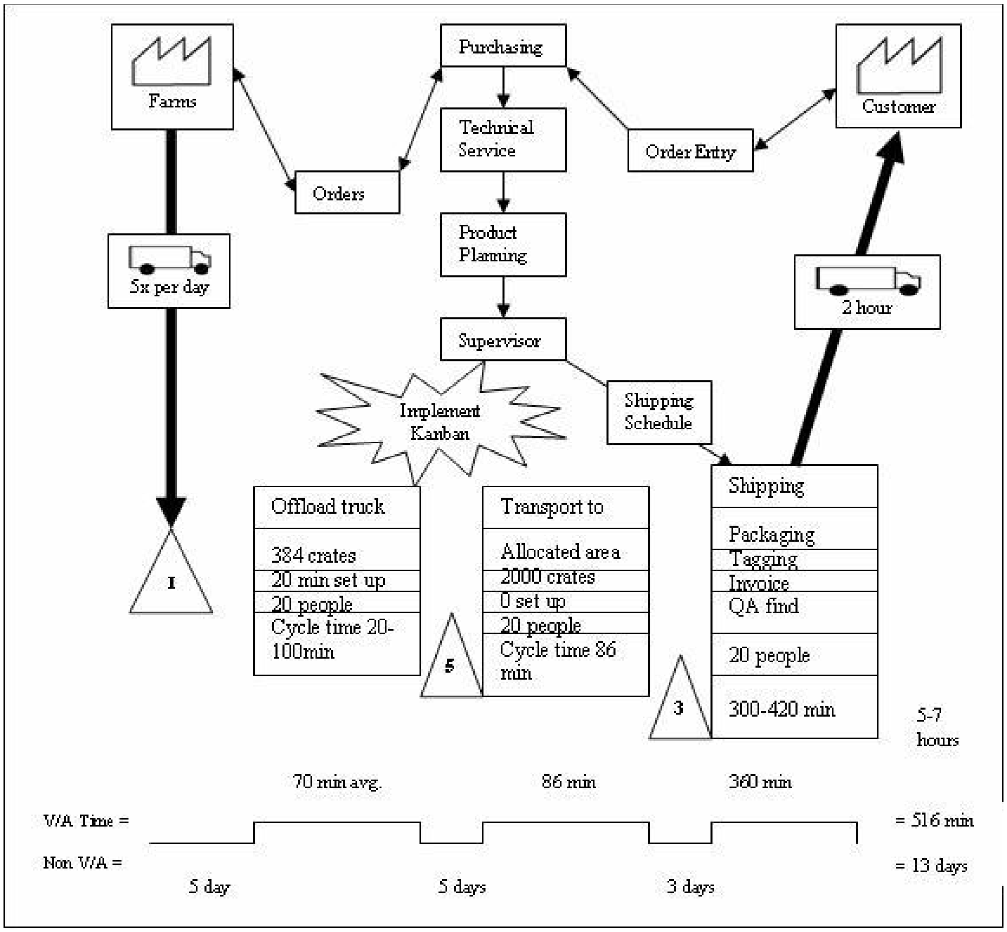



*Figure 4. Example of current VSM (Sofokleous, 2007)*

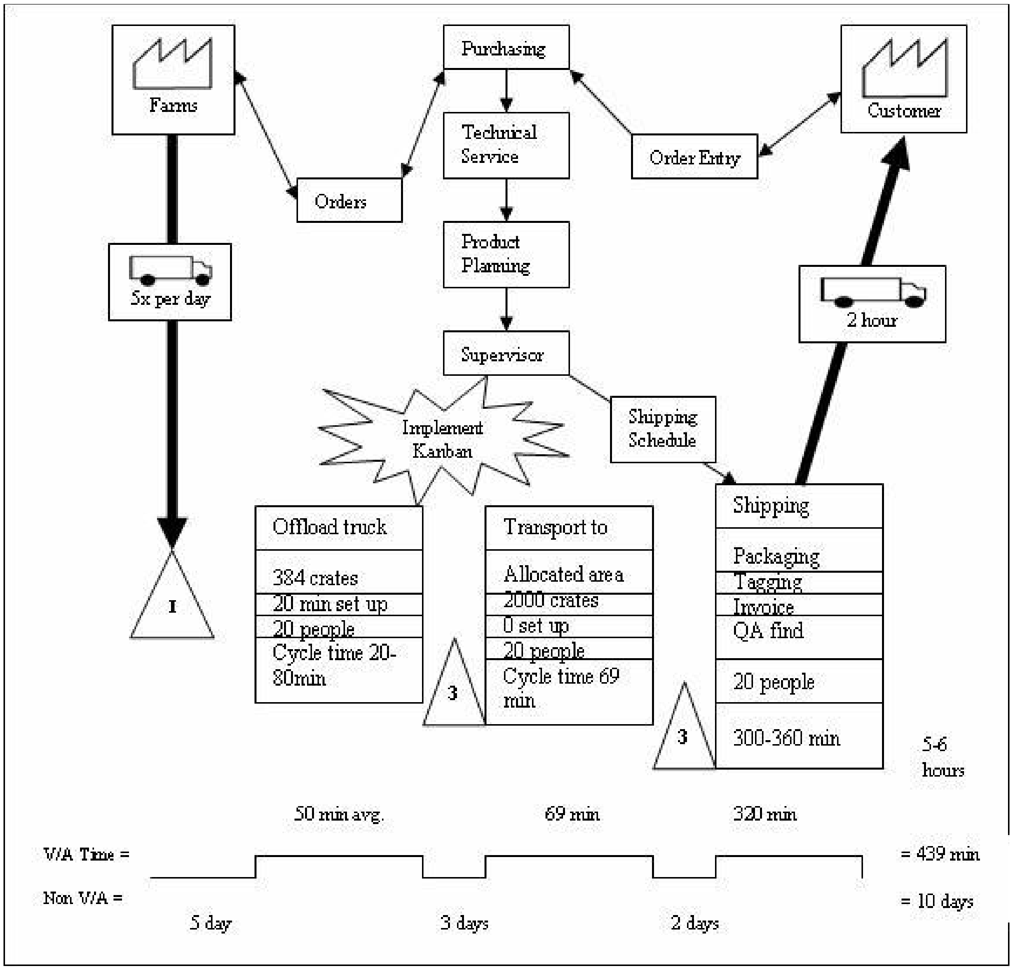



*Figure 5. Example of future VSM (Sofokleous, 2007)*

**Benefits of Value Stream Maps**

Value Stream Mapping has seen implementation in various sectors and its success cannot be overemphasized. Kocakulah and Upson (2005) used Value Stream Mapping in assessing the implementation of a Computerized Physician Order Entry System (CPOE), which involved using an information system that reduced or eliminated medication errors at a hospital's value stream. The study suggested that in spite of the CPOE system having a negative Net Present Value (NPV) because of high capital and maintenance costs, CPOE systems presented future cost savings and were likely to be very common in most hospital environments in the future.

Prabhu, Sureka, Holla, and Patel (2008) in a study to assess the Indian truck transport industry suggested that the level of disorganization in the industry required some analytical support to improve their operations. The authors set out to use Value Stream Mapping in identifying wasteful activities associated with loading/unloading, waiting, and documentation. They further suggested remedies including multiple handling of goods in trucks, effective planning of trips, and simultaneously documenting and loading/unloading could go a long way to address and improve truck transportation flow.

In a study to analyze the upholstery furniture engineering process, Wang, Quesada-Pineda, Kline, and Buehlmann (2011) presented a structured approach for streamlining the process of a furniture manufacturer in China. Data collected over a half-month period indicated that steps in the process including creating drawings, generating packaging files, checking and signing off on documents, and creating Computer Numerical Control (CNC) programs presented many deficiencies in the upholstery process. The development of a current state VSM by the researchers indicated that engineering change orders and unpredictable process cycle times posed problems in the company’s engineering process. Subsequently, the research, through the development of a future state VSM, suggested that measures such as improving work methods, standardization of the process, increased utilization of people, recognition of work layout, and the use of a 3D-driven engineering design solution would provide effective countermeasures to address the problems identified.

In a pioneering study, Emiliani and Stec (2004) used VSMs to ascertain leadership beliefs, behaviors, and competencies. According to the authors, leaders display beliefs, behaviors, and competencies that influence how people at various levels of a business carry out tasks and relate to one another. A current VSM created by the authors showed traditional and conventional leadership practices typically taught by most business schools, such as the necessity of many processing steps, acceptance of long lead-times, and over-reliance on single-skilled workers. Some of these beliefs lead to behaviors such as ignorance of queues as source of costs, ignorance of cross training of workers with similar functions, non-questioning of current processes, and a general laxity towards improvement of an overall system. Emiliani and Stec subsequently created a future state VSM that illustrated the beliefs, behaviors, and competencies of leaders skilled in progressive management thinking and practices rooted in the Toyota management system. According to the authors, these progressive leaders exhibited skills such as striving to reduce costs, responsiveness to changing customer needs, identification and elimination of waste, synchronization of material and information flow, and having a strong focus on processes. In effect, these progressive leaders constantly challenge the status quo.

**Summary of Review**

This review indicated that cocoa is very significant to the economy of Ghana in addition to the fact that it has effects on cocoa affairs worldwide. The literature also identified that production activities concerning the SPU of the COCOBOD could be fine-tuned in order to maximize results. The philosophies of Lean manufacturing help to identify and eliminate waste in an operation in a systemic manner. Various tools and techniques of Lean help to add value to processes and contribute to continuous improvement of organizations. Baitmangalkar (2009) suggested that Lean, when adopted as a culture exudes optimism, and helps in achieving significant results such as improvement in productivity and profit generation. The fundamentals of Lean aim to identify and eliminate waste, and techniques such as Value Stream Mapping enable organizations to have a holistic view at efficiency, know where they are, and map a route by which they can continually improve processes. The use of VSM as a technique of Lean is appropriate for investigating effects on cocoa production levels as evidenced in the literature review.

# Methodology

This chapter describes the research procedures adopted in carrying out the study. The chapter describes the pollination process undertaken on the seed gardens and how the researcher put together and trained the teams on the various gardens. The chapter also describes the data analysis used in the study.

## Research Approach

### Teams for seed gardens

Eighteen (18) seed gardens were used for the study because no pollination processes were being undertaken on the remaining active seed gardens during the study period. The researcher made initial visits to each of the selected gardens and held meetings with the technical officers of each garden to brief them on the nature of the study. The researcher, with the aid of the technical officers selected teams of four persons each (with one as team leader) for each of the gardens. The researcher then trained the teams concerning the processes for observation as well as the data they were to collect over the period. The training involved approximately two hours briefing on the need of the study and a general overview on the Lean principle of Value Stream Mapping and its application on processes. The training touched on capturing all aspects of their pollination process and data including the average age of trees, the number of pollinators, the average age of pollinators, and the number of flowers pollinated. After paying visits to the gardens intended for use of the study and interacting with the technical officers, the researcher decided that the study would span a period of thirty days, since that provided a realistic period over which the pollination processes could be captured on all eighteen gardens. Subsequently, the researcher decided to gather data over the thirty-day period.

**Process Flow on Seed Gardens**

The researcher observed the process flow, which involved cleaning and preparation of the trees, choice of male and female trees, as well as harvesting of the pollen. Furthermore, the researcher observed the removal of the staminate and harvesting of the stamen from the male plant, and the final identification marking. The observation helped establish a pattern for the various processes necessary for the manual pollination.

After establishing the process flow, which was fundamentally the same for all the gardens, the researcher and the teams developed a current VSM first by hand, and subsequently by computer (with the aid of QI Macros by KnowWare International Inc, 2010). After observing the process over the study period, the researcher with the aid of the technical officers and the team leaders identified value-added and non-value added processes through deliberations on aspects of the processes that were actually not too essential for the success of the pollination. This was based on the premise that any aspect of the process that could be eliminated and still achieve the desired results was considered as non-value adding. Following the identification of the value-added and non-value added aspects, a future VSM was developed after eliminating the non-value added processes to give an indication of how the process could run and still achieve the desired results. Furthermore, the future VSMs considered aspects of the process that required some fine-tuning, although they could be maintained. The future VSMs were then shared with the technical officers and the team leaders, although the officers admitted that administrative requirements would not permit them to implement fully the proposals suggested by the VSMs.

**Data Analysis**

Analysis done for the study primarily involved assessing the pollination process with the aid of the current VSM and subsequently developing the future VSM to indicate how the process could be improved. A comparative and descriptive analysis between and among seed gardens such as the effect of age of pollinators, age of trees, weather, pollination time, etc. on the success of pollination was also done as auxiliary findings for the study.

**Threats to Validity**

The inability of the researcher to be available on each seed garden for each day of the study period implied a complete reliance on the teams constituted for each garden. The technical officers and team leaders served as vital sources of information for the study. In addition, time constraints did not allow extensive observation of some of the processes.

Furthermore, weather conditions did not allow the study to be conducted on all the gardens on the same days, since some days were rained off or simply called off on some of the gardens due to weather conditions. Finally, the non-implementation of the future VSM by the units did not give an exact indication of the effect it might have had on their processes.

## Findings and Analysis

### Pollination Process on Seed Gardens

Typically, the pollination process started with the cleaning and preparation of the trees and choosing the male and female trees that were to carry the pods. The choice of these trees took into consideration sanitation as well as a good knowledge of the various trees on the farm. The cleaning involved pruning the selected trees to ensure they had enough light for flowering. Fertilizers were then applied to ensure that the trees would be able to carry many pods. Insecticide treatment was also carried out as part of the cleaning and preparation before the pollination, but it was observed that that was not always the case. The pollinators checked the trunk of the trees (usually between 50cm to 2m in height) and the main branches for cleanliness since pollination was highly successful on flowers in this area, and also because pollinators could reach and take care of such flowers easily.

After the sanitation procedure, the choice of the trees was the next task for the pollinators. Based on the prior sanitation work done on the trees, they selected the female trees that would carry the pods as well as the male trees from which the pollen grains would be obtained. A pre-identification marking was then carried out on the selected trees to make them easily visible. All these activities were done within a week prior to the actual day for pollination.

On the actual day of the pollination, the pollinators harvested pollen from the male trees in a bowl to be stored for use. The selection targeted whitish looking flowers (most suitable for pollination) and avoided the yellowish or orange looking ones. On most of the farms, it was observed that the male trees were situated quite far from the female ones and therefore pollinators had to do a lot of walking (an average of ten minutes) to harvest the male flowers to pollinate them with the female ones. They then removed stamen of the male flower to expose it for easy extraction and then carefully detached it while holding it to the staminate. They then used forceps to split the pollen sac and then made deposits on the pistil by rubbing the pistil carefully with pollen (Figure 6 shows researcher observing and timing the pollination process). The pollinators then cleaned the forceps with spirit-soaked cotton to get rid of any pollen that might be stuck on them.

*Figure 6. Researcher observing and timing the pollination process*

Finally, they used protective devices, mostly in the form of small plastic bags or improvised cover cloth to cover the flowers for about two days to prevent the pollination from destruction, usually by strong winds or rain. Afterwards, with the aid of tape, they put paper labels bearing details such as the date of the operation, name of the pollinator, or any other necessary information on the trees after pollination.

**Similarities and Differences Among Seed Gardens**

Activities on almost all the seed gardens, largely, were the same. While all the farms adopted the same procedures in their pollination processes, there were slight differences in approach on some of the gardens. For example, the presence of a lot of weeds and caterpillars on some of the gardens greatly hampered the pollination process. While weeds made it difficult for pollinators to have easy access to the trees, caterpillars on the other hand attacked the trees, fed on the flowers, and caused a slowdown of the process for at least 24 hours, according to the pollinators. Gardens that carried out cleaning and sanitation practices regularly and not only in anticipation of pollination had lesser problems on the actual pollination days as compared to gardens that only carried out sanitation practices only in anticipation of pollination.

Some gardens also suffered loss of some pollinated flowers due to non-settlement after pollination. After pollination, usually between the time of pollination and a week, there are chances of some pollen falling off due to factors such as wind, or any movement within the area of the trees that have been pollinated. When pollinators do not go back to the trees to check on the pollination, some trees suffer this non-settlement and results in pollination being unsuccessful. Very few of the farms (five of them) actually had technical officers that insisted on pollinators checking for non-settlement of pollen and fixing them in order to count such trees towards the success of the pollination.

Apart from the Bunso seed garden (in the Eastern Region), none of the gardens had the opportunity for all-year pollination. The presence of irrigation facilities implied that the Bunso garden could permit pollination during any time of the year irrespective of the existing rainfall situation. It was also observed that many of the farms had the male trees situated far from the female trees. This meant that pollinators had to walk longer distances to go and get the pollen from the male trees in order to carry out the pollination. This provided some difficulty for the pollinators in terms of the work area layout.

There were generally few or no men at all among the pollinators on the farms. On each farm visited, men constituted less than five percent of the pollinators on farms that had any men. On most others, there were no men at all. The reasons given were due to the general alcoholic behavior of the men in those areas, which prevented them to have steady hands, an important characteristic of good pollinators (Appendix C shows the records from the various seed gardens).

**Current VSM Based on the Process**

After observing the current processes on the various gardens, the current VSM as shown in Appendix A was developed. Cleaning and preparation of trees were done over three days at an average of seven hours per day. In addition, an average of six hours daily for two days were required for choosing the male and female trees required for pollination. Finally, the actual pollination process involving harvesting pollen from the male trees to identification marking for the pollinated trees required an average of two hours and five minutes.

## Conclusion

### Descriptive Analysis of Observations and Suggestions

Observations on the various farms indicated that there were a number of factors that influenced the pollination process. While some of the farms were able to deal with some of these factors, other farms continue to grapple with the effects of these factors. A proper consideration and addressing of these factors will go a long way to improve the efforts of the various seed gardens that are grappling with them. One of such factors is the issue of the weather. According to the technical officers, the weather accounts for about fifty percent of the success of the pollination. Pollination is unsuitable in extreme weather conditions such as extremely warm conditions. Pollinators therefore usually have to work from the early mornings till just before the sun gets high up, and then stop work whether the daily target has been met or not.

Another issue observed was the absence of pollinators on the farms during weekends when flowers opened up. Of the eighteen farms, only one had pollinators working on weekends and therefore were able to pollinate when flowers opened up during those days. The others mostly worked only on Mondays through Fridays and were not available to pollinate on weekends. Therefore, it is recommended that most of the gardens engage pollinators for the weekends, especially during periods of warmth and increased rainfall when flower initiation is most common.

Age was another factor that influenced pollination on the farms. Observations indicated that younger people (below 40 years) pollinated at a rate, which was almost fifty percent higher than of that of older pollinators (40 years and over). Pollinators aged below 40 years had advantages such as ability to use ladders to reach taller trees and better eyesight required for the close work. Figure 7 shows a younger pollinator using a ladder. The average age of pollinators on 10 out of the 18 gardens was found to be 40 years. Consequently, most of the pollinators in these gardens required a relatively longer period to undertake pollination.

*Figure 7. A younger pollinator using a ladder*

The issue of very few or no men at all on most of the gardens is another situation that is worth considering. Inasmuch as the reason given was plausible, the tendency for men to be denied jobs as pollinators was very common even when they were not necessarily alcoholics. Since men are naturally breadwinners, it would be prudent that at least a good number of them be given the chance to take up jobs as pollinators in order to provide a means for fending for themselves and their families. Furthermore, recruitment efforts for men could target younger men in order for the process to benefit from aforementioned advantages of having younger pollinators.

The provision of irrigation facilities in all the gardens as in the case of Bunso would ensure that the rest of the gardens are able to undertake pollination all year round and thereby increase output. Regarding the work area layout for pollinators, given that trees cannot be just uprooted and moved around, it is recommended that new male and female trees planted subsequently should be located relatively closer in order to provide an easier work area layout for pollinators.

**Future VSM**

The future VSM proposed (Appendix B) assessed aspects of the pollination process that improvements could be made. Areas included the cleaning and preparation stage, the choice of male and female flowers, and the actual pollination process involving harvesting of pollen to the identification marking. An extra two or three hours has the potential of reducing the cleaning and preparation of trees for pollination to two days instead of the original three days. This is especially so because it was observed that workers idled for a greater part of the current average of seven hours average per day for three days.

Secondly, the researcher observed that some and not all of the pollinators were involved in choosing the male and female trees, hence resulting in two days for the exercise. Involving all pollinators or a couple of extra hands for an average of eight hours has the potential of reducing the process to a single day. In addition, male and female trees on the gardens were situated at quite a distance from each other and pollinators therefore had to walk for extended periods to harvest the pollen from male trees to pollinate with the female ones. Although this cannot be done for trees already planted, future male and female trees can be sited closer together in order to reduce travel time.

Regarding the actual pollination process, improvements such as the use of ladders and engaging younger pollinators can go a long way to reduce the pollination time. Older pollinators were generally slower than younger pollinators and could not use ladders for pollination in areas where trees were higher. Younger pollinators were able to pollinate at a faster rate and pollinate more trees than the older pollinators. Older pollinators could therefore be assigned to trees that pollination would be a lot easier for them. Finally, having pre-identified labels to put on pollinated trees would reduce the identification marking process after pollination.

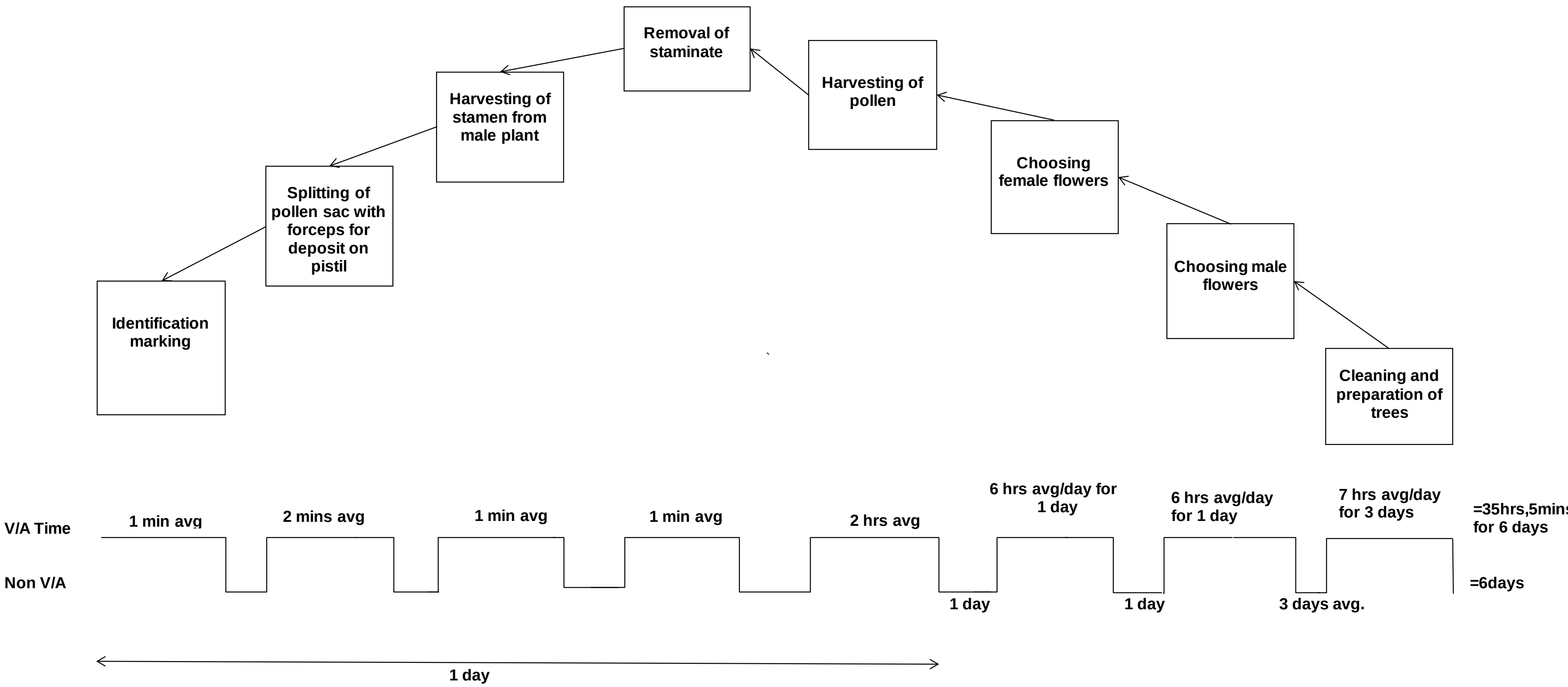
**Interpretation of Findings**

Overall, the improvements to the processes have the potential of reducing value added time from a total of thirty-five hours and five minutes over six days to twenty-eight hours, two minutes, and thirty seconds over a period of four days. Furthermore, the non-value added time could also be reduced from a period of six days to four days as indicated on the current and future state value stream maps. These improvements in the processes and reduction in time will subsequently provide opportunities for increases in output by enhancing current production levels. Tables D1 and E1 show a box score and a summary respectively of the conditions on the seed gardens before and after the improvements. The future state value stream map therefore supported $H_1$1: Implementing the Lean technique of Value Stream Mapping on the artificial pollination process will show opportunities that can result in an increase in annual cocoa production.

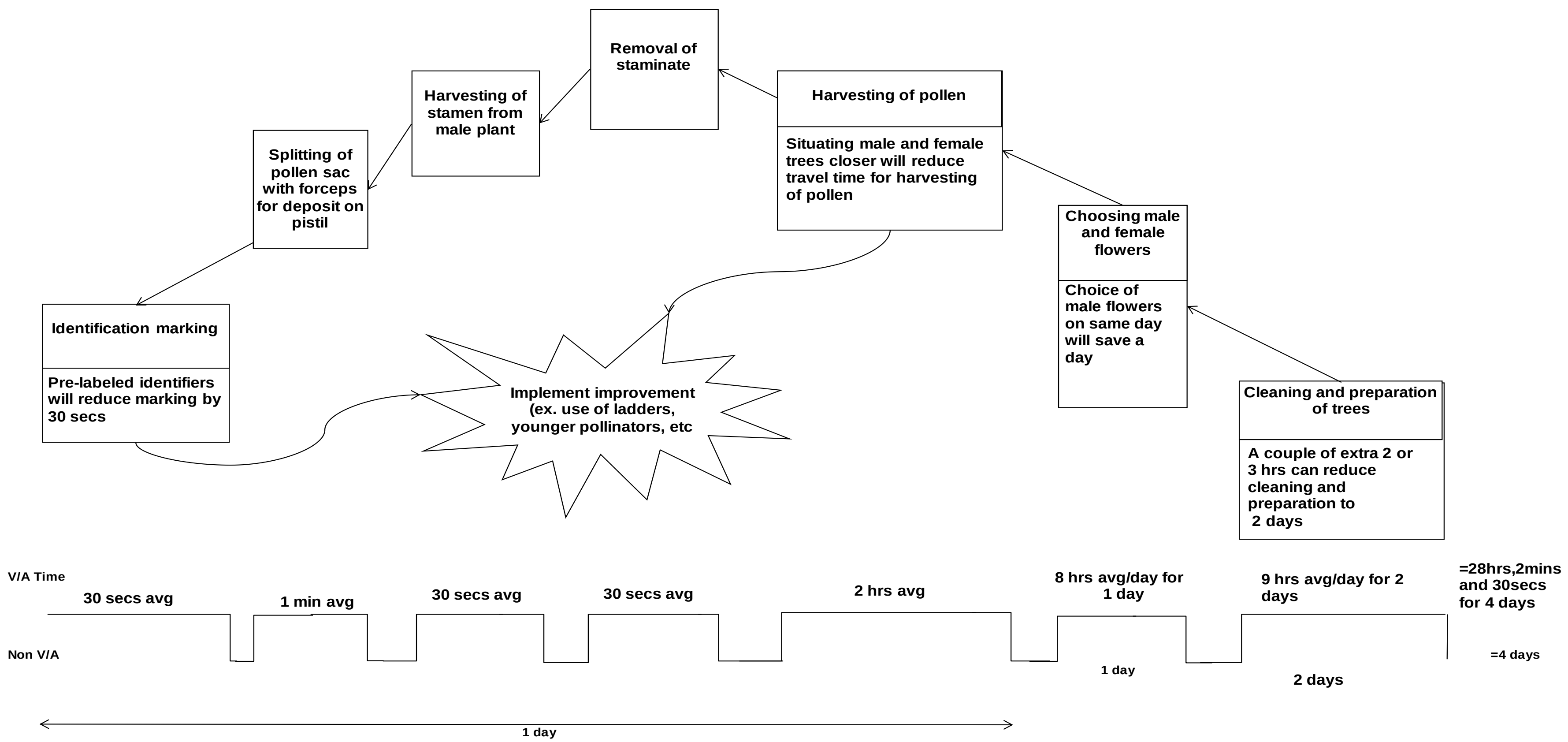
**Suggestions for Future Study**

Interactions with technical officers and workers on the various gardens suggested that the weather played a very crucial role in the pollination process and extreme conditions such as warm weather do not permit pollination. Weather conditions did not allow the study to be conducted continuosly for thirty days even on a single garden, let alone across all the gardens. Future studies can aim at continuosly observing the process over a selected period. Furthermore, future studies can aim at implementing proposed future value stream maps in order to ascertain their feasibilities or otherwise.

# Appendix A: Current State Value Stream Map



# Appendix B: Future State Value Stream Map



## Appendix C: Table showing records from various seed gardens

Table C1.

*Records from various seed gardens.*

| Unit | No. of pollinators | Avg. age of pollinators | Avg. age of trees | Pollination (30 day period) |
|---|---|---|---|---|
| Akumadan | 14 | 40 | 30 | 142,340 |
| Poano | 9 | 35 | 25 | 247,135 |
| Jamasi | 12 | 45 | 18 | 307,236 |
| Fumso | 18 | 40 | 15 | 526,509 |
| Juaso | 11 | 35 | 20 | 342,000 |
| Sankore | 15 | 35 | 15 | 592,450 |
| Bunso | 13 | 30 | 15 | 760,447 |
| Bechem | 10 | 40 | 20 | 546,000 |
| Breman Asikuma | 31 | 45 | 25 | 324,047 |
| Assin Fosu | 28 | 40 | 20 | 253,442 |
| Pankese | 11 | 30 | 24 | 643,727 |
| Apedwa | 14 | 45 | 25 | 234,706 |
| Asamankese | 9 | 50 | 25 | 252,585 |
| Bieni | 10 | 45 | 28 | 392,584 |
| Akwadum | 9 | 50 | 15 | 132,136 |
| Ampeyo | 8 | 35 | 15 | 229,627 |
| Boako | 18 | 35 | 20 | 517,384 |
| Saamang | 11 | 30 | 15 | 676,920 |

**Appendix D: Box score showing measures before and after improvement of pollination process**

Table D1.

*Box score showing measures before and after improvement of pollination process.*

| Metric | Performance (Current State) | Target (Future State) | Target (% Reduction) |
|---|---|---|---|
| Cleaning and preparation of trees | 7 hrs avg/day for 3 days | 9 hrs avg/day for 2 days | 14.29 |
| Choosing male and female flowers | 6 hrs avg/day for 2 days | 8 hrs avg/day for 1 day | 33.33 |
| Harvesting of pollen | 2 hrs avg | 2 hrs avg | 0 |
| Removal of staminate | 1 min avg | 30 secs avg | 50 |
| Harvesting of stamen from male plant | 1 min avg | 30 secs avg | 50 |
| Splitting of pollen sac with forceps for deposit on pistil | 2 mins avg | 1 min avg | 50 |
| Identification marking | 1 min avg | 30 secs avg | 50 |
| | **Projected Performance After Lean Improvements** | | |
| | **Value Added Time** | **Current** | **Future** |
| | Hours | 35 hrs, 5 mins | 28 hrs, 2 mins, and 30 secs |
| | Days | 6 days | 4 days |

## Appendix E: Table showing summary of conditions on seed gardens

Table E1.

*Summary of conditions before and after improvement measures.*

| **Condition Before** | **Condition After** | **Expected Outcome** |
|---|---|---|
| Cleaning and sanitation practices on gardens only in anticipation of pollination | Regular cleaning and sanitation practices on gardens | Avoidance of problems such as weeds, caterpillar attacks, and a general slowdown of pollination process |
| Higher population of older pollinators | Higher population of younger pollinators | Younger pollinators have advantages of better eyesight and agility that will generally enhance pollination |
| Few or no men on most gardens | A good number of men on most gardens | Provision of jobs for men, and especially for younger men to address issues relating to older pollinators |
| Non-availability of irrigation facilities on gardens | Availability of irrigation facilities | Ability to engage in pollination all year round |
| Non-availability of pollinators on weekends | Availabilityof pollinators on weekends | Abilityto engage in pollination when flowers open up during the weekends |

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