Defective Coffee Beans Reduction: A Case Study of Small-scale Coffee Beans Production in Shan State, Myanmar

Ah Soet*

Received: *October 27, 2023* *Revised: March 14, 2024* *Accepted: March 25, 2024*

Abstract

This case study focuses on how Lean Six Sigma methodology can be applied to enhance performance and support the creation of business improvement activities. The main objectives of this case study on coffee production are to identify the underlying reasons for the high defect rates of coffee green beans and to find out the most efficient ways to address the issue, make it better and more durable, and implement the solution within the company. The processes were carried out by applying Lean Six Sigma, such as DMAIC, to expedite the procedure and systematic thinking. A detailed analysis method, including Measurement System Analysis (MSA), SIPOC, Process Map, Pareto Chart, and Fishbone Diagram, identifies potential causes and offers possible corrective measures. One of the main issues faced by Jadae Akha Coffee is the high rate of defects in coffee beans caused by poor farming techniques, a lack of equipment (a Refractometer, a tool for checking Brix or sugar content, to examine the coffee cherries' level of sugar content at 18 degrees or ripeness before beginning the harvesting process), inexperienced workers, and insufficient handling experience of hulling machines, which has a substantial negative

* Supply Chain Management, Assumption University
88 Moo 8 Bang Na-Trad Km. 26, Bang Sao Thong, Samut Prakan 10570 THAILAND
E-mail: tharahsoet@gmail.com

impact on the quality of sustainable production as well as marketability. Through the development of DMAIC standardized handling procedures and the provision of the necessary training to farmers and employees, the defect rate decreased from 25.09% to 9.83%. This not only reduced costs but also addressed the company's high defect rate of coffee beans. However, the company must maintain progress even though the percentage is declining to avoid a repeat of the problem, and the researcher also offered recommendations for developing a long-term strategy for the operational enhancement of the firm as well as a roadmap for improvement.

Keywords: Coffee Beans, Defective, Arabica, Immature Beans, Parchment, and Broken at Dry Mill

การลดข้อบกพร่องของเมล็ดกาแฟสาร: กรณีศึกษาการผลิตเมล็ดกาแฟสารขนาดเล็กในรัฐฉาน ประเทศเมียนมาร์

อาโซ่ต์*

รับวันที่ 27 ตุลาคม 2566 *ส่งแก้วันที่ 14 มีนาคม 2567* *ตอบรับตีพิมพ์วันที่ 25 มีนาคม 2567*

บทคัดย่อ

กรณีศึกษานี้มุ่งเน้นไปที่วิธีการประยุกต์วิธีการแบบ Lean Six Sigma เพื่อเพิ่มประสิทธิภาพและสนับสนุนการสร้างกิจกรรมการปรับปรุงภายในธุรกิจ วัตถุประสงค์หลักของ กรณีศึกษาเกี่ยวกับการผลิตกาแฟนี้คือเพื่อระบุสาเหตุเบื้องหลังที่ทำให้เมล็ดกาแฟสารมีอัตราข้อบกพร่องสูง และค้นหาวิธีที่มีประสิทธิภาพที่สุดในการแก้ไขปัญหา ทำให้ดีขึ้นและคงทนมากขึ้น และดำเนินการแก้ไขปัญหาภายใน บริษัท กระบวนการดำเนินการโดยใช้เทคโนโลยีแบบ Lean เช่น DMAIC เพื่อเร่งกระบวนการและการคิดอย่างเป็นระบบ วิธีการวิเคราะห์โดยละเอียด รวมถึงการวิเคราะห์ระบบการวัด (MSA) SIPOC แผนที่กระบวนการ, แผนภูมิพาเรโต และแผนภาพก้างปลา ใช้เพื่อระบุสาเหตุที่เป็นไปได้และเสนอมาตรการแก้ไขที่เป็นไปได้ หนึ่งในปัญหาหลักที่กาแฟจแดอาข่าต้องเผชิญคืออัตราข้อบกพร่องในเมล็ดกาแฟสารที่สูงซึ่งเกิดจากเทคนิคการทำฟาร์มที่ไม่ดี ขาดอุปกรณ์ (Refractometer เครื่องมือสำหรับตรวจสอบปริมาณบริกซ์หรือน้ำตาลเพื่อตรวจสอบระดับน้ำตาลของผลเชอร์รี่กาแฟ อุณหภูมิ 18 องศาหรือความสุกก่อนเริ่มกระบวนการเก็บเกี่ยว) คนงานไม่มีประสบการณ์ และประสบการณ์ในการจัดการกับเครื่องกะเทาะไม่เพียงพอ ซึ่งส่งผลกระทบเชิงลบอย่างมากต่อคุณภาพของ การผลิตที่ยั่งยืนและความสามารถทางการตลาด ด้วยการพัฒนาขั้นตอนการจัดการที่เป็นมาตรฐานของ DMAIC และ การฝึกอบรมที่จำเป็นแก่เกษตรกรและพนักงาน อัตราของเสียลดลงจาก 25.09% เป็น 9.83% สิ่งนี้ไม่เพียงแต่ลดต้นทุนเท่านั้นแต่ยังจัดการกับอัตราเมล็ดกาแฟที่มีข้อบกพร่องที่ในระดับสูงของ อย่างไรก็ตาม บริษัทจะต้องรักษาความก้าวหน้าแม้ว่าร้อยละจะลดลงเพื่อหลีกเลี่ยงไม่ให้เกิดปัญหาซ้ำอีก และผู้วิจัยยังได้เสนอข้อเสนอแนะในการพัฒนากลยุทธ์ระยะยาวในการเพิ่มประสิทธิภาพการดำเนินงานของบริษัทตลอดจนแผนงานในการปรับปรุง

คำสำคัญ: เมล็ดกาแฟ เมล็ดข้อบกพร่อง อราบิก้า เมล็ดอ่อน เมล็ดกะลากาแฟและเมล็ดแตกที่โรงสีแห้ง

* การจัดการโซ่อุปทาน มหาวิทยาลัยอัสสัมชัญ
88 หมู่ 8 ถนน บางนา-ตราด กม.26 บางเสาธง สมุทรปราการ 10540
อีเมล: tharahsoet@gmail.com

Introduction

The importance of the world coffee industry is rapidly surpassing that of other agricultural sectors (García, Candelo-Becerra, & Hoyos, 2019). It is also one of Myanmar's most cherished and in-demand goods (Won & Nuangjamnong, 2021). Jadae Akha Coffee is a coffee company founded in 1994, registered in 2020, and run by Mae Nuum Co., Ltd. in Keng Tung, Eastern Shan State, Myanmar. It produces Arabica coffee, tea, and plum-based beverages, with its core business being exporting, roasting, and distributing Arabica coffee green beans. The company serves both B2B and B2C customers.

The COVID-19 lockdown and Russia-Ukraine war have disrupted the global supply chain, causing inflation to rise and leading to high costs of items (Allam, Bibri, & A. Sharpe, 2022), including Arabica specialty coffee beans. The COVID-19 pandemic has triggered a series of socio-economic disruptions, including labor shortages, increased transportation costs, and an escalation in raw material pricing, that threaten to create another severe production crisis in the coffee industry (Rhiney, et al., 2021). Lockdowns and travel restrictions limited access to workers, a crucial part of the coffee-harvesting workforce. This resulted in higher labor costs to attract and retain available workers. Restrictions on movement and border closures led to a rise in shipping charges and transportation fees for coffee beans. The combined effect of labor shortages and higher transportation costs pushed up the price of raw coffee beans.

Russia is the biggest fertilizer producer in the world, and its sluggish shipments have forced farmers around the globe to deal with fertilizer scarcity and price increases to ensure a sufficient harvest and a sustainable yield (Farradas, 2023). This has affected the global supply chain for coffee (Pitigala, 2022), and Jadae Akha Coffee suffered financial losses because it had to pay more for the necessary fertilizer. Due to scarcity, prices have increased significantly, and the fact that our country depends heavily on fertilizers imported from abroad makes matters worse.

This study targeted reducing the high defect rate in coffee green beans by employing Six Sigma's DMAIC methodology. DMAIC, which stands for Define, Measure, Analyze, Improve, and Control (Dadan & Sukmana, 2018), provides a structured framework with five key phases that guide management tools and activities to achieve certain outcomes (Smutkupt & Naratornsawatdikul, 2019). Lastly, to create a monitoring DMAIC system to prevent future occurrences of defective coffee beans.

Jadae Akha Coffee's annual production of 3,300 kg of defective coffee beans not only reduces the total amount they can sell but also negatively affects the overall quality of their marketable product. Despite efforts to lower the high defect rate of coffee beans, there is still a 900-990 kg defect rate in the output each year, or 25-30% of the total output. The primary research question is, **"How can Jadae Akha Coffee raise the quality of its product and the way coffee green beans are produced to reduce and eventually eliminate the high defect rate?"**. Therefore, it is necessary to address the problem of the high defect rate of coffee beans in Jadae Akha Coffee manufacturing.

Literature Review

Six Sigma

The business idea known as Six Sigma was initially created by a Motorola engineering team in 1979 and consists of several instruments for lowering process variation (K. Hassan, 2013). Six Sigma is a methodical, scientific, statistical, and smarter technique that improves management and operational quality by utilizing data to increase the effectiveness of operations (Jongkautrakul, 2004) in both production and business environments at organizations of all sizes (Holtz & Campbell, 2003).

According to the study by Smutkupt (2022), by implementing Six Sigma, businesses can significantly enhance the quality of their processes. This not only elevates the final product or service, leading to increased customer satisfaction but also streamlines operations for greater efficiency and potential revenue growth (Jamil, et al., 2020).

In this study, the DMAIC technique will be utilized to identify the underlying factors contributing to the manufacturing of coffee green beans with a high defect rate. Theories, various tools, methodologies, and approaches are chosen for this study and are presented.

DMAIC (Define, Measure, Analyze, Improve, Control)

Mousli, Sayed, Zaki, and Abdelmonem (2023) stated in their research that one of the most important tools in Six Sigma is the DMAIC method, (Mandal, 2012) which stands for Define-Measure-Analyze-Improve-Control. The DMAIC five-step process can help organizations improve productivity, and profitability (Karout & Awasthi, 2017) while ensuring that the appropriate process execution strategy is applied (Jirasukprasert, Garza-Reyes, Kumar, & Lim, 2014). The specific benefits of using the DMAIC method include reduced waste and maximized value, reduced cycle times, improved logistics, increased sales forecasting ability, increased capacity, enhanced productivity rates, the elimination of defects, and improved reliability of both products and services (Limsirivallop, Roach, & Srisarkun, 2016).

In the following sections, five phases of DMAIC (Define, Measure, Analyze, Improve, and Control) are going to be discussed.

Define Phase

The Define Phase is the first and most crucial phase, where the project scope is developed by gathering historical data (Sawangjan, 2014), because this methodology is utilized when current processes or products do not meet standards (Tilokavichai, 2003). Therefore, it is where the team defines the problem that they are trying to solve as well as the customer and business needs (Kumar, Satsangi, & Prajapati, 2013) with a clear specification, magnitude, and time frame (Desai & Shaikh, 2018).

Measure Phase

The Measure Phase is important because it allows the team to establish baseline performance metrics and identify the problem's primary causes by obtaining precise data. This information will be used in the analysis phase to develop and implement solutions (Sanitrat, 2018). Furthermore, as reported in the previous research by Lertanantasuk (2013), multiple measures might be necessary to assess a particular area of performance because no single measure can provide a complete picture of the process.

Analyze Phase

In the Analyze Phase, the team uses the data that was collected from the Measure Phase to identify the root cause of the problem using tools and techniques like Pareto Analysis, Fishbone Diagrams, Control Charts, and Statistical Analysis (Sampat, 2012). By using data analysis, the team can identify the source of issues including delay, flaws, substandard, and waste (Chatrattanawuth, 2014) by deciding on a few root cause and effect connections that can be made to the input and output processes (Supalearkrattana, 2013).

Additionally, this phase provided ideas for framework enhancement measures that may be used in the following phase (Kumar, Singh, & Bhamu, 2021).

Improve Phase

This phase's major objective is to offer a better way to handle the issue for everyday operations. The focus of the improvement phase is on fixing problems while identifying benefits that give a competitive edge (Onlamai, 2018) by reducing the defects found and raising quality through continual improvement (Abualsauod, 2023).

These solutions can take many different shapes, but they typically entail technology, adjustments to current strategies and techniques, and a strict deployment schedule (Wartati, et al., 2021). The team should use caution throughout this phase to prevent errors that could introduce new weaknesses rather than fix existing ones and use a variety of methods to make improvements, from group brainstorming to generating ideas for solutions (Smętkowska & Mrugalska, 2018), mind mapping to visualize the problems and potential solutions by using sophisticated computer simulations (Southard, Chandra, & Kumar, 2012).

Control Phase

The Control Phase is the last phase of the DMAIC process, focused on sustaining the improvements made in previous phases. This involves monitoring the process and institutionalizing the new processes and procedures as standard practice (Garza-Reyes, Flint, Kumar, Antony, & Soriano-Meier, 2014). Amatyakul (2018) also stated in previous research that the Control Phase is not the end of the improvement process. It is simply the beginning of a new phase of continuous improvement. If the process starts to drift back to its old, non-optimized state, the team will need to repeat steps 1-5 of the DMAIC process. This will involve identifying the root cause of the problem, developing and implementing a solution, and then monitoring the process to make sure that the improvements are sustained (Amornbadee, 2011).

The 3M Company had a significant number of product defects that resulted in customer complaints for seven years. When tackling problems, 3M used the DMAIC approach to identify the root cause using the Cause-and-Effect diagram and Pareto analysis. After identifying the root cause, DMAIC was applied to recommend corrective actions. As a result, 3M saw a 90% decrease in customer complaints as well as a 54% increase in income (Rungrueng, 2015).

The quality tools Measurement System Analysis (MSA), SIPOC, Process Mapping, Cause-and-Effect Diagram (Fishbone), and Pareto Chart will be covered in the sections that follow.

Measurement System Analysis (MSA)

Measurement System Analysis (MSA) is a set of procedures used to test a numerical examination of the statistical method (Simion, 2019) for assessing the effectiveness of determining the system's overall accuracy, precision, and sources of variance by quantifying in the measuring framework (Arani & Erdil, 2017). This is done to find out the degree of fluctuation within the estimation information under steady conditions (Hoffa & Laux, 2007). Bias, reproducibility, dependability, and stability are the four criteria that MSA uses to characterize data quality and error (Chettanacharoenchai, 2004).

Supplier-Input-Process-Output-Customer (SIPOC)

SIPOC stands for Suppliers, Inputs, Processes, Outputs, and Customers (Marques & Requeijo, 2009). It is a tool used to understand and improve business processes (Souza, Pinto, Antunes, & Grutzmann, 2023). By mapping out these five elements, the user can get a high-level view of how a process works and identify areas for improvement. The SIPOC analysis can also be used as a simple, effective standalone tool to improve processes such as reducing waste, improving efficiency, and increasing customer satisfaction (Rehman, Asif, Saeed, Akbar, & Awan, 2012). Mishra and Sharma (2014) also stated in their research that the SIPOC diagram is used to group the interactions between different entities and each process, conveniently segmenting the scope.

Process Mapping

Process mapping is a process of identifying, documenting, evaluating, and developing an improved process (Anjard, 1998) by defining the tasks, decisions, and actions needed at particular points in a typical workflow. It also keeps track of how information, resources, and documents move through the process (Barbrow & Hartline, 2015). Process Mapping is also one of the tools most popular and frequently used in business process improvement (Bowles & Gardiner, 2018) by looking for waste, inefficiency, and duplication effort (Soliman, 1998). Additionally, Salas and Huxley (2014) asserted in their research that Process Map offers a new channel for organizations to communicate without relying on any particular methodology for developing a strategy.

Cause-and-Effect Diagram (Fishbone Diagram)

According to earlier research by Yi, Feng, Prakash, and Ping (2012), Cause-and-Effect analysis is a systematic approach to identifying the root cause of a problem. It is also known as Fishbone Diagram or Ishikawa Diagram and the main causes of the problem are then listed on the bones of the fish. These main causes can then be broken down into smaller causes, and so on. The categories of causes in the Cause-and-Effect diagram are typically based on the 5Ms and 1P, which are mother nature, machine, method, material, measurement, and people.

Pareto Chart

The Pareto principle, also known as the 80/20 rule, was first observed by Vilfredo Pareto, an Italian economist, in the late 19th century (Plaitho, 1999). Pareto noticed that 80% of the land in Italy was owned by 20% of the population. Numerous areas, including marketing and sales, customer service, quality assurance, manufacturing, business, economics, and engineering, have used the Pareto principle (Aummontha, 2017). Araman and Saleh (2023) specified that Pareto charts are easy to understand and use, even for people who are not familiar with statistical analysis and can track progress over time. This can help to see if the corrective actions that have been taken are having the desired effect.

Analysis and Finding

This analysis covers theories, tools, methodology, and techniques that were used to address and resolve the problems Jadae Akha Coffee was having. The first technique is known as DMAIC. The DMAIC process is described in Table 1, which also provides an overview of it. It includes several useful tools for continuous improvement.

Table 1: DMAIC Process

Phase	Methodology	Tool
Define	Step 1: Identify the problem Step 2: Create the Project Charter	High-Level Process Flow, Pareto Chart, Project Charter
Measure	Step 3: Collect data	Process Map, Measurement System Analysis (MSA)
Analyze	Step 4: Apply graphical analysis	Fishbone, Pareto Histogram
Improve	Step 5: Brainstorm to develop a new proce dure and put it into practice in accordance with the plan	Brainstorming a new procedure
Control	Step 6: Monitor and ensure the continuation of the improvements	KPI, Gemba Kaizen

Define Phase

The defining step begins the process for the DMAIC approach. The study focused solely on the 2022-2023 seasons, which ran from January 2023 to June 2023, to reduce the high defect rate of coffee green beans. Data from the production and quality control departments was gathered by the researcher to determine the coffee green bean defect that occurred during the 2020-2021, 2021-2022, and 2022-2023 seasons. The company's target is to reduce the defect rate from 463.18 kg, or 25.09% of the total cost of 13,895,400 MMK, to 10%, which will save approximately 8,357,160 MMK.

Table 2 shows each season's total production of green beans, total defects, percentage of defects, price per kilogram, and total defect cost in Myanmar currency, Kyats (MMK).

Table 2: Coffee Green Bean Defect Cost in 2020-2021, 2021-2022, and 2022-2023

No	Description	Total Production in Kg	Defect in Kg	Defect in Percentage	Price P/Kg	Total Cost in MMK	Remark
1	Coffee Green Beans 2020-2021 Season	3198	896.00	28.00%	20,000.00	26,880,000.00	MMK (Myanmar Currency)
2	Coffee Green Beans 2021-2022 Season	3299.8	989.94	30.00%	30,000.00	29,698,200.00	
3	Coffee Green Beans 2022-2023 Season	1846.08	463.18	25.09%	30,000.00	13,895,400.00	Decreased in Production

Figure 1 displays defect types and Figure 2, the Pareto Chart illustrates the necessity for action to lower the high defect rate of coffee green beans, such as the most common top three defects are Immature Bean, Parchment, and Broken at Dry Mill respectively.

Immature Bean　Parchment　Broken at Dry Mill

Figure 1: Immature Bean, Parchment, and Broken at Dry Mill

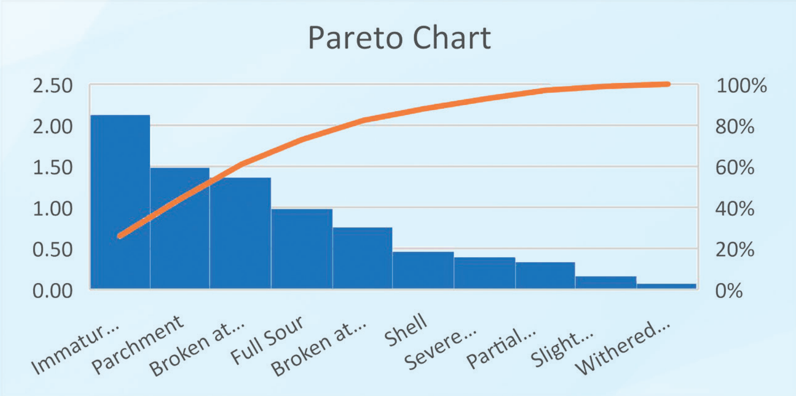

Figure 2: Pareto Chart of Coffee Bean Defects

Table 3 Project Charter displays the project name, scope, objective, milestone, and team members of the project for this research summary. It is designed to ensure that the entire team is on the same page regarding the project's objectives and requirements.

Table 3: Project Charter

Project Name	DMAIC Model for the coffee green beans production
Business Case	Reducing high defect rate of coffee green beans
Problem Statement	Both the quality of sustained production and the coffee beans that can be sold on the market are impacted by high defect rates. Approximately, 3,300 kg per year of coffee beans produced by Jadae Akha Coffee have a notably high defect rate. Despite efforts to lower the high defect rate of coffee beans, there is still 900–990 Kg of defect rate in the output each year, or 25–30% of the total output. Therefore, it is necessary to address the problem of the high defect rate of coffee beans in Jadae Akha Coffee manufacturing.
Goal Statement	Bringing down the high defect rate of coffee green beans to no more than 10% of total production per season.
Benefits to Internal and External Customer	1) The company's revenue and profit will increase. 2) Customers will receive high-quality products.
Project Scope	The project was concentrated on the production of coffee and the quality control before customer delivery.

Table 3: Project Charter (continue)

Project Milestone	Define: 1st week of January Measure: 2nd week of January
	Analyze: 3rd week of January Improve: February to June Control: February to June
Team Members	1) Production Department 2) Quality Control Department

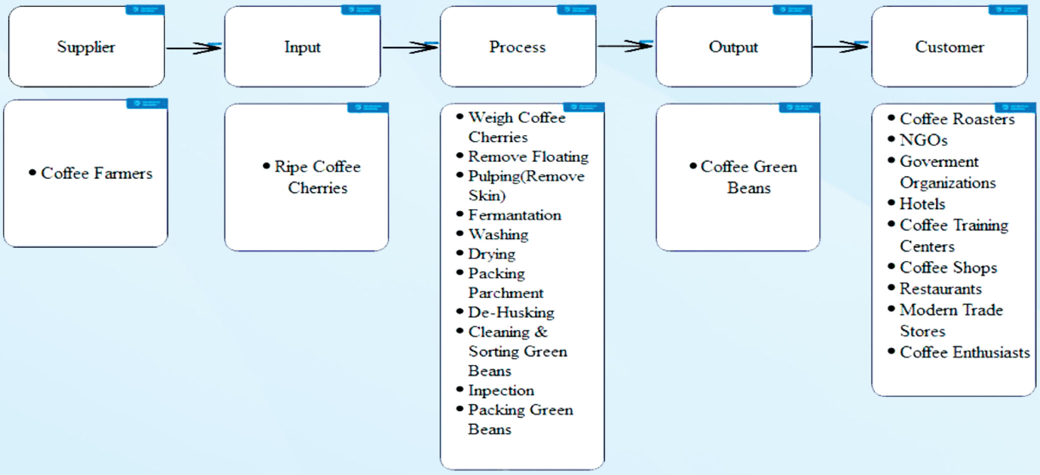

Figure 3: SIPOC shows the Jadae Akha Coffee (JAC) coffee green bean production processes.

Measure Phase

The Measure phase of Six Sigma collects data to measure the current process state and identify areas for improvement. Data comes from the quality control department, which inspects finished products and verifies them with production.

Figure 4, the As-Is Process Map, shows a detailed overview of the coffee green bean production process at Jadae Akha Coffee Company. After they are gathered, coffee cherries must be processed within 24 hours of being picked. The production team sorts the cherries and removes any floating cherries. The QC team then performs a quality check to determine the processing method. After that, the pulping machine is used to remove the skin from the coffee cherries.

Following fermentation and washing, the parchment beans are dried for 7-10 days to a moisture content of 10-12%. Subsequently, the QC team performs another quality check to ensure the accuracy of the process. Upon completion of the quality check, use the hulling machine to remove the parchment skin, and the green beans are hand-sorted. Once again, the QC team inspects the quality of the green beans from the hulling machine. The hulling machine is recalibrated if the quality is not up to the required standard. Finally, the green beans are packed in two layers of bags and undergo a final quality inspection to ensure they are defect-free before being stored and delivered to customers.

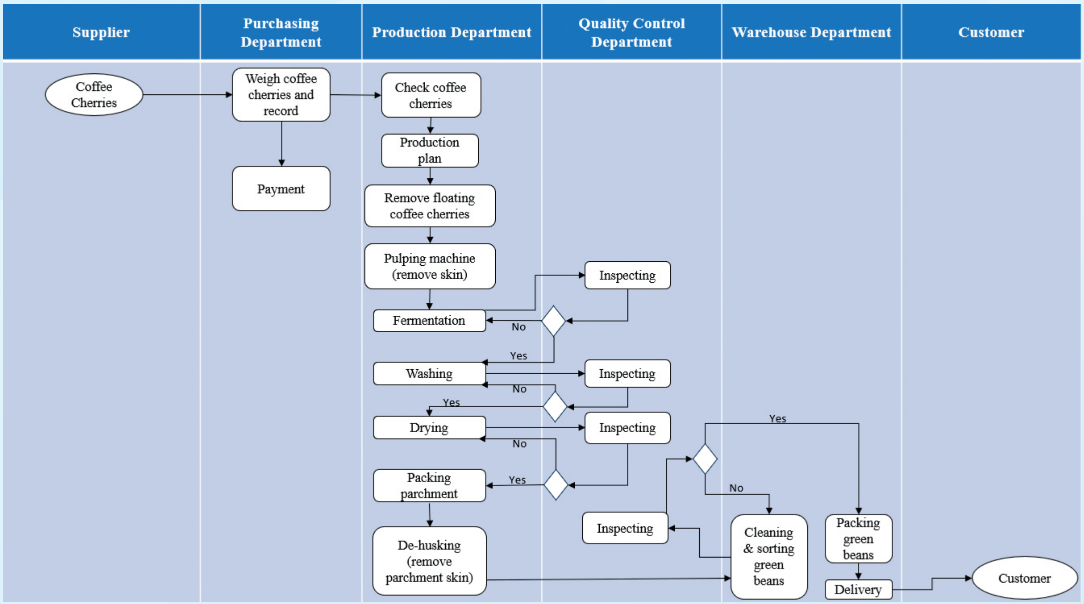

Figure 4: As-Is Process Flow

After As-Is Process Flow, the team applied Measurement System Analysis (MSA), a statistical method for assessing the data's correctness, to obtain accurate data.

First of all, the project team will create operational definitions. Such as,

1. What information and details are needed, and why?
2. How is the data collection form used?

3. What is a defect, and what is not?
4. How can exceptional circumstances that could bias the data be explained?

After developing operational definitions, the project team used a Standard Classification Method data collection form to gather 10 samples of each of the 10 different kinds of coffee green bean defects. The data collectors verified the form, and the QC team members inspected the samples before calculating the average number of defects per sample. In exceptional circumstances, large amounts of coffee samples were used. At each stage of the collection and inspection processes, samples of defects were taken using the Standard Classification Method, and documentation was made for future review as needed.

Figure 5 Pareto Chart depicts the percentages of various coffee green bean defects for the 2022–2023 production season.

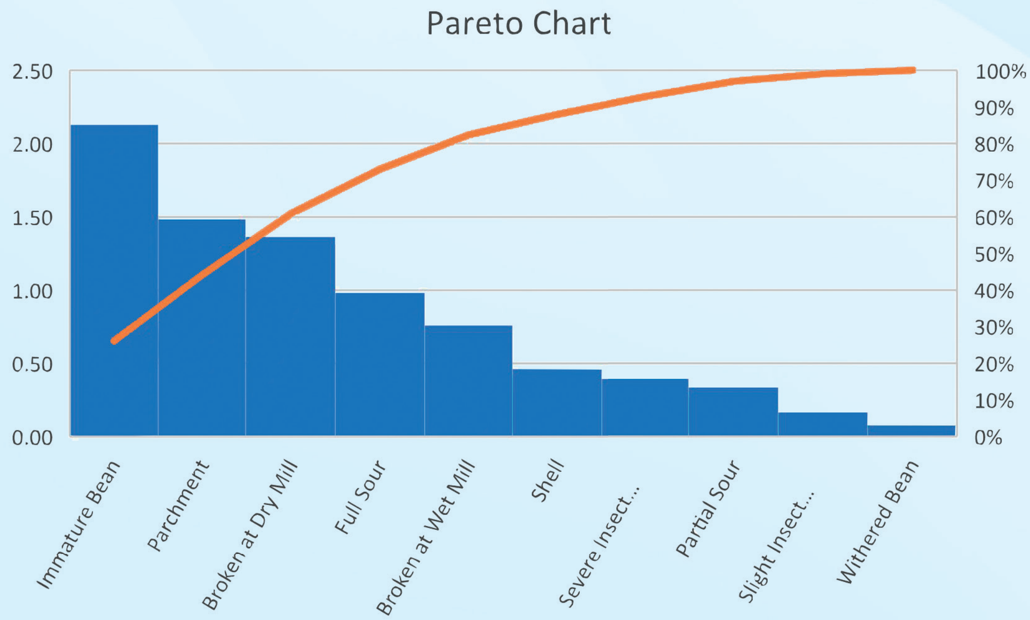

Figure 5: Pareto Chart Different Types of Coffee Green Bean Defects in % 2022-2023

Analyze Phase

The analysis phase aims to identify the root cause of the high defect rate of coffee green beans in the production process. The researcher used graphical tools like a Fishbone Diagram to analyze the root causes.

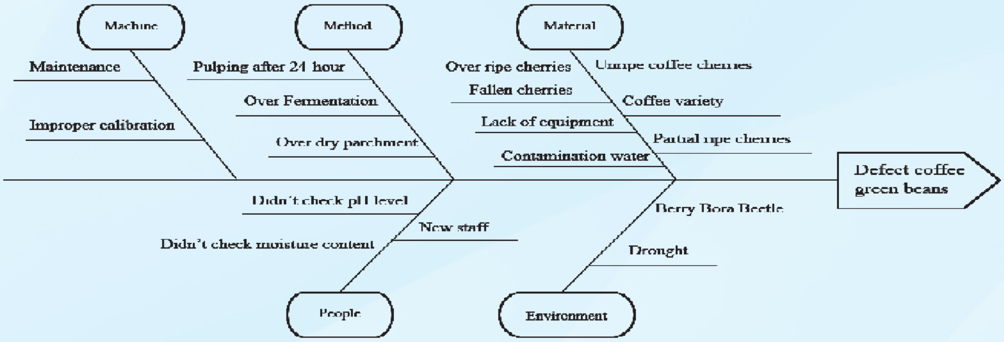

Figure 6: Fishbone Diagram

Figure 6 Fishbone Diagram illustrates the specific reasons for the high defect rate of coffee green beans and identifies potential causes to develop corrective actions to improve the quality of coffee green beans. Farmers must use a Refractometer to check the sugar content of coffee cherries before harvesting. This ensures that the cherries are ripe enough to be picked. Immature Beans are primarily caused by failing to monitor the sugar content, late-ripening types grown at high elevations, and inadequate fertilizer application due to a lack of necessary skills and equipment. Mixing ripe and unripe cherries also resulted in Immature Beans since the workers hurried the harvest because their pay depended on how many kilograms of coffee cherries they had picked.

Moreover, workers do not sieve the Parchment to separate medium and small-sized from very large and large-sized before putting them into the hulling machine. Workers not adjusting the huller machine in the right setting to de-husk the Parchment coffee by the size of 15mm or 16mm was the main cause of defective Parchment.

Furthermore, coffee hulling machines need to be properly calibrated to avoid breaking the coffee beans. Inexperienced workers applying too much pressure to parchment coffee during hulling is one of the main causes of Broken coffee at the dry mill.

The researcher identified the potential causes that might occur during coffee production processes after analyzing a Fishbone diagram. The major factors contributing to the high number of defective coffee beans are a lack of equipment, such as a Refractometer, which can indicate the ripeness of the coffee cherries and help reduce Immature Beans, Parchment size separator trays, and a lack of skills in machine handling or setting, which can cut back on high defects in Parchment and Broken coffee at the dry mill.

Improve Phase

In the improvement phase, the researcher focused on creating and putting solutions into practice to address the fundamental problems. To make the procedures better, the defects that were found must be properly managed and rectified. Therefore, a meeting was convened among farmers, the production team, and the quality department to establish a strategy that would be effective and efficient to implement solutions to address the root causes of the high defect rate.

Conduct Field-Based Training

The company provided field-based training by local coffee specialists to see and apply new approaches in their fields with the company's relevant people, who received a one-week training to increase farmers' and workers' abilities in coffee farming practices. Techniques for growing coffee as well as an assessment of how to utilize the tools and harvest were covered in the course.

Figure 7 clearly shows Field-Based training at Jadae Akha Coffee Farm.

Figure 7: Field-Based Training at Jadae Akha Coffee Farm

Provide Proper Tools for Picking and Checking Coffee Cherries

Before beginning coffee picking, all necessary gear and equipment were purchased and distributed to farmers and laborers. For instance, after getting training, 21 farm workers were given a Refractometer to enable them to measure the maturity of the coffee cherries. Additionally, gloves, rubber gloves, long rubber boots, caps, long sleeve protectors, baskets, bags, rope, and size separator trays were provided for the workers to keep them safe when selectively picking coffee cherries.

Implement Reward Program

The management developed a financial and non-financial Reward Program to enhance the skills of unskilled and unmotivated employees. After the coffee season, the management evaluated the coffee and increased the price of coffee cherries by 5% for farmers and a bonus payment for workers as part of a financial Reward Program, based on the quality of coffee cherries from farmers and worker performance. As a non-financial program, management offered professional development training and promotion to enhance their morale, motivate and engage them, and thus encourage them to take on more responsibility in their jobs.

Implement Regular Quality Inspection System

Table 4 shows the Inspection Task Form, the researcher developed an Inspection Task Form in consultation with relevant authorities to ensure that coffee production operations are conducted effectively and efficiently and that the quality of the coffee cherries meets the required standards. Workers started inspecting the equipment, gear, and coffee cherries daily to identify and correct any problems at an early stage.

Table 4: Inspection Task Form

Department:			Date:
Area Inspected:			Inspected By:
Task	Yes	No	Corrective Action-Date
Checking Refractometer working or not			
Checking Gloves, Boots, Hat, Protector are in good condition or not			
Verifying whether Basket, Bag, and Parchment size separator trays are usable or not			
Measuring Coffee Cherries whether fully ripe or not			
Checking production area clean or not			
Checking water tank storage full or not			
Checking electrical cords present a tripping hazard or not			
Checking warning sign are properly placed or not			
Checking pulping machine fuel and water			
Checking pulping machine is clean or not			
Checking hulling machine fuel and water			
Checking hulling machine is clean or not			

Conduct Hands-On Machine Handling Training

The training was conducted with three staff members by a certified instructor who was familiar with the specific coffee hulling machine that would be used. The trainer used hands-on practice and visualization to demonstrate the fundamentals of operating a coffee hulling machine safely and effectively.

Provide Proper Work Instruction

Specific work instructions were essential for ensuring the consistent and standardized execution of tasks. This was especially important in the coffee production process, where there were many steps involved and even minor mistakes could harm the end product's quality. Management introduced a proper work instruction form immediately following the training in February 2023.

Implement Regular Team Meetings and Knowledge Sharing Section

Regular team meetings were held twice a month to improve communication, collaboration, decision-making, information sharing, the generation of fresh concepts, or just keeping everyone informed of current events. The team meetings also facilitated relationship-building and the development of a more supportive work environment. In addition, team meetings were used to discuss progress on projects and goals, assign tasks and responsibilities, receive feedback, encourage participation, and follow up on action items.

Implement a Proper and Regular Maintenance System

To ensure their longevity and performance, machines needed to be maintained properly and regularly. Additionally, it might help to prevent costly breakdowns and repairs. As a result, following the training, the management implemented a specific and regular weekly maintenance schedule for the machine operator. The schedule included all of the essential maintenance tasks, such as oil changes, lubrication, and cleaning.

A weekly machine breakdown maintenance check sheet, shown in Table 5, would indicate Tick (√) based on machine operator inspection with a remark for any identifying concerns.

Table 5: Weekly Machine Breakdown Maintenance Check Sheet

Operator Name:	**Sheet No:**						
Date:	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Total**	**Remark**
Checking Fuel Tank							
Checking Engine Oil							
Oil Change							
Lubrication							
Cleaning Machine							
Cleaning Blade							

Table 5: Weekly Machine Breakdown Maintenance Check Sheet (continue)

Operator Name:	**Sheet No:**						
Date:	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Total**	**Remark**
Checking Fan Belt							
Checking Water							
Tighten Screws and Nerves							

Before and After Implementation

Table 6 presents the Before and After implementation, which shows the 2022-2023 season of the total defect in 10 samples. Before implementation, 463.18 kg, or 25.09%, of the 1,846.08 kg produced were defective and cost 13,895,400 MMK.

Program implementation resulted in a significant decrease in the defective rate. Of the 1,846.08 kg produced, only 181.47 kg, or 9.83%, were defective and cost 5,444,100 MMK. As a result of the corrective action plans, the overall total defective was reduced, and it saved approximately 8,451,300 MMK for the company.

Table 6: Before and After Implementation

Before					
2022-2023 Season					
2022-2023 Season	Total Production in Kg	Defect Quantity in Kg	Defect %	Total Cost P/ Year (MMK)	Remark
Coffee Green Bean	**1846.08**	**463.18**	**25.09%**	**13,895,400**	↑
After					
Coffee Green Bean	**1846.08**	**181.47**	**9.83%**	**5,444,100**	↓

Control Phase

The Control Phase of DMAIC is the final stage, and it ensures that the improvements made in the earlier stages are sustained. This phase focuses on implementing policies and procedures to monitor the coffee production process and adjust as needed. The team must follow the Standard Operation Procedures (SOPs) to ensure that the process is followed consistently. They must also monitor the company's performance in terms of reducing coffee green bean defects to meet the KPI.

Provide Proper Training and Equipment

The company will regularly provide training and development opportunities to farmers and employees twice a year, in January and June, to help them stay up-to-date with the latest coffee equipment, processes, and technology, including how to calibrate a Refractometer using Myanmar Coffee Association guidelines.

Standard Operating Procedures (SOPs)

Standard Operating Procedures (SOPs) are crucial for regular and standardized farming activities. Farming and Harvesting, Hulling or De-Husking, and Sorting SOPs were implemented in February 2023 and updated every six months following National Coffee Expertise recommendations. Managers or supervisors conduct end-of-day evaluations to ensure that employees are meeting quality standards. If not, corrective action is taken immediately.

Gemba Kaizen

Gemba Kaizen was applied by the management with an emphasis on quality, cost, and delivery because it encourages enhanced process control within the coffee-producing sectors.

Figure 8 demonstrates how to identify different types of coffee beans using color-coded trays and labeling to help employees avoid confusion.

Figure 8: Coffee Green Beans Sorting Trays

Conclusion and Discussion

By implementing the DMAIC steps, the company completely identified the root causes of defects and improved its coffee production processes. The results of this study showed that DMAIC can be an effective tool for reducing coffee defects. This can lead to increased customer satisfaction, reduced costs, and improved profitability. Program implementation resulted in a significant decrease in the defective rate. The average defective rate dropped to 9.83% from 25.09%.

Auayingsak (1999) also used DMAIC processes in her research on quality improvement monitoring before and after for a producer of computer keyboards. After using Pareto analysis, the primary defect in the production of the poorly printed button is reduced from 42% to 6%.

As stated by Yadav, Mathiyazhagan, and Kumar (2019), they conducted research on the production of CMMs and CNC machines in the UK and Ireland using Six Sigma. Delivery efficiency increased by up to 95%, and the monthly scrap and rework costs dropped from £1,100 to £400. The growth of the project turned a loss into an annual saving of £60,000.

This study, however, has certain limitations because the researcher only focused on historical data from the 2022–2023 coffee production season that had the greatest impact on the company and the highest frequency of occurrences inside it due to information availability and time constraints. This study did not contain data from any other parts of Myanmar; it solely included data from Jadae Akha Coffee, which is in Keng Tung, Shan State's eastern region. As a result, it didn't address all coffee-related problems. Therefore, the highest defect rate of coffee green beans the company experienced was the sole focus of the analysis. This was only implemented from January 2023 to June 2023. Despite the researcher's thorough planning, the study nonetheless may have some flaws and restrictions.

If further research is conducted in other geographical areas of Myanmar and other parts of the coffee production regions for an extended period, the researcher might obtain more accurate analysis and different research findings.

An additional recommendation is to adopt technology (e.g., Hyperspectral imaging or infrared reflectance) (Chu, Yu, Zhao, & He, 2018) to increase the effectiveness of coffee bean grading, accuracy, speed, consistency, traceability, cost-effectiveness, roasting, and flavor profiling. In addition to these benefits, these technologies can also be used to identify the best beans for different brewing methods and gather data about the chemical composition of the beans (Jakkaew, Yingchutrakul, & Aunsri, 2024).

References:

Abualsauod, E. H. (2023). Quality improvement in retail-distribution of Saudi thobe using Six-Sigma. *International Journal of Retail & Distribution Management.* doi:10.1108/IJRDM-02-2023-0091

Allam, Z., Bibri, S., & A. Sharpe, S. (2022). The rising impacts of the COVID-19 pandemic and the Russia–Ukraine War: Energy Transition, Climate Justice, Global Inequality, and Supply Chain Disruption. *Resources*, 11, 2-17. doi.org/10.3390/resources11110099

Amatyakul, N. (2018). How to improve delivery on time by accelerating the processing time in vendor creation/modification. *Bangkok: Assumption University.* Retrieved from https://repository.au.edu/handle/6623004553/21905

Amornbadee, S. (2011). Using DMAIC Six Sigma to improve transportation cost by optimizing truck space utilization: A case study of chilled and frozen distribution center. *Bangkok: Assumption University.* Retrieved from https://repository.au.edu/handle/6623004553/3214

Anjard, R. (1998). Process Mapping: A valuable tool for construction management and other professionals. *Facilities, 16*(3/4), 79-81. https://doi.org/10.1108/02632779810205611

Araman, H., & Saleh, Y. (2023). A case study on implementing Lean Six Sigma: DMAIC methodology in aluminum profiles extrusion process. *The TQM Journal*, *35*(2), 337-365. doi:10.1108/TQM-05-2021-0154

Arani, O., & Erdil, N. (2017). Measurement System Analysis in Healthcare: Attribute Data. ResearchGate, 1109-1113. Retrieved from https://www.researchgate.net/publication/337731165_Measurement_System_Analysis_in_Healthcare_Attribute_Data

Auayingsak, S. (1999). Quality improvement at an out-of-box audit (OBA) station for a computer keyboard manufacturer. *Bangkok: Assumption University***.** Retrieved from https://repository.au.edu/handle/6623004553/5637

Aummontha, W. (2017). Business process improvement of customer service for eBay business jewelry *company. Bangkok: Assumption University.* Retrieved from https://repository.au.edu/handle/6623004553/21852

Barbrow, S., & Hartline, M. (2015). Process Mapping as organizational assessment in academic libraries. *Performance Measurement and Metrics, 16*(1), 34-47. doi:10.1108/PMM-11-2014-0040

Bowles, D., & Gardiner, L. (2018). Supporting process improvements with process mapping and system dynamics. International Journal of *Productivity and Performance Management, 67*(8), 1250-1270. doi:10.1108/IJPPM-03-2017-0067

Chatrattanawuth, T. (2014). Defect reduction by the DMAIC concept: A case study of a bakery manufacturing. Bangkok: Assumption University. Retrieved from https://repository.au.edu/handle/6623004553/3140

Chettanacharoenchai, P. (2004). Measurement System Analysis for ultraviolet and visible absorption spectroscopy. *Bangkok: Assumption University.* Retrieved from https://repository.au.edu/handle/6623004553/5911

Chu, B., Yu, K., Zhao, Y., & He, Y. (2018). Development of Noninvasive Classification Methods for different roasting degrees of coffee beans using Hyperspectral Imaging. *Sensors, 18*(4), 1259. Retrieved from https://doi.org/10.3390/s18041259

Dadan, R., & Sukmana, F. (2018). Operational strategy analysis using Lean Six Sigma at PT. four Jeffee Indonesia. *Russian Journal of Agricultural and Socio-Economic Sciences, 81*(9), 417-423. Retrieved from https://doi.org/10.18551/rjoas.2018-09.49

Desai, D., & Shaikh, A. (2018). Reducing failure rate at high voltage (HV) testing of insulator using Six Sigma methodology. *International Journal of Productivity and Performance Management*, *67*(5), 791-808. doi:10.1108/IJPPM-11-2016-0235

Farradas, C. (2023). Lost resilience and staggering risks: The adverse effects of a highly Trade-Dependent Global Food System: A case study of the war in Ukraine and its consequences in Colombia. *Baltimore: Johns Hopkins SAIS EUROPE*. Retrieved from https://doi.org/10.2139/ssrn.4518607

García, M., Candelo-Becerra, J., & Hoyos, F. (2019). Quality and defect inspection of green coffee beans. *Applied Sciences, 9*(19), 1-18. doi:https://doi.org/10.3390/app9194195

Garza-Reyes, J., Flint, A., Kumar, V., Antony, J., & Soriano-Meier, H. (2014). A DMAIRC approach to lead time reduction in an aerospace engine assembly process. *Journal of Manufacturing Technology Management, 25*(1), 27-48. https://doi.org/10.1108/JMTM-05-2012-0058

Hoffa, D., & Laux, C. (2007). Gauge R&R: An effective methodology for determining the adequacy of a new measurement system for micron-level metrology. *Journal of Industrial Technology, 23*(4), 1-9. Retrieved from https://lib.dr.iastate.edu/abe_eng_conf/347/

Holtz, R., & Campbell, P. (2003). Six Sigma: Its implementation in Ford's facility management and maintenance functions. *Journal of Facilities Management, 2*(4), 320-329. https://doi.org/10.1108/14725960410808285

Jakkaew, P., Yingchutrakul, Y., & Aunsri, N. (2024). A data-driven approach to improve coffee drying: Combining environmental sensors and chemical analysis. *PLOS ONE, 19*(2), e0296526. Retrieved from https://doi.org/10.1371/journal.pone.0296526

Jamil, N., Gholami, H., Saman, M., Streimikiene, D., Sharif, S., & Zakuan, N. (2020). DMAIC-based approach to sustainable value stream mapping: Towards a sustainable manufacturing system. *Economic Research-Ekonomska Istraživanja, 33*(1), 331-360. doi:10.1080/1331677X.2020.1715236

Jirasukprasert, P., Garza-Reyes, J., Kumar, V., & Lim, M. (2014). A Six Sigma and DMAIC application for the reduction of defects in a rubber gloves manufacturing process. *International Journal of Lean Six Sigma, 5*(1), 2-21. doi:10.1108/IJLSS-03-2013-0020

Jongkautrakul, J. (2004). Six Sigma application for reduction of the defective ratio in consumer products manufacture. *Bangkok: Assumption University.* Retrieved from https://repository.au.edu/handle/6623004553/5868

K. Hassan, M. (2013). Applying Lean Six Sigma for waste reduction in a manufacturing environment. American *Journal of Industrial Engineering, 1*(2), 28-35. doi:10.12691/ajie-1-2-4

Karout, R., & Awasthi, A. (2017). Improving software quality using Six Sigma DMAIC-based approach: A case study. *Business Process Management, 23*(4), 842-856. doi:10.1108/BPMJ-02-2017-0028

Kumar, P., Singh, D., & Bhamu, J. (2021). Development and validation of DMAIC based framework for process improvement: A case study of Indian manufacturing organization. *International Journal of Quality & Reliability Management, 38*(9), 1964-1991. doi:10.1108/IJQRM-10-2020-0332

Kumar, S., Satsangi, P., & Prajapati, D. (2013). Improvement of Sigma level of a foundry: A case study. *The TQM Journal, 25*(1), 29-43. doi:10.1108/17542731311286414

Lertanantasuk, T. (2013). Dead stock reduction by the DMAIC concept: A case of construction fittings trading company. *Bangkok: Assumption University*. Retrieved from https://repository.au.edu/handle/6623004553/3216

Limsirivallop, K., Roach, S., & Srisarkun, V. (2016). Using DMAIC to improve an in-store delivery service. *Journal of Supply Chain Management: Research & Practice*, 28-43. Retrieved from https://repository.au.edu/handle/6623004553/19339

Mandal, P. (2012). Improving process improvement: Executing the analyze and improve phases of DMAIC better. *International Journal of Lean Six Sigma, 3*(3), 231-250. doi:10.1108/20401461211282727

Marques, P., & Requeijo, J. (2009). SIPOC: A Six Sigma tool helping on ISO 9000 quality management. *XIII Congreso De Ingeniería De Organización,* 1229-1238. Retrieved from http://adingor.es/congresos/web/uploads/cio/cio2009/1229-1238.pdf

Mishra, P., & Sharma, R. K. (2014). A hybrid framework based on SIPOC and Six Sigma DMAIC for improving process dimensions in supply chain network. *International Journal of Quality & Reliability Management, 31*(5), 522-546. doi:10.1108/IJQRM-06-2012-0089

Mousli, H., Sayed, I., Zaki, A., & Abdelmonem, S. (2023). Improving VTE prophylaxis in ward and ICU surgical urology patients: A Six-Sigma DMAIC methodology improvement project. *The TQM Journal*, ISSN: 1754-2731. https://doi.org/10.1108/TQM-09-2022-0281

Onlamai, J. (2018). An application of business process improvement for new product development process: A case study of electronic manufacturer. *Bangkok:Assumption University*. Retrieved from https://repository.au.edu/handle/6623004553/21205

Pitigala, N. (2022). COVID-19 AND RUSSIA-UKRAINE WAR: Trade impacts on developing and emerging markets. *Sri Lanka Journal of Economic Research, 10*(1), 113-137. Retrieved from https://doi.org/10.4038/sljer.v10i1.177

Plaitho, S. (1999). A quality improvement plan and in an electroplating factory. *Bangkok: Assumption University*. Retrieved from https://repository.au.edu/handle/6623004553/5645

Rehman, H., Asif, M., Saeed, M. A., Akbar, M. A., & Awan, M. U. (2012). Application of Six Sigma at cell site construction: A case study. *Asian Journal on Quality, 13*(3), 212-233. doi:10.1108/15982681211287775

Rhiney, K., Guido, Z., Knudson, C., Avelino, J., M. Bacon, C., Leclerc, G., . . . P. Bebber, D. (2021). Epidemics and the future of coffee production. *Proceedings of the National Academy of Sciences of the United States of America, 118*(27), 1-10. Retrieved from https://doi.org/10.1073/pnas.2023212118

Rungrueng, S. (2015). An application of DMAIC method to reduce defects: A case study of buckle manufacturing. *Bangkok: Assumption University.* Retrieved from https://repository.au.edu/handle/6623004553/19363

Salas, K., & Huxley, C. (2014). Enhancing visualisation to communicate and execute strategy Strategy-to-Process Maps. *Journal of Strategy and Management, 7*(2), 109-126. doi:10.1108/JSMA-10-2012-0055

Sampat, N. (2012). DMAIC concept for sustainable dead stock reduction: A case of a textile company. *Bangkok: Assumption University*. Retrieved from https://repository.au.edu/handle/6623004553/3142

Sanitrat, P. (2018). An application of DMAIC concept to improve delay delivery: A case study of Japanese car manufacturing company. *Bangkok: Assumption University*. Retrieved from https://repository.au.edu/handle/6623004553/21909

Sawangjan, O. (2014). Customs clearing time reduction by applying DMAIC model: A case study of petrochemical company. *Bangkok: Assumption University.* Retrieved from https://repository.au.edu/handle/6623004553/3314

Simion, C. (2019). Measurement System Analysis by attribute, an effective tool to ensure the quality of the visual inspection process within an organization. *MATEC Web of Conferences, 290, 05004.* https://doi.org/10.1051/matecconf/201929005004

Smętkowska, M., & Mrugalska, B. (2018). Using Six Sigma DMAIC to improve the quality of the production process: A case study. *Procedia-Social and Behavioral Sciences*, 238, 590-596. doi:10.1016/j.sbspro.2018.04.039

Smutkupt, S. (2022). Applying Lean Six Sigma to improve telephone bill payment: A case study of a real estate developer. *NIDA Case Research Journal, 14*(2), 87-109. Retrieved from https://so04.tci-thaijo.org/index.php/NCRJ/article/view/263605

Smutkupt, S., & Naratornsawatdikul, U. (2019). An improvement of delivery lead time: A case study of a trading company. *NIDA Case Research Journal, 19*(3), 616-627. Retrieved from https://so02.tci-thaijo.org/index.php/hasss/article/view/137283

Soliman, F. (1998). Optimum level of process mapping and least cost business process re-engineering. *International Journal of Operations & Production Management, 18(*9/10), 810-816. https://doi.org/10.1108/01443579810225469

Southard, P., Chandra, C., & Kumar, S. (2012). RFID in healthcare: A Six Sigma DMAIC and simulation case study. *International Journal of Health Care Quality Assurance, 25*(4), 291-321. doi:10.1108/09526861211221491

Souza, T. A., Pinto, G. A., Antunes, L. G., & Grutzmann, A. (2023). SIPOC-OI: A proposal for open innovation in supply chains. *Innovation & Management Review, 20*(1), 76-93. doi:10.1108/INMR-12-2020-0182

Supalearkrattana, S. (2013). Applying DMAIC for improving production yield in telecommunication manufacturing. *Bangkok: Assumption University*. Retrieved from https://repository.au.edu/handle/6623004553/3258

Tilokavichai, N. (2003). Improvement of credit card payment: A case study of the pizza delivery company. *Bangkok: Assumption University*. Retrieved from https://repository.au.edu/handle/6623004553/5358

Wartati, D., Garza-Reyes, J., Dieste, M., Nadeem, S., Joshi, R., & González-Aleu, F. (2021). A Six-Sigma DMAIC approach to improve the sales process of a technology start-up. *International Journal of Mathematical Engineering and Management Sciences, 6*(6), 1487-1517. doi:10.33889/IJMEMS.2021.6.6.089

Won, T. L., & Nuangjamnong, C. (2021). The effect of coffee-mix experience and experience quality through perceived value, satisfaction towards repurchase intention in Myanmar. *AU-GSB e-Journal, 15*(1), 12-23. Retrieved from http://www.assumptionjournal.au.edu/index.php/AU-GSB/index

Yadav, N., Mathiyazhagan, K., & Kumar, K. (2019). Application of Six Sigma to minimize the defects in glass manufacturing industry. *Journal of Advances in Management Research, 16*(4), 594-624. doi:10.1108/JAMR-11-2018-0102

Yi, T. P., Feng, C. J., Prakash, J., & Ping, L. W. (2012). Reducing electronic component losses in lean electronics assembly with Six Sigma approach. I*nternational Journal of Lean Six Sigma, 3*(3), 206-230. doi:10.1108/20401461211282718