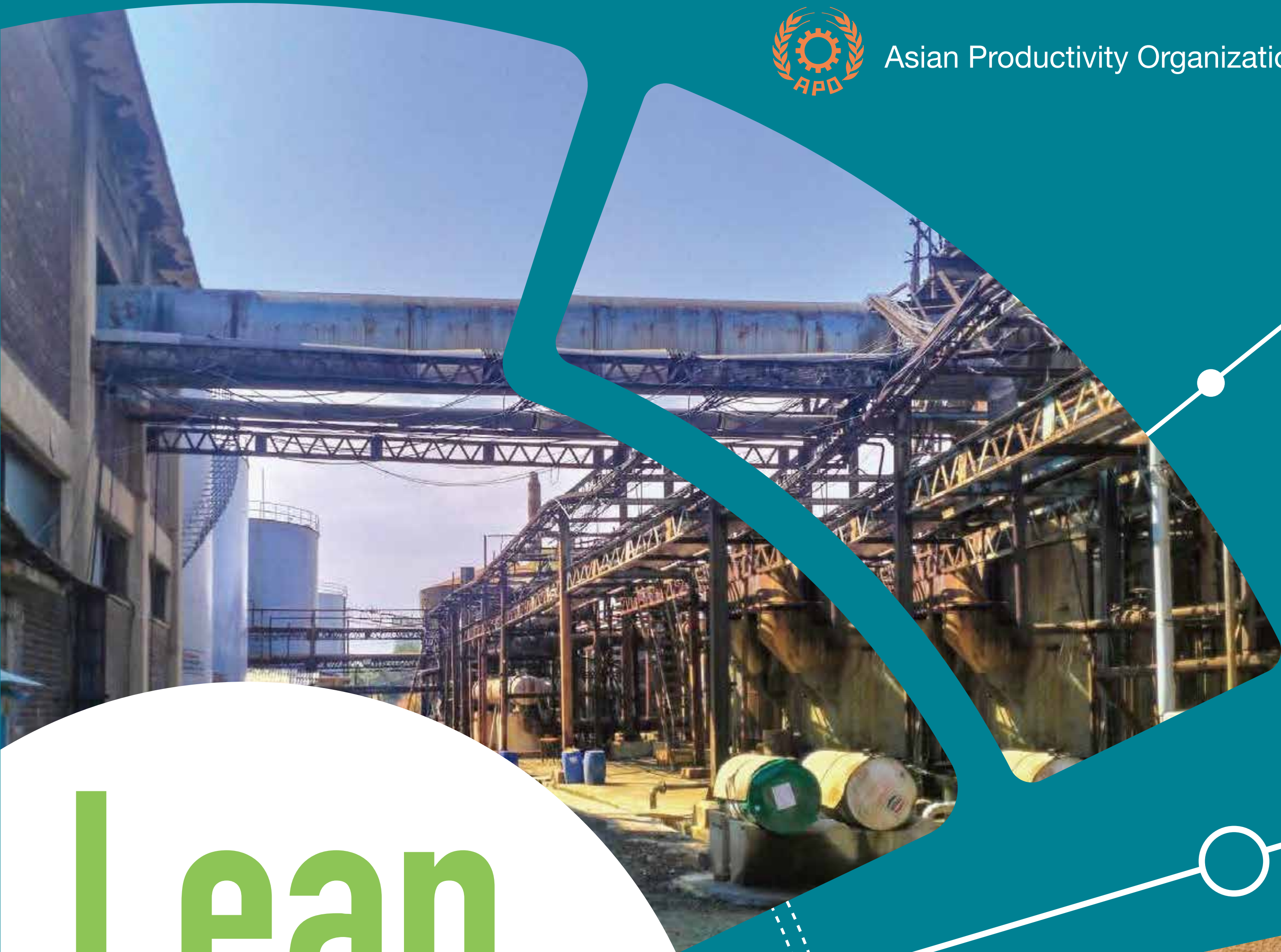
Asian Productivity Organization



Lean Management Systems

Case Studies from Bangladesh's Chemical Industry

The Asian Productivity Organization (APO) is an intergovernmental organization that promotes productivity as a key enabler for socioeconomic development and organizational and enterprise growth. It promotes productivity improvement tools, techniques, and methodologies; supports the national productivity organizations of its members; conducts research on productivity trends; and disseminates productivity information, analyses, and data. The APO was established in 1961 and comprises 21 members.

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LEAN MANAGEMENT SYSTEMS

CASE STUDIES FROM BANGLADESH'S CHEMICAL INDUSTRY

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Lean Management Systems: Case Studies from Bangladesh's Chemical Industry

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FOREWORD

Originating from the Toyota Production System in Japan, lean management systems (LMSs) have become a globally recognized approach for enhancing productivity and operational efficiency. Rooted in principles such as waste elimination, workflow optimization, and continuous improvement, LMSs empower organizations to improve quality, reduce costs, and respond more effectively to changing market demands. This makes LMSs particularly relevant for industries with complex operations and high raw material consumption, where minimizing waste and enhancing process performance are critical for competitiveness and sustainability.

In Bangladesh, the chemical industry plays a vital role in supporting agriculture, infrastructure, and industrial supply chains. Yet the sector remains heavily import dependent, with imported chemicals accounting for 70% of domestic demand and 3.5% of the country's total imports in 2017–2018 (Syeda, 2020). This underscores the urgent need for more efficient operations and waste reduction across production systems.

This publication, authored by Nobuhiro Ishii, small and medium-sized enterprise management consultant and APO resource person, shares insights from the APO Development of Demonstration Companies project titled Application of Lean Management Systems in the Chemical Industry. It features the LMS journeys of three state-owned enterprises under the Bangladesh Chemical Industries Corporation: Bangladesh Insulator and Sanitaryware Factory Limited, DAP Fertilizer Company Limited, and Triple Super Phosphate Complex Limited.

The case studies document how these organizations adopted LMSs by using the Toyota eight-step problem-solving approach and applying kaizen tools to identify and resolve the root causes of their productivity bottlenecks. These bottlenecks included decreasing heat transfer rate in the dilution cooler, increasing acid strength and temperature, low production rates, and a shortage of fresh water. Through this publication, readers will gain practical insight into applying LMSs in public sector manufacturing, which can support them in adopting lean practices in their own organizations to boost productivity and foster a culture of continuous improvement.

We extend our sincere appreciation to the National Productivity Organisation, Bangladesh; the Bangladesh Chemical Industries

Corporation; the participating companies; and Nobuhiro Ishii for their dedication and contributions. We hope this can be a valuable reference for APO member economies and organizations working toward sustainable productivity through lean transformation.

Dr. Indra Pradana Singawinata
Secretary-General
Asian Productivity Organization
Tokyo

INTRODUCTION

Lean management systems (LMSs) are an approach to business management and organization aimed at improving overall performance. They focus on eliminating waste, maximizing customer value, and fostering continuous improvement. By introducing lean management, businesses can gradually enhance processes and increase corporate value through greater efficiency and quality.

Robin (2022), referring to data from the Bangladesh Bank, states that the total value of chemicals imported by companies in the 2017–18 fiscal year amounted to BDT175.48 billion, but in the 2007–08 fiscal year it was only BDT61.03 billion. He also points out that chemical imports had been increasing at an average rate of 12% in Bangladesh over the preceding few years, and that chemicals are used on a large scale in many industries, including pesticides, textiles, leather, pharmaceuticals, paints, fertilizers, and footwear.

Bangladesh, which is the second largest exporter of apparel in the world, has a significant impact on the environment due to its extensive use of resources such as water, energy, and chemicals, and the resulting wastewater is also a problem (Uddin et al., 2023). Large-scale initiatives focusing on material reduction, water conservation, and energy management are underway. By implementing an LMS, businesses can optimize processes to eliminate various forms of waste such as non-value-added tasks, unnecessary transportation, waiting periods, and overproduction.

Bangladesh Chemical Industries Corporation (BCIC) is a fully government-owned company established in July 1976 by a presidential decree (Bangladesh National Portal, n.d.-c). Historically, it controlled 88 state-owned enterprises. Following government-led restructuring, BCIC now manages 13 large and medium-sized industrial enterprises, comprising eight fertilizer factories, one paper factory, and four other chemical and related industrial facilities producing urea, triple superphosphate (TSP), diammonium phosphate (DAP), paper, cement, glass sheets, hardboard, sulfuric acid, sanitary ware, insulators, tiles, and fire bricks. As one of the largest conglomerates in Bangladesh, BCIC oversees and coordinates these enterprises while fostering the development of new industries in the chemical and related sectors.

The introduction of an LMS seeks to develop measures to reduce material, energy, and water usage, all of which are critical national concerns for BCIC. To achieve this goal, the APO and the National Productivity Organisation (NPO), Bangladesh, implemented a Development of Demonstration Companies project titled Application of Lean Management Systems in the Chemical Industry (23-SN-04-GE-DMP-C-BD01) at three BCIC companies: Triple Super Phosphate Complex Limited (TSPCL), DAP Fertilizer Company Limited (DAPFCL), and Bangladesh Insulator and Sanitaryware Factory Limited (BISFL). A demonstration of LMS implementation was then conducted at these demonstration companies.

This case study highlights the specific improvement activities undertaken by these demonstration companies, along with the results they achieved. We hope it will guide organizations in planning and implementing lean management–based productivity initiatives with the active engagement of all stakeholders. We also anticipate that these efforts will spur a nationwide productivity campaign, resulting in sustainable business growth, waste reduction, capacity building, and knowledge-driven productivity improvements throughout Bangladesh.

PROJECT OVERVIEW

Company Profile

To implement an LMS at BCIC, three demonstration companies were selected: Triple Super Phosphate Complex Limited, DAP Fertilizer Company Limited, and Bangladesh Insulator and Sanitaryware Factory Limited. Their profiles are as follows.

Triple Super Phosphate Complex Limited

TSPCL is a state-owned fertilizer company in Bangladesh that primarily produces phosphate fertilizers. TSPCL was established under the former East Pakistan Industrial Development Corporation and commenced commercial production in 1974 (Bangladesh National Portal, n.d.-b). It consisted of two units with a total annual production capacity of 152,000 metric tons (Unit 1: 32,000 tons, Unit 2: 120,000 tons) at the time of installation. The company was registered as a limited company on 18 August 1980. The challenges for TSPCL were to mitigate environmental pollution and reduce raw material waste.

DAP Fertilizer Company Limited

DAPFCL is an enterprise of BCIC and was incorporated as a public limited company under the Companies Act 1994 on 28 August 2006 (G. KIBRIA & Co. & A. Hoque & Co., 2024). The company is fully owned by the Government of the People's Republic of Bangladesh. The company operates two plants (DAP-1 and DAP-2), both located in Rangadia, Chattogram, within the Chittagong Urea Fertilizer Limited (CUFL) premises. DAPFCL was established using Chinese (DAP-1) and Japanese (DAP-2) machinery and technology, and its principal activities are the manufacture and marketing of DAP fertilizer. The challenges for DAPFCL were to ensure national food security and reduce dependence on imports by boosting the supply of raw materials and utilities and increasing technical, financial, and institutional capacity for DAP fertilizer production.

Bangladesh Insulator and Sanitaryware Factory Limited

BISFL is a state-owned enterprise under BCIC, itself under the Ministry of Industries of the Government of the People's Republic of Bangladesh. It is the only government entity in the country producing insulating materials and sanitary ware. Located on Mirpur Zoo Road, under the jurisdiction of Shah Ali Police Station and Dhaka North City Corporation, it occupies an area of 30.37 acres (Bangladesh National Portal, n.d.-a). The challenge for BISFL was to make the factory more profitable by increasing productivity in all stages of production and services.

Project Goals and Objectives

In Bangladesh, the excessive use of chemicals and unsustainable water consumption are pressing concerns for industry. The proper management of chemicals and waste is an important factor in ensuring sustainable production and achieving the SDGs. In this project, an LMS was introduced as a sustainable production method in the chemical industry.

The project aims were to select demonstration companies to apply the LMS, to present the process and results of applying productivity improvement tools and methods, and to use these as reference benchmarks for productivity improvement through LMSs.

Partnerships and Stakeholders

BCIC was created by presidential decree in July 1976 (Bangladesh National Portal, n.d.-c). It currently manages 13 large and medium-sized industrial enterprises and is one of the country's largest conglomerates. Its mission is to supervise, coordinate, and manage the companies under its umbrella and to develop new industries in chemical and related sectors.

The goal of introducing an LMS is to formulate high-impact measures for reducing material, energy, and water consumption, which could ultimately serve as national management models for BCIC.

LEAN MANAGEMENT SYSTEM PROJECT METHODOLOGY

Lean management is a systematic approach to optimizing efficiency by minimizing waste and maximizing customer value. This management method, which originated in the Toyota Production System, is characterized by its focus on value creation through the thorough pursuit of improvement and the elimination of waste.

Purpose of Lean Management Systems

The main aim of lean management is to improve efficiency and effectiveness by reducing the time spent on activities that do not add value and optimizing the flow of work. Wasteful tasks in lean management include overproduction, waiting time, unnecessary transport, excess inventory, unnecessary processing, and defects (Businessmap, n.d.).

By introducing an LMS, an organization can expect the following effects:

- **Eliminate waste:** Lean management examines each step of business processes to remove unnecessary procedures and resource use, saving time and money.
- **Increase productivity:** Optimized processes enable organizations to achieve more with the same resources, thus creating additional value.
- **Maximize customer value:** Lean management centers on understanding customer needs and offering products and services that directly address those needs.
- **Reduce costs:** Waste reduction leads to lower operating costs, improved price competitiveness, and higher profits.
- **Foster a continuous improvement culture:** Incorporating the PDCA (plan, do, check, act) cycle encourages rapid problem-solving and ongoing enhancement of processes.
- **Improve employee engagement:** Engaging employees in improvement activities boosts motivation, morale, and overall organizational performance.
- **Facilitate faster decision-making:** Well-organized information supports quicker, more flexible responses to market changes, ensuring a competitive edge.
- **Improve quality:** Transparent processes simplify quality control and enhance products and services, gaining customer trust.
- **Increase flexibility:** Lean management helps companies adapt swiftly to market needs and environmental changes.
- **Support sustainable growth:** Operational efficiency underpins sustainable business development and long-term success.

Eight Steps of Lean Management Systems

Recognizing and reducing waste is essential for enhancing efficiency, cutting costs, and improving throughput (Toyota Material Handling, 2021). Gaining fresh perspectives on problems often involves reexamining them from different angles and drawing new insights, and Toyota's eight-step problem-solving approach makes this possible. It is a systematic, effective method for solving organizational issues. By thoroughly understanding each step, companies can foster long-lasting improvement activities. The steps are explained below in detail.

Step One: Clarify the Problem

Clearly define the organizational or departmental issues. This entails identifying the gap between the current state and the ideal state (the desired condition). Accurately defining the problem sets the direction for solutions and forms a solid foundation for action. At this stage, adopting a strategic perspective is crucial to pinpoint the core issue.

Step Two: Break Down the Problem

Analyze major issues in depth and break them into smaller, more specific problems. This allows one to see the big picture and prioritize what needs immediate attention. Techniques such as data collection and analysis help visualize the problem at a more concrete level.

Step Three: Set a Target

Establish specific numerical goals and deadlines for resolving the identified issues. Clearly defined targets are vital for assessing progress and measuring impact. They also build shared understanding within the organization and help motivate the team.

Step Four: Analyze the Root Cause

Use methods like "why-why analysis" and fishbone diagrams to uncover the underlying cause of the problem rather than focusing on surface-level symptoms. Addressing the true source of the issue helps prevent recurrence. This stage is critical in problem-solving and demands thorough, thoughtful analysis to avoid choosing quick fixes.

Step Five: Develop Countermeasures

Propose multiple possible solutions to address the root cause, evaluating each in terms of effectiveness, cost, and risk. From there, formulate an implementation schedule for the chosen countermeasures. At this stage, prioritize quality, cost, and delivery to create a clear roadmap.

Step Six: Implement the Countermeasures

Put the selected measures into action according to the plan. Visualizing progress (e.g., through charts or status boards) and promptly responding to deviations helps keep implementation on track. Coordination with all relevant parties is vital to ensure effective execution.

Step Seven: Evaluate Results and Process

After implementing countermeasures, assess whether the goals have been met and reflect on the entire process. Identify success factors and areas needing further improvement and use these insights to inform future problem-solving. Employ data to numerically measure effectiveness and maintain the PDCA cycle.

Step Eight: Standardize Successful Processes

Finally, standardize proven measures and extend them throughout the organization. This practice prevents the same issues from occurring in other areas and drives broader, organization-wide improvements. Standardization ensures sustainability, while horizontal expansion maximizes overall impact.

By following these eight steps in sequence, companies strengthen both the precision and repeatability of problem-solving. Ultimately, this approach enables ongoing improvements that benefit the entire organization.

Lean Management System Project Timeline

The introduction of the LMS in Bangladesh occurred in three stages from July 2023 to September 2024.

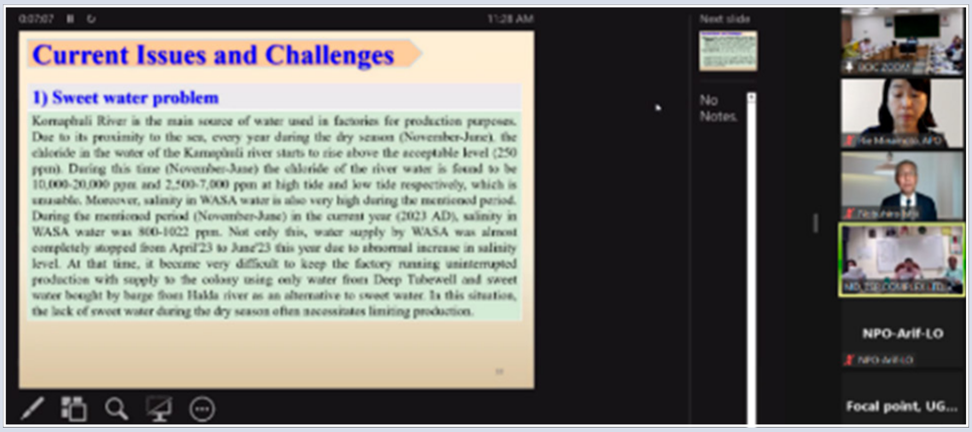
Stage One: Planning

Kickoff Meeting

In July 2023, BCIC and the three demonstration companies—BISFL, TSPCL, and DAPFCL—as well as the NPO, Bangladesh, and the APO, participated in the online kickoff meeting (Figure 1). The project objectives, an LMS overview, and the schedule were introduced along with each organization's role. Attendees included top management, project leaders, and team members from each organization.

FIGURE 1

BCIC PARTICIPANTS AND PRESENTATION IN THE KICKOFF MEETING.



Source: APO (2023).

The goal of this meeting was to ensure that participants understood the overall project scope and its importance, with a focus on the following topics:

- Definition of LMS
- Lean, the Toyota Way
- Three key elements of lean management
- Problem-solving through Toyota lean management
- Kaizen tools for LMSs
- Implementation of LMSs

This introduction corresponded to the first of the eight LMS steps, clarify the problem. The demonstration companies were asked to outline their current issues and challenges, define their ideal state, and identify the measures necessary to close any gaps.

Planning

The project teams discussed and compiled the challenges they had identified, and considering available resources such as budgets and staff, they determined which issues to prioritize. Finally, the current situation, goals, and required timeline for closing the gaps were clearly defined for each selected issue.

Stage Two: Implementation

The companies' project teams executed their first projects (each defined as "Project One") in line with the plan. To monitor each organization's issues, a format was established that outlined the situation, the goals, and the actions and timeline necessary for closing the gap. This information was shared for ongoing progress management. The state of the improvement target at project initiation was documented using data and photographs to objectively measure final outcomes.

FIGURE 2

MEETINGS WITH DEMONSTRATION COMPANIES.

DAP Fertilizer Company Limited, Chittagong

(Continued on next page)

(Continued from the previous page)

Triple Super Phosphate Complex Limited, Uttar Potenga, Chittagong

Bangladesh Insulator and Sanitaryware Factory Limited, Mirpur, Dhaka

Source: APO (2023).

Every two weeks, progress was reviewed through online meetings and other channels to confirm adherence to the plan (Figure 2). If goals were not met, the team identified why, adjusted the action plan, allocated additional resources, or adopted a different strategy. The focus remained on effectively achieving each project goal.

If Project One did not proceed as intended, the plan was updated (e.g., by reallocating resources), ensuring that the team remained focused on meeting the established goals. After completing Project One, the outcomes were documented, and planning for Project Two began.

Stage Three: Evaluation and Dissemination

Evaluation

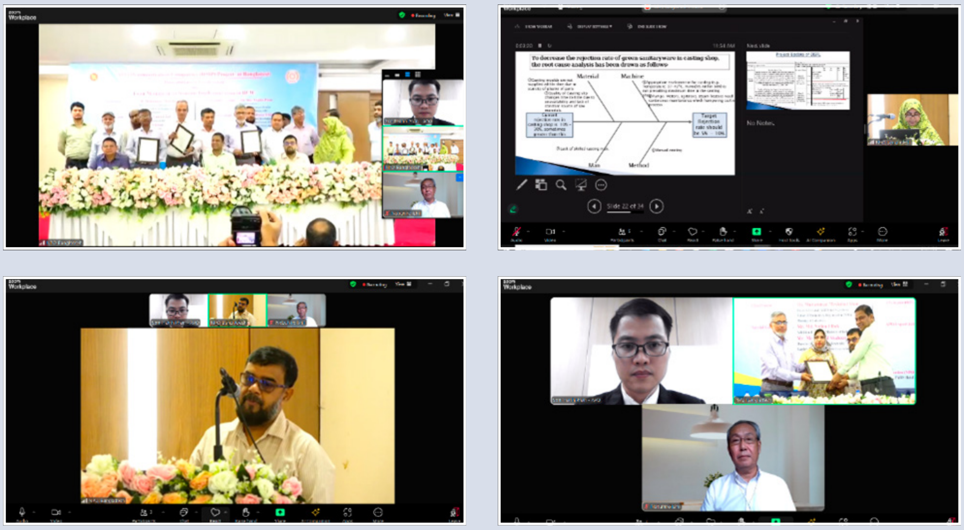
The outcomes from Project One were documented, and Project Two was planned similarly. The processes gained from implementing the LMS were then rolled out to other departments, raising the overall capability and performance of the organization.

Dissemination

The achievements of the three demonstration companies were shared across BCIC (see Figure 3), leading to organization-wide improvements and encouraging the continuous application of LMS principles.

FIGURE 3

PHOTOS OF THE PROJECT DISSEMINATION CONFERENCE HELD ON 4 SEPTEMBER 2024.



Source: APO (2024).

PROJECT IMPLEMENTATION AND ACHIEVEMENTS

Triple Super Phosphate Complex Limited

The following sections summarize how TSPCL applied the LMS following the eight-step process.

Step One: Clarify the Problem

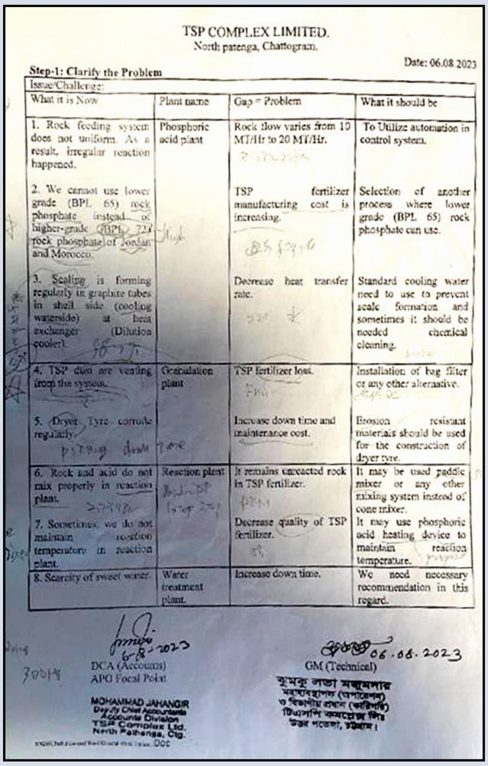
To mitigate environmental pollution and reduce raw material waste, TSPCL had installed bag filters. However, the company had encountered multiple issues (see Figure 4), including the following:

- **Dilution cooler:** Regular scaling on graphite tubes decreased the heat transfer rate and hindered productivity.

- **Freshwater issue:** The Karnaphuli River, close to the sea, is the primary water source. During the dry season (November–June), chloride levels can exceed 250 ppm, rendering the water unusable and forcing production restrictions.

FIGURE 4

TSPCL CLARIFIES THE PROBLEM.



TSP COMPLEX LIMITED.
North patenga, Chattogram.

Date: 06.08.2023

Step-1: Clarify the Problem

Issue/Challenge:

What it is Now	Plant name	Gap = Problem	What it should be
1. Rock feeding system does not uniform. As a result, irregular reaction happened.	Phosphoric acid plant	Rock flow varies from 10 MT/Hr to 20 MT/Hr.	To Utilize automation in control system.
2. We cannot use lower grade (BPL 65) rock phosphate instead of higher-grade (BPL 72) rock phosphate of Jordan and Morocco.		TSP fertilizer manufacturing cost is increasing.	Selection of another process where lower grade (BPL 65) rock phosphate can use.
3. Scaling is forming regularly in graphite tubes in shell side (cooling waterside) at heat exchanger (Dilution cooler).		Decrease heat transfer rate.	Standard cooling water need to use to prevent scale formation and sometimes it should be needed chemical cleaning.
4. TSP dust are venting from the system.	Granulation plant	TSP fertilizer loss.	Installation of bag filter or any other alternative.
5. Dryer Tyre corrode regularly.		Increase down time and maintenance cost.	Erosion resistant materials should be used for the construction of dryer tyre.
6. Rock and acid do not mix properly in reaction plant.	Reaction plant	It remains unreacted rock in TSP fertilizer.	It may be used paddle mixer or any other mixing system instead of cone mixer.
7. Sometimes, we do not maintain reaction temperature in reaction plant.		Decrease quality of TSP fertilizer.	It may use phosphoric acid heating device to maintain reaction temperature.
8. Scarcity of sweet water.	Water treatment plant.	Increase down time.	We need necessary recommendation in this regard.

6-8-2023
DCA (Accounts)
APO Focal Point

MOHAMMAD JAHANGIR
Deputy Chief Accountant
Accounts Division
TSP Complex Ltd.
North Pathenga, Ctg.

06.08.2023
GM (Technical)

Source: Paper presented by TSPCL at the LMS planning meeting, Chittagong, Bangladesh, 13 August 2023.

- **Zero-discharge plan:** The Department of Environment has strict requirements regarding the recycling of liquid effluents after proper treatment. TSPCL must develop and implement a zero-discharge plan with official approval.

Step Two: Break Down the Problem

TSPCL categorized its main challenges in detail (as illustrated in Figure 4) to identify and prioritize areas requiring immediate attention.

Step Three: Set the Target

As shown in Figure 4, a number of issues were raised. The project members explained that all the issues were important. While it was recognized that each issue was important, it would be very difficult to solve all the major issues at once. TSPCL agreed to break down the major issues into smaller pieces and solve them one by one. First, they set a goal that was high priority and achievable within six months.

TSPCL designated the dilution cooler issue as "Project One" and documented the current conditions:

- Outlet acid temperature: 80^{o}C
- Diluted sulfuric acid (H_2SO_4) strength: 83%

The company aimed to achieve the following conditions by February 2024:

- Outlet acid temperature: 65^{o}C
- Diluted H_2SO_4 strength: 75%

From steps one through three, TSPCL was well prepared and organized and had good discussions. They provided the necessary operational data to proceed with the project.

Step Four: Analyze the Root Cause

One way to analyze the root cause is through brainstorming using a framework. A framework is a structure that guides the development process and transforms a structure into something useful. TSPCL agreed to apply the 4M (man, machine, material, method) framework to analyze the root cause of the identified issues.

Based on the analysis, TSPCL identified the following root causes:

- Decreasing heat transfer rate
- Increasing outlet acid temperature
- Dilution cooler cannot dilute sulfuric acid properly
- Process becomes abnormal
- Using low quality cooling water
- Using cooling water with high turbidity and high levels of total dissolved solids

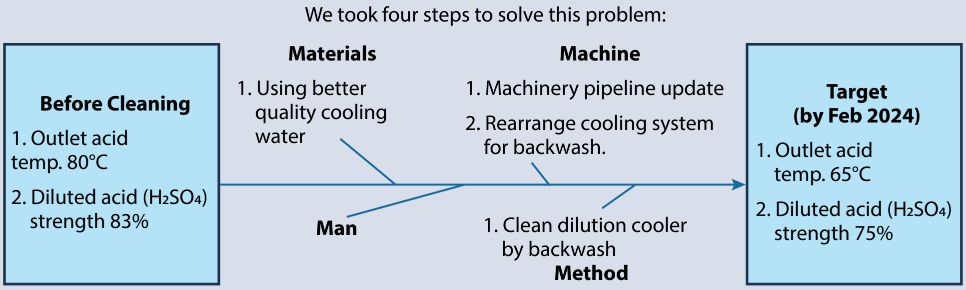
Step Five: Develop Countermeasures

After the root cause analysis was carried out, TSPCL members proposed the following countermeasures (see Figure 5):

- Clean the dilution cooler using backwash
- Rearrange the cooling system for backwash
- Use better quality cooling water
- Update the machinery pipeline
- Backwash manually from time to time

FIGURE 5

TSPCL DEVELOPS COUNTERMEASURES.



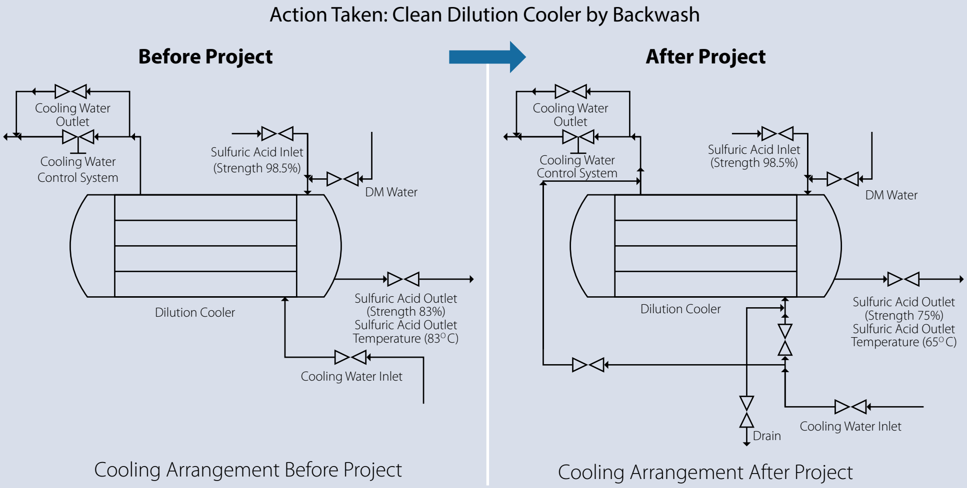
Source: Reproduced from a paper presented by TSPCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Six: Implement Countermeasures

After the specific actions were decided, the TSPCL members were quick to carry out the outlined measures (see Figure 6 as an example).

FIGURE 6

ACTION TAKEN BY TSPCL.



Source: Reproduced from a presentation by TSPCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

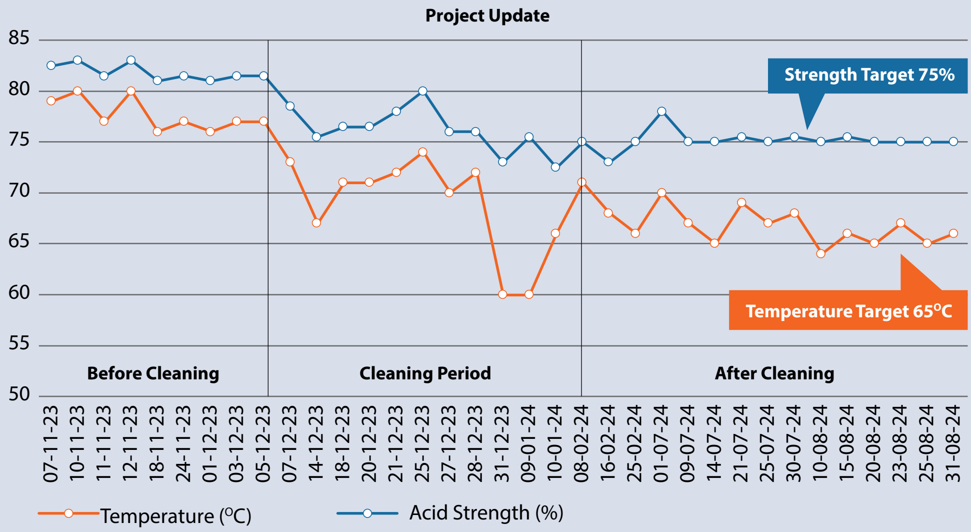
Step Seven: Evaluate Results and Process

The results of the improvements made through their swift actions were very impressive. After evaluating the measures, TSPCL determined the following:

- The dilution cooler functions smoothly.
- Acid strength and temperature now meet target values (Figure 7).
- Overall processes have improved substantially.

FIGURE 7

TSPCL EVALUATES RESULTS AND PROCESSES.



Source: Reproduced from a presentation by TSPCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Eight: Standardize Successful Processes

TSPCL formalized the improved process to ensure consistent performance and organizational learning.

In the early stages of the project, there was not enough activity on the LMS, but as the project progressed, the team's understanding of the LMS improved, with excellent results. TSPCL achieved its initial targets and plans to continue applying the LMS for ongoing improvements.

Future Actions

- Launch a second project to address the freshwater shortage
- Install a heater in the reaction plant to maintain proper reaction temperatures
- Resolve recurring dryer tire corrosion by appointing a specialized contractor

DAP Fertilizer Company Limited

Step One: Clarify the Problem

The company's mission was to ensure national food security and reduce dependence on imports by boosting the supply of raw materials, improving utilities, and increasing technical, financial, and institutional capacity for DAP fertilizer production.

DAPFCL faced multiple challenges:

- Lack of in-house utility facilities (e.g., steam, electricity), leading to dependence on CUFL services
- Insufficient phosphoric acid and ammonia storage capacity to operate two plants simultaneously
- Design flaws in DAP-2 preventing operation at full capacity (the general contractor did not complete the performance guarantee test run)
- Absence of dedicated utilities (power, steam, water) limiting normal operations to a single plant unless CUFL utilities are running and restricting both plants during CUFL shutdowns

Step Two: Break Down the Problem

DAPFCL categorized its main obstacles (see Table 1 and Table 2) to identify and prioritize specific areas requiring immediate action.

TABLE 1

DAPFCL CLARIFIES THE PROBLEM: ISSUES AND CHALLENGES IN DAP-1.

Issue and Challenges: DAP-1		
What It Is Now	**Gap = Problem**	**What It Should Be**
Utility facilities (steam, electricity, power, etc.) are not installed, so DAPFCL is dependent on CUFL utility service.	During CUFL running time, can only run one plant	Self-dependence in utility facilities
Production: 16 MT/hr	• Could not run drier pipe reactor • Material build-up in drier • Screen net problem	35.6 MT/hr
Yearly downtime: 2,706 hours in last six months of fiscal year 2022–23	• Utility problem • Furnace problem • Screen net problem • Availability of raw materials	2,010 hours yearly

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Issue and Challenges: DAP-1		
What It Is Now	**Gap = Problem**	**What It Should Be**
Yearly production: 68,569 MT in fiscal year 2022–23	• Utility problem • Furnace problem • Availability of raw materials • Screen net problem	240,000 MT
DAP-1 primary screening machine runs by multimotor	Motor trip, motor burn out, damaged rubber bush, etc.	Modified primary screen control system of DAP-1 to prevent unwanted breakdown
Furnace frequently tripped by dust deposition	Downtime increases	Need modification
Drier pipe reactor does not run	Not achieved desired production	Drier pipe reactor should run

Note: DAP-1, Plant 1 of DAP Fertilizer Company Limited; CUFL, Chittagong Urea Fertilizer Limited; MT, metric tons. Text has been amended for grammar and style.
Source: Reproduced from a paper presented by DAPFCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

TABLE 2

DAPFCL CLARIFIES THE PROBLEM: ISSUES AND CHALLENGES IN DAP-2.

Issue and Challenges: DAP-2		
What It Is Now	**Gap = Problem**	**What It Should Be**
Utility facilities (steam, electricity, power, etc.) are not installed, so DAPFCL is dependent on CUFL utility service.	During CUFL running time, can only run one plant	Self-dependence in utility facilities
Production: 16.5 MT/hr	• Pipe reactor not designed correctly • Not designed for 800 MT per day	33.5 MT/hr
Yearly downtime: 1,918 hours in last six months of fiscal year 2022–23	• Utility problem • Granulator outlet chute too narrow, causing blockage • Screen net problem • Material build-up in casing of granulator's induced draft fan 301 • Availability of raw materials	1,260 hours yearly

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Issue and Challenges: DAP-2		
What It Is Now	**Gap = Problem**	**What It Should Be**
Yearly production: 50,563 MT in fiscal year 2022–23	• Utility problem • Granulator outlet chute too narrow, causing blockage • Screen problem • Material build-up in casing of granulator's induced draft fan 301 • Availability of raw materials	250,000 MT yearly
Due to design fault of DAP-2, unable to operate at designed capacity (general contractor failed to complete the performance guarantee test run)	• Pipe reactor is not designed correctly • Granulator outlet chute is too narrow, causing blockage	• Chute modification is required • Pipe reactor should be redesigned

Note: DAP-2, Plant 2 of DAP Fertilizer Company Limited; CUFL, Chittagong Urea Fertilizer Limited; MT, metric tons. Text has been amended for grammar and style.
Source: Reproduced from a paper presented by DAPFCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Three: Set the Target

Though many important problems were recognized, it is difficult to solve big problems all at once. DAPFCL agreed to break down big problems into small pieces and solve them one by one. First, they set a goal that was high priority and achievable in six months. DAPFCL chose to boost production in DAP-1 from 250 MT/day to 400 MT/day. To achieve this objective, Project One focused on enhancing the pipe reactor feed rate.

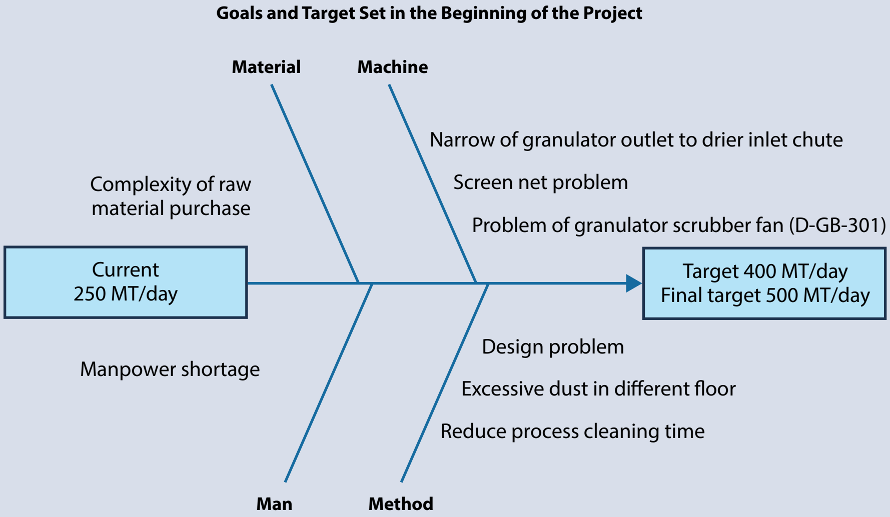
Step Four: Analyze the Root Cause

To analyze the root cause of the identified issues and guide the development process, DAPFCL agreed to apply the 4M framework (Figure 8). Based on the analysis, DAPFCL identified several contributing factors:

- Complicated raw material procurement process
- Narrow chute from the granulator outlet to the drier inlet
- Inefficient screen net
- Issues with the granulator scrubber fan (D-GB-301)
- Manpower shortage
- Design flaws
- Excessive dust accumulation on multiple floors
- Extended process cleaning times

FIGURE 8

DAPFCL ANALYZES THE ROOT CAUSES.



Note: MT, metric tons.
Source: Reproduced from a paper presented by DAPFCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Five: Develop Countermeasures
DAPFCL proposed the following actions (see Table 3):

- Modify the chute from a narrow to a wider, rounded design
- Replace the current low-quality screen net with a higher-grade net
- Replace the granulator's rubber lining
- Install a new motor for the granulator scrubber fan
- Clean the entire dedusting system
- Shorten cleaning times
- Follow a maintenance schedule based on a prepared Gantt chart

Step Six: Implement Countermeasures
At the initial implementation stage of their countermeasure activities, the DAPFCL project team members only achieved limited progress. This initiated active discussions among related departments, which raised some concerns regarding the level of contributions among them. However, under the guidance of the APO resource person and continued dialogue, the project team recognized the significance of interdepartmental collaboration and gradually aligned on a common direction. This cooperative approach led to the successful implementation of key improvements, including the renovation of the chute, equipment upgrades, and the development of systematic maintenance planning (see Table 4).

TABLE 3

DAPFCL DEVELOPS COUNTERMEASURES.

Goals and Target Set in the Beginning of the Project

Project Purpose	Project Target
Low production due to inability to increase pipe reactor feed	Current: 250 MT/day Project target: 400 MT/day Final target: 500 MT/day

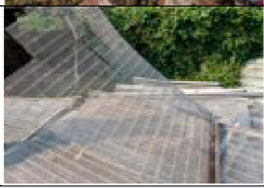
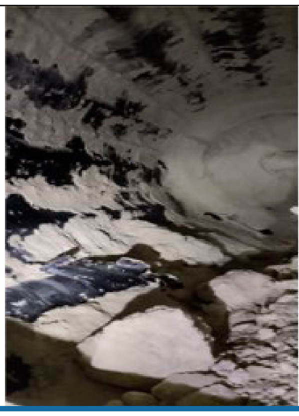
Major Items	Detailed Action Plan	Person in Charge	Remarks
Chute Modification	Chute modification Current: Narrow Target: Wide and round (as possible)	GM (MTS) Mechanical & Research Committee	It is under supervision of Research Committee.
Screen Net Problem	Replace screen net Current: Low quality Target: As design	GM (MTS) Mechanical	Replaced.
Granulator Rubber Lining	Replace granulator rubber lining Current: Damage Target: Replace	GM (MTS) Mechanical	Replaced.
Problem of Granulator Scrubber Fan (D-GB-301)	Replace motor of granulator scrubber fan Current: Lower amp. rating Target: Design amp. rating	GM (MTS) E&I	Fan motor changed to design ampere rating.
Clean Entire Dedusting System	Cleaning work Current: Partially blocked Target: Unblock	GM (Operation)	Cleaned and unblocked.
Reduce Cleaning Time	Reduce cleaning time Current: 6 hours Target: 2 hours	GM (Operation)	Reduced cleaning time to 4 hours.
Maintenance Schedule	Maintenance schedule Current: Gantt chart prepared Target: Work to be done as per Gantt chart	GM (MTS) Mechanical & GM (MTS) E&I	Done. Now maintenance work continuing as per Gantt chart schedule.

Note: MT, metric tons; GM, general manager; MTS, maintenance; E&I, electrical and instrument. Text has been amended for grammar and style.
Source: Reproduced from a paper presented by DAPFCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

TABLE 4

DAPFCL IMPLEMENTS COUNTERMEASURES.

Implemented Activities

Items	Before	After
Reduce cleaning	4~6 hr/day	3~4 hr/day
Clean entire dedusting system	Partially blocked	Clean and unblocked
	Damaged	Replaced
Screen net problem	 	
Maintenance schedule (Gantt chart)	Partially followed by Gantt chart	Completely followed by Gantt chart
Granulator scrubber fan suction damper automation		 
Granulator scrubber fan motor problem	Amp does not increase up to rated amount (245A); it has to maintain within 220A	Maintenance done: Amp increases up to 235A
	Damaged	Repaired
Granulator rubber liner		

Note: Text has been amended for grammar and style.
Source: Reproduced from a paper presented by DAPFCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Seven: Evaluate Results and Process

In addition to the conflict between departments, factors such as the interruption of power supply and delays in funding meant that it took time for the situation to improve visibly. Nonetheless, DAPFCL achieved its production target of 400 MT/day. Table 5 and Figure 9 show the positive results achieved.

TABLE 5

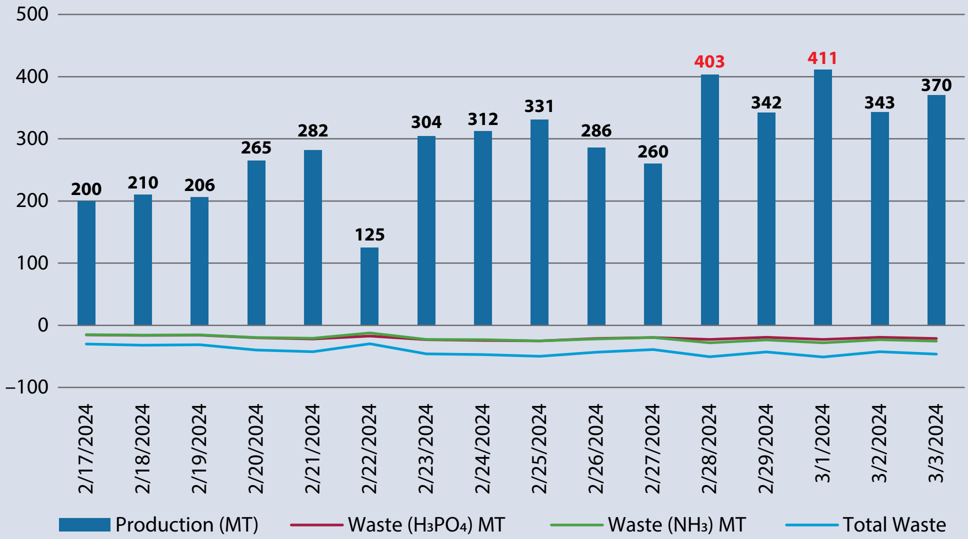
DAPFCL EVALUATES RESULTS AND PROCESSES: ACHIEVEMENTS AFTER THE PROJECT.

Date	Production (MT)	H_3PO_4 (MT)	NH_4 (MT)	Waste (H_3PO_4) MT	Waste (NH_3) MT	Total Waste
2/17/2024	200	194	59	−15.20	−14.80	−30.00
2/18/2024	210	204	62	−16.26	−15.59	−31.85
2/19/2024	206	200	61	−15.84	−15.47	−31.31
2/20/2024	265	257	78	−20.09	−19.44	−39.53
2/21/2024	282	274	83	−21.89	−20.68	−42.57
2/22/2024	125	129	40	−17.25	−12.38	−29.63
2/23/2024	304	295	90	−23.22	−22.82	−46.04
2/24/2024	312	303	92	−24.07	−23.05	−47.12
2/25/2024	331	321	98	−25.09	−24.85	−49.94
2/26/2024	286	277	85	−21.32	−21.79	−43.11
2/27/2024	260	252	77	−19.56	−19.54	−39.10
2/28/2024	403	383	117	−22.72	−27.94	−50.66
2/29/2024	342	325	99	−19.25	−23.42	−42.67
3/1/2024	411	390	119	−22.57	−28.17	−50.74
3/2/2024	343	326	99	−19.36	−23.2	−42.56
3/3/2024	370	352	107	−21.22	−25.23	−46.45

Note: MT, metric tons; H_3PO_4, phosphoric acid; NH_4, ammonium; NH_3, ammonia.
Source: Reproduced from a paper presented by DAPFCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

FIGURE 9

DAPFCL EVALUATES RESULTS AND PROCESSES: DAILY PRODUCTION (METRIC TONS).



Note: MT, metric tons; H_3PO_4, phosphoric acid; NH_4, ammonium; NH_3, ammonia.
Source: Reproduced from a paper presented by DAPFCL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Eight: Standardize Successful Processes

DAPFCL successfully standardized the improved procedures for long-term consistency. The project leader of DAPFCL led the team with tenacity. At first, there were many conflicts of opinion, causing concern about the future of the project, but as the project progressed, the teams came together, with positive results. DAPFCL reached its production target and will continue implementing the LMS.

Future Actions

- Conduct productivity-enhancement training with the NPO, Bangladesh
- Upgrade spillage and dust feeding in the recycle loop via minor modifications
- Reduce ammonia vapor loss by operating the boil-off gas compressor in the mother tank
- Aim to achieve 150,000 MT production in the current fiscal year and maintain sales for agricultural security
- Continue striving for an annual production capacity of 200,000 MT

Bangladesh Insulator and Sanitaryware Factory Limited

Step One: Clarify the Problem

BISFL had the following major problems:

- Old, manually operated technology
  - Established in 1981, BISFL relies on outdated manual processes such as plaster molding, manual casting, finishing, glazing, and kiln loading.
  - Frequent material rejection occurred at multiple production stages, preventing large-scale output of modern, high-quality designs.
- Shortage of raw materials
  - Stony raw materials like feldspar and local clay are scarce for environmental reasons, requiring extra time and cost to procure.

Step Two: Break Down the Problem

From the start of the project, BISFL's top management understood the importance of the LMS. With their cooperation, a good team was formed. BISFL classified the main issues (see Table 6) and identified areas that needed to be urgently addressed and further analyzed.

TABLE 6

BISFL CLARIFIES THE PROBLEM.

What It Is Now	Gap = Problem	What It Should Be
• Old technology • Old machinery • Low installed insulator production capacity	• 42-year-old manual technology • Unavailability of spare parts for existing machinery	Environmentally friendly, energy-efficient, sustainable modern technology with high capacity

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What It Is Now	Gap = Problem	What It Should Be
• Unavailability of raw materials • Low market demand • Scarcity of running capital	• Low production capacity in large production hall • Stony raw materials need crushing for both production lines using manual technology • High energy consuming kiln with decreasing attainable production capacity due to its long lifetime • Current attainable production capacity: º Sanitary ware: 1,200 MT/year º Insulators: 900 MT/year **Insulator production:** • Large manual production line has low capacity. • Crushing unit, filter press, pug mills, and dryer kiln do not give continuous performance due to old age, so production is interrupted, producing low-quality products and high rejection rates. • In the insulator kiln, energy consumption per day is approximately 4,884 m^3. • Maintenance cost is high due to old machinery. **Sanitary ware production:** • Prepared casting slip from mass body section needs to be pumped to the casting shop, passing a long distance. • High green rejection rate due to manual casting. • Manual casting needs extensive finishing. • In spite of extensive finishing, products cannot reach the required quality. • The continuous tunnel kiln having old technology consumes high energy (sanitary ware kiln: approx. 4,092 m^3/day), which increases production cost. Sometimes it also creates firing defects. • Overall quality cannot reach that of products made using modern technology, thereby decreasing market demand.	

Note: MT, metric tons; m^3, cubic meters. Text has been amended for grammar and style.
Source: Reproduced from a paper presented by BISFL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Three: Set the Target

BISFL agreed to break down the problems into small pieces and solve them one by one, first setting a high priority goal that would be achievable in six months. BISFL's first project aimed to reduce the rejection rate of green sanitary ware during casting from 10%–30% to 5%–10%.

From steps one through three, BISFL was well prepared and organized and had good discussions. The company created a detailed action plan for the first project.

Step Four: Analyze the Root Cause

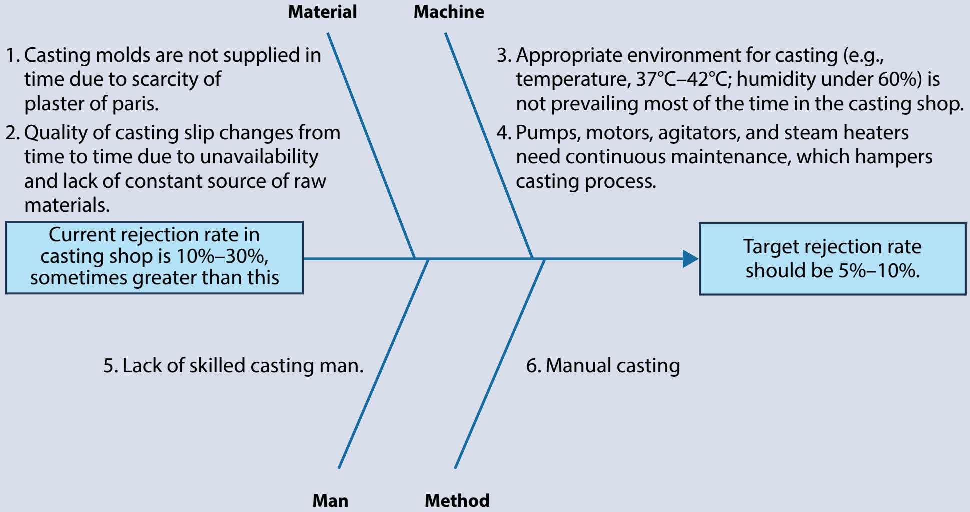
BISFL agreed to apply the 4M framework to analyze the root causes (see Figure 10). Based on the analysis, BISFL identified the following factors causing high rejection rates:

- Delays in supplying casting molds due to limited plaster stock
- Inconsistent casting slip quality from unreliable raw material sources
- Inadequate casting environment (e.g., temperature ranges of 37°C–42°C and humidity near 60%)
- Frequent maintenance needed for pumps, motors, agitators, and steam heaters, disrupting casting operations
- Shortage of skilled casting personnel
- Manual, labor-intensive casting processes

FIGURE 10

BISFL ANALYZES ROOT CAUSES.

To decrease the rejection rate of green sanitary ware in casting shop, the root cause analysis has been drawn as follows:



Note: Text has been amended for grammar and style.
Source: Reproduced from a paper presented by BISFL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Five: Develop Countermeasures

BISFL proposed the following actions (see Table 7):

- Acquire proper casting modules to ensure timely mold supply
- Enforce strict quality control for casting slip
- Maintain suitable casting conditions (e.g., temperature, humidity) to reduce defects

TABLE 7

BISFL DEVELOPS COUNTERMEASURES.

Project Update of BISFL

Project Purpose			Project Target					
Casting Shop Improvement			Current Rejection Rate in Casting Shop: 30% Target Rejection Rate: 5%–10%					
Major Item	Detailed Action Plan	Person in Charge		1M	2M	3M	4M	5M
				Oct	Nov	Dec	Jan	Feb
Casting molds	Casting molds are not supplied in time due to scarcity of plaster of paris. To procure plaster of paris within its shelf life (6 months) according to the requirements of the plaster shop, the user department will raise an SPR and the commercial department will complete the next procurement process. There should be no gaps in plaster of paris stock in the factory. The time schedule of IOTM is minimum 5 months to enable the purchase of the same materials from the local market by RFQ, OTM, and LTM.	Head of Production, Account & Finance, and Commercial	Plan	Store purchase requisition (SPR) raised for procure-ment				SPR procurement completed
			Actual	105 tons plaster of paris factory entered. As per the demand of the casting department, the work of making the casting mold is in progress.				
Raw materials	The quality of casting slips changes from time to time due to unavailability and the lack of constant sources of raw materials. To procure clay and stony raw materials according to BISF specifications, the user department will complete the next procurement process. There should be no gaps in supplies of the main raw materials. If possible, the source of raw materials should be the same. Time schedule of IOTM is minimum 5 months to enable the purchase of the same materials from the local market by RFQ, OTM, and LTM.	Head of Production, Account & Finance, and Commercial	Plan	SPR raised for procure-ment by OTM and IOTM		Procurement completed by OTM	Procurement completed by OTM	
			Actual	Feldspar (lamp) SPR for procurement raised in October. Procurement not yet completed.				

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<table>
<tr><th colspan="2">Project Purpose</th><th colspan="7">Project Target</th></tr>
<tr><td colspan="2">Casting Shop Improvement</td><td colspan="7">Current Rejection Rate in Casting Shop: 30%

Target Rejection Rate: 5%–10%</td></tr>
<tr><td rowspan="2">Major Item</td><td rowspan="2">Detailed Action Plan</td><td rowspan="2">Person in Charge</td><td rowspan="2"></td><td>1M</td><td>2M</td><td>3M</td><td>4M</td><td>5M</td></tr>
<tr><td>Oct</td><td>Nov</td><td>Dec</td><td>Jan</td><td>Feb</td></tr>
<tr><td rowspan="4">Steam heater</td><td rowspan="4">Appropriate environment for casting (e.g., temperature, 37°C–42°C; humidity under 60%) is not prevailing most of the time in the casting shop. Replacement of total steam line, steam heater, and condensate drain line. Extension of steam heater position. Procurement of new pumps and spare parts for pumps and steam heater. To carry on running maintenance. Pumps, motors, agitators, steam heaters need continuous maintenance, which hampers the casting process. (Machines are installed during commissioning period.)</td><td rowspan="4">Head of Production, MTS, Account & Finance, and Commercial</td><td>Plan</td><td>SPR raised for procurement by OTM, IOTM, and LTM; work request submitted for maintenance</td><td>Procurement by LTM</td><td></td><td>Procurement by IOTM</td><td></td></tr>
<tr><td>Actual</td><td colspan="5">Maintenance and replacement of total steam line and condensate drain line. Extension of steam heater position and MTS work completed.</td></tr>
<tr><td>Plan</td><td colspan="5"></td></tr>
<tr><td>Actual</td><td colspan="5">Slip tank pump and agitator procurement and cost estimation ongoing. Running maintenance of pump, steam heater, and motor ongoing.</td></tr>
</table>

Note: SPR, store purchase requisition; IOTM, international open tendering method; RFQ, request for quotation; OTM, open tendering method; LTM, limited tendering method; MTS, maintenance and testing services. Text has been amended for grammar and style.
Source: Reproduced from a paper presented by BISFL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

Step Six: Implement Countermeasures
BISFL carried out the outlined measures to stabilize the supply of molds, improve slip quality, and maintain optimal casting conditions.

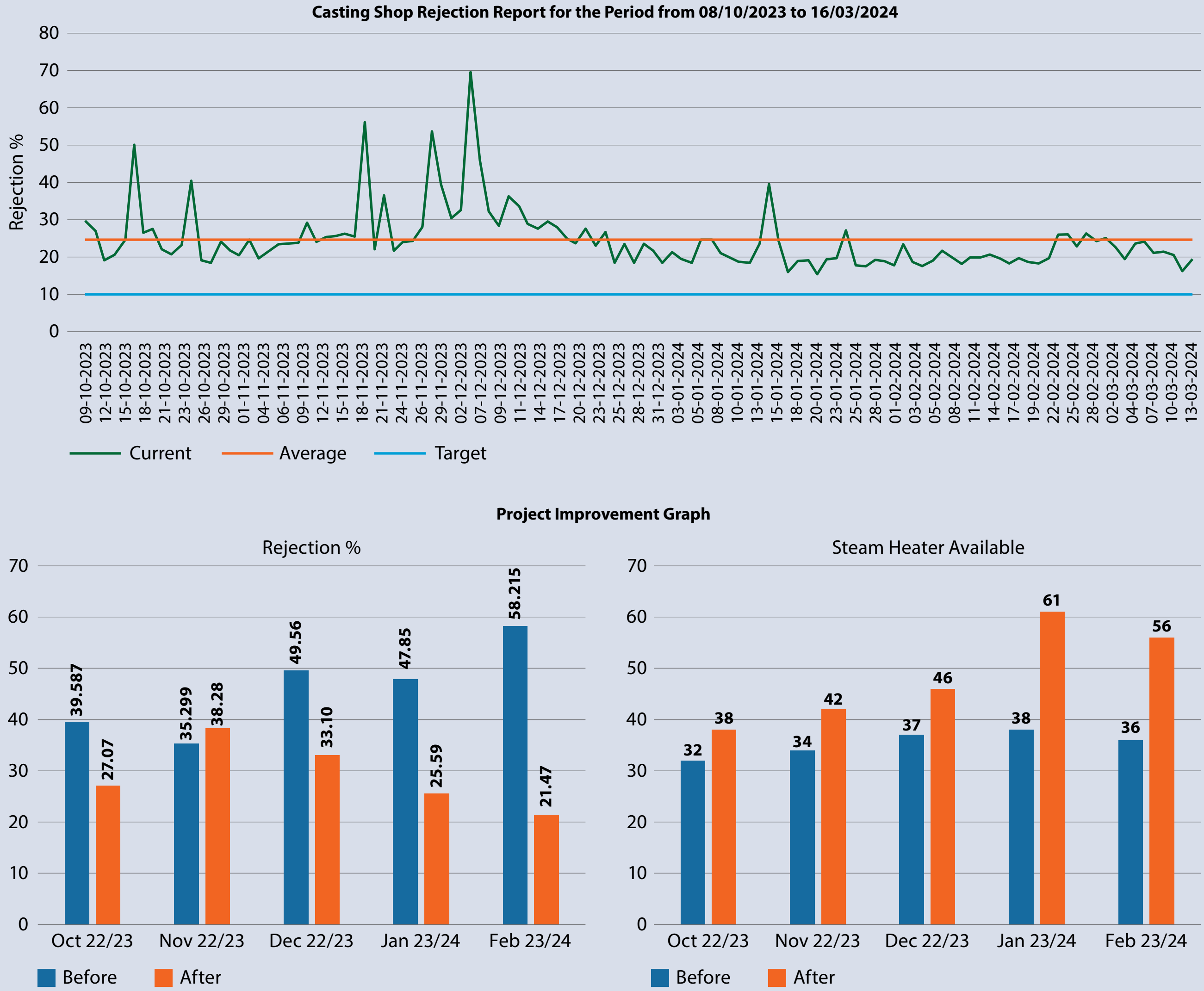
Step Seven: Evaluate Results and Process
BISFL noted a marked decline in rejection rates and improved productivity compared to the previous year. However, the company did not fully meet its set target. See Figure 11 for project progress details.

Step Eight: Standardize Successful Processes
Because of the placement of a new casting mold, casting rejection was not reduced to the target level. BISFL is trying to optimize this mold to reduce casting rejection further. In addition, BISFL is unable to achieve the required temperature due to the lack of natural gas supply.

BISFL could not achieve the project goals, but it did achieve significant productivity improvements. Based on this achievement, they will introduce a standardization process and will continue to use the LMS approach to achieve the project goals. A second project aims to lower production costs by introducing energy-efficient kiln car furniture.

FIGURE 11

BISFL EVALUATES RESULTS AND PROCESSES.



Source: Reproduced from a paper presented by BISFL at the project dissemination conference, Dhaka, Bangladesh, 4 September 2024.

BISFL's project leader has led the team with tenacity. In addition, as mentioned above, the support of management has been significant since the project began. Although they were unable to reach the initial project goals, they can continue to make improvements by continuing to follow the LMS process.

BEST PRACTICES AND LESSONS LEARNED

There were aspects of each of the TSPCL, DAPFCL, and BISFL projects that could be called best practices.

Once the TSPCL project got underway, good teamwork quickly brought about improvements. The TSPCL team was able to move straight on to the second project based on these results.

The DAPFCL project showed the importance of cooperation between departments. In projects involving multiple departments or teams, it is common for friction to occur between them. It took some time, but the departments worked together sincerely, exchanging frank opinions and aligning the direction of their project activities. As a result, they were able to produce good results.

BISFL demonstrated the importance of including top management in project activities. Top management showed an understanding of the project activities and actively participated in them, leading to lively activities throughout the company.

As a lesson learned, in future LMS activities, the objectives and goals of the LMS should be shared in a way that is easy for everyone to understand and based on specific examples from the outset. This can prevent discrepancies from arising in relation to the expected effects. The importance of cooperation between organizations and the importance of active management involvement should also be shared in advance. With these measures, LMS project activities can lead to effective results in a short period of time.

CONCLUSION

The usefulness of LMSs was demonstrated through the three demonstration company projects. By following the eight steps outlined in the Lean Management System Project Methodology chapter, companies can expect significant results. In addition, other companies in Bangladesh are aiming to improve their internal departments by applying the LMS approach based on the results of this project.

However, it is not easy to follow the eight steps. It is crucial to continue to promote continuous improvement activities while maintaining teamwork. Employees and management need to continue to work together as a team to achieve high goals with perseverance.

We hope other organizations will apply these case studies to ensure collaboration and stakeholder commitment for continuous productivity improvement. We expect a nationwide productivity movement in Bangladesh that fosters sustainable growth, reduces waste, and enhances knowledge-based productivity.

APPENDIX

Project Documentation Samples

Introduction to the lean management system, prepared by the author.

Definition of Lean Management System

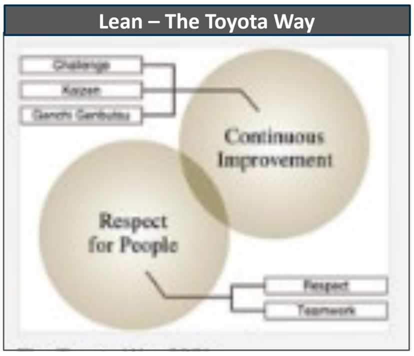
Lean management

is a business approach for maximizing customer value while minimizing waste. It is based on the principles of the Toyota Production System (TPS) and aims to create a culture of continuous improvement in an organization.

Lean – The Toyota Way

In 1950's Toyota faced

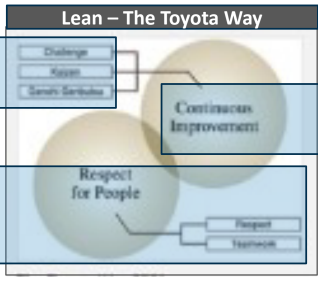
- ✓ Lack of Money
  ➡ Efficient use of capital
- ✓ Lack of Manpower
  ➡ Human Productivity Improvement
- ✓ Lack of Equipment
  ➡ Equipment Productivity Improvement



https://www.toyota-global.com/company/history_of_toyota/75years/data/conditions/philosophy/toyotaway2001.html

Three Key Elements of Lean Management

1. Eliminate Waste



2. Continuous Improvement

3. Involvement of Everyone

Eliminate Waste

Waste is considered as any activity which does not add value to the operation.

Followings are the major 7 wastes.

- ✓ Overproduction – making too much too early
- ✓ Waiting – need to keep a flow of material/customers
- ✓ Unnecessary Motions – ergonomics and layout
- ✓ Transporting – unnecessary movements/handling
- ✓ Processing – too much capacity in one machine
- ✓ Inventory – raw material, work in process and finished goods
- ✓ Defects – costs of defects tend to escalate

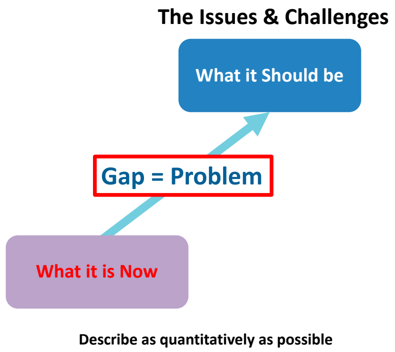
Evaluate by Data

Problem Solving Through Toyota Lean Management

	Steps	
P	Step 1	**Clarify the problem**
	Step 2	**Break down the problem**
	Step 3	**Set a target**
	Step 4	**Analyze the root cause**
	Step 5	**Develop countermeasures**
D	Step 6	**Implement countermeasures**
C	Step 7	**Evaluate Results and Process**
A	Step 8	**Standardize Successful Processes**

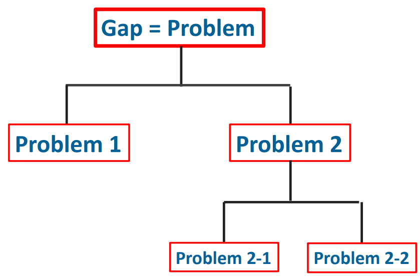
Project Phase-1 : Planning – Step1

P	Step 1	Clarify the problem
	Step 2	Break down the problem
	Step 3	Set a target
	Step 4	Analyze the root cause
	Step 5	Develop countermeasures
D	Step 6	Implement countermeasures
C	Step 7	Evaluate Results and Process
A	Step 8	Standardize Successful Processes



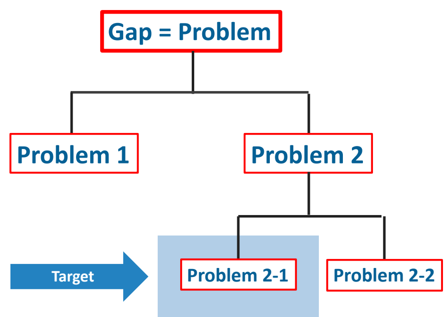
Project Phase-1 : Planning – Step2

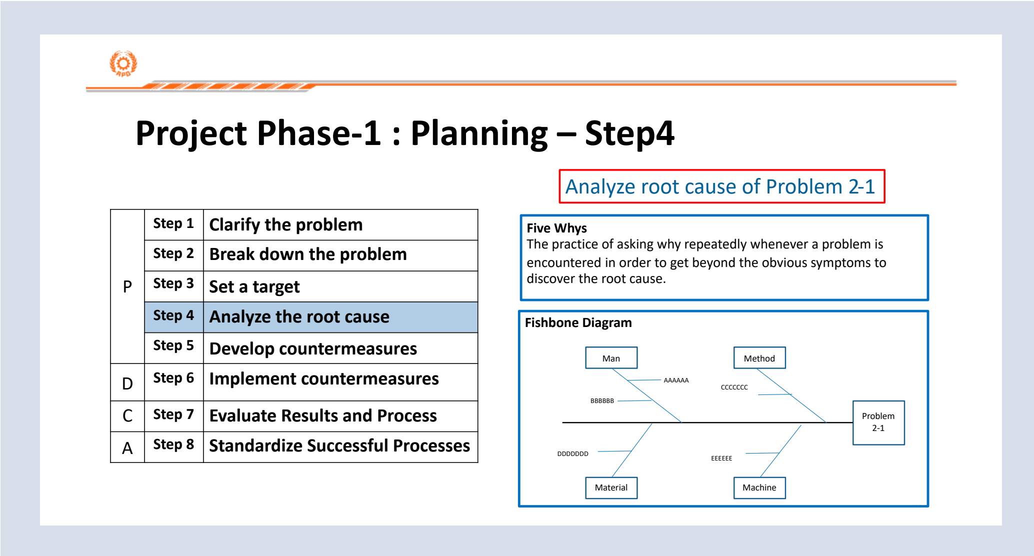
P	Step 1	Clarify the problem
	Step 2	Break down the problem
	Step 3	Set a target
	Step 4	Analyze the root cause
	Step 5	Develop countermeasures
D	Step 6	Implement countermeasures
C	Step 7	Evaluate Results and Process
A	Step 8	Standardize Successful Processes

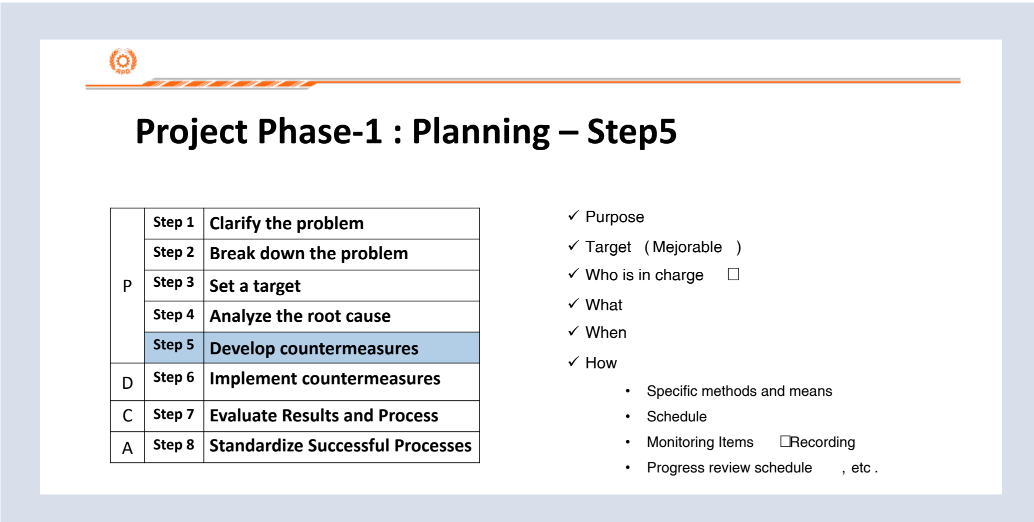


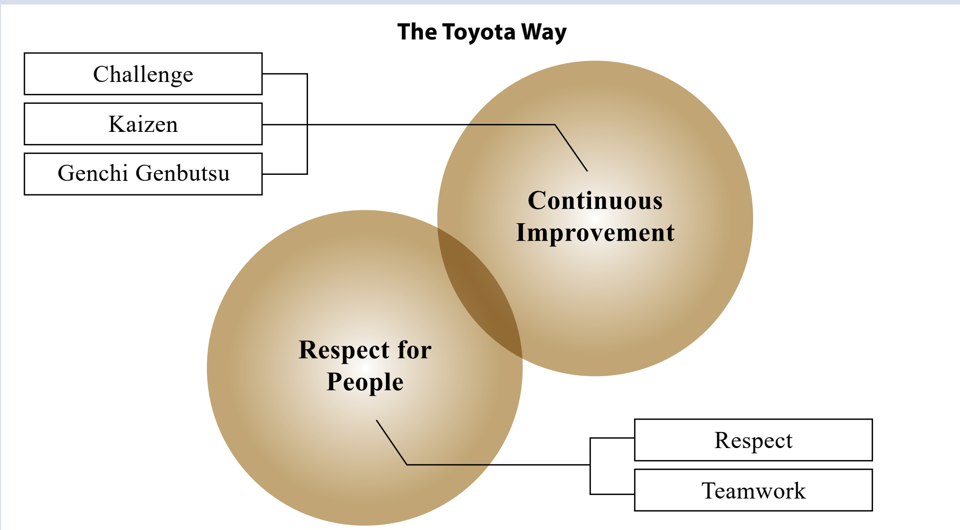
Project Phase-1 : Planning – Step3

P	Step 1	Clarify the problem
	Step 2	Break down the problem
	Step 3	Set a target
	Step 4	Analyze the root cause
	Step 5	Develop countermeasures
D	Step 6	Implement countermeasures
C	Step 7	Evaluate Results and Process
A	Step 8	Standardize Successful Processes









Source: Toyota Motor Corporation (n.d.).

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LIST OF ABBREVIATIONS

4M	Man, machine, material, method
BCIC	Bangladesh Chemical Industries Corporation
BDT	Bangladeshi taka (currency of Bangladesh)
BISFL	Bangladesh Insulator and Sanitaryware Factory Limited
CUFL	Chittagong Urea Fertilizer Limited, Bangladesh
DAP	Diammonium phosphate
DAP-1	Plant 1 of DAP Fertilizer Company Limited
DAP-2	Plant 2 of DAP Fertilizer Company Limited
DAPFCL	DAP Fertilizer Company Limited, Bangladesh
LMS	Lean management system
MT	Metric tons
NPO	National Productivity Organisation, Bangladesh
PDCA	Plan, do, check, act
ppm	Parts per million
SDGs	Sustainable Development Goals
TSP	Triple superphosphate
TSPCL	Triple Super Phosphate Complex Limited, Bangladesh

LIST OF TABLES

LIST OF FIGURES