Operational Analysis of Pak Argo Packaging Ltd.

By

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NUST Business School (NBS)

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Islamabad, Pakistan

(2024)

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A business project report is submitted to the National University of Sciences and Technology, Islamabad, in partial fulfillment of the requirements for the degree of

Executive Master of Business Administration (EMBA)

Supervisor: Dr. Mujtaba Hassan Agha

NUST Business School (NBS)

National University of Sciences & Technology (NUST)

Islamabad, Pakistan

(2024)

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ACKNOWLEDGEMENTS

All praise to Allah Almighty under whose blessing, I have been able to complete and present this report on "Operational Analysis of Pak Argo Packaging Ltd." It was a combined effort with the cooperation of all near and dear ones. I am indebted to them and seek their guidance, help and encouragement in future.

I would like to express my gratitude to Dr. Mujtaba Agha, who helped me in every part of this project. He motivated me to work on this project and support a lot in countering the problems we faced during the project.

Finally, I would like to emphasize my gratitude to my family for their continuous encouragement and unconditional love. A special mention of my parents' innumerable sacrifices and unwavering support which has allowed me to reach this far in life. Lastly I would like thank my wife and two sons for their unconditional support and love and I hope to do better every day in order to provide them with the best of everything. This dissertation is dedicated to them.

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ABSTRACT

Small and Medium Enterprises (SMEs) are considered to be the engine of an economy as they contribute significantly in the country's GDP and are a big source of employment generation. Currently there are more than 5 million SMEs in Pakistan that contribute 40% of the country's GDP and 25% in overall exports. The focus of this business project also revolves around one such SME called **Pak Argo Packaging Ltd. (PAPL**) that is based in Phase IV, Hattar Industrial Estate, KPK, Pakistan.

PAPL is Pakistan's pioneer and forefront company engaged in manufacturing of agricultural textile products. It's primary product Greenhouse Shade enjoys a 50% market share and its production and related operations shall be the emphasis of this business project.

A comprehensive operational analysis for this product was done for PAPL in which process flow charts for production of Greenhouse shade were prepared, accurate forecasting techniques were incorporated to predict month wise demand for 2023, plant's current production capacity was evaluated, raw material's inventory management progression was developed and the control limits, sigma level and the capability of the production process was assessed.

The operational analysis concluded that PAPL's current plant's production capacity is not sufficient to meet the forecasted demand of Y2023 and a shortfall of 72,155kgs would be observed. An addition of a Raschel Knitting machine was proposed in which an

investment of PKR 17.5M is required and the payback period for this investment would be four years.

Increasing productivity for SMEs is extremely important and for that it is highly recommended that an operational audit of their production operations is conducted annually so that market demand is met every time.

CHAPTER 1: INTRODUCTION

This chapter gives a brief introduction about Pak Agro Packaging Ltd (PAPL), company's core strength, product wise revenue mix and the overall footprint in Pakistan. A brief introduction to PAPL's main product line i.e. Greenhouse Shade will be given. This product would be the focus of our study as our entire analysis would be revolved around it's production operations. Several applications of Greenhouse Shades would be discussed and a snapshot of the production facility along with its location and contact details would be shared.

1.1 COMPANY INTRODUCTION

Figure 1.1.1: PAPL's Production Facility in Hattar Industrial Estate

Pak Agro Packaging Ltd (PAPL) is Pakistan's pioneer and forefront company engaged in manufacturing of agricultural textile products. PAPL is engaged in the business of providing textile products for a wide range of agricultural applications with more than two decades of experience and associated manufacturing acumen. The company's Head Office is located at **Office No. 302, 3rd Floor, Green Trust Tower, Jinnah Avenue, Blue Area, Islamabad, Pakistan** whereas the Production Facility situated at **Plot 22 & 23, Phase IV, Hattar Industrial Estate, Haripur, K.P.K, Pakistan.**

PAPL's journey began in May 2001 with a humble investment of Rs. 6M only. Through sheer hard work and sensible business decision making, the Company's Total Sales Revenue of Y2021 was PKR402.5M with a Net Profit (after taxation) of PKR 33.6M. A timeline of major events is given in **Appendix A** whereas organogram of the company's management team is given in **Appendix B** and company's SWOT Analysis has been done in **Appendix C.**

Commencing its operations as a net bag manufacturer relying on flat yarn supply from external vendors in the year 2000, PAPL has consistently expanded production capabilities, coupled with an emphasis on back-end integration. PAPL is considered as a fully integrated textile manufacturer and supplier of Greenhouse Shades, Support Nets, Anti Insect, Anti Hail, Bale Nets and Bags for a wide variety of agricultural applications. Apart from serving farmers' crop production and shading needs, PAPL also develops items for storage and packaging, protection and enhancement, and fishing/livestock uses. Aside from scaffolding, PAPL products meet several residential purposes also.

Figure 1.1.2: PAPL's Operational Outline
Source: Information Memorandum for Growth Enterprise Market Board Listing

The Company is a market leader in its particular market. PAPL enjoys a market share of 50% in Greenhouse Shades and most of its other products. It operates nationwide through a network of distributors without offering any credit facilities hence immune from credit risk. A large portion of the company's investment in its assets has been primarily funded by internally generated funds. Following is the company's footprint in Pakistan:

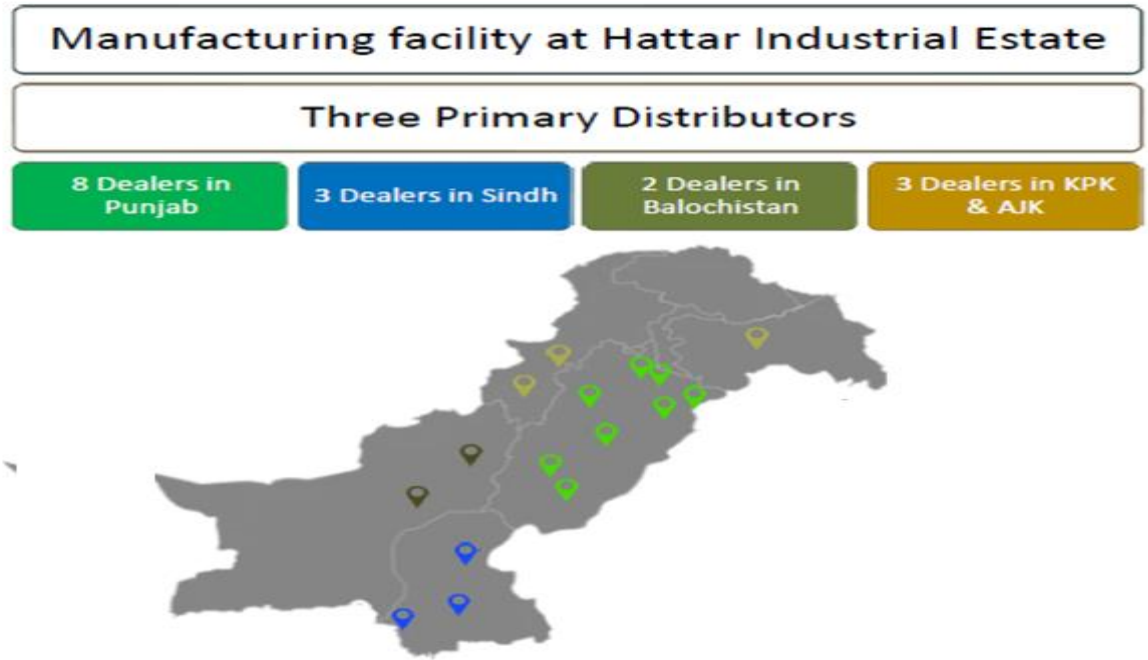

Figure 1.1.3: PAPL's Operational Outline
Source: Information Memorandum for Growth Enterprise Market Board Listing

Following two decades of successful operations, the company has finally taken a leap of faith and has expanded its operations into fishing net manufacturing. Post implementation of favorable tax amendments to promote localization of fish nets, PAPL intends to become a market leader in this vertical. For this purpose, solely, PAPL is now listed on the Growth Enterprise Market (GEM) board of Pakistan Stock Exchange. This enlistment in the will facilitate PAPL to raise capital for their future growth, expansion and diversification plans as the board aims to promote businesses especially the growing Small and Medium Enterprises (SME's).

1.2 PRODUCT LINE

PAPL produces several types of agricultural products namely Greenhouse Shades, Plant Support Nets, Specialized Net Shades, Net Bags and Other Net Products like Bale Nets and Filters. Only Greenhouse shades would be discussed in detail because it's production operation is our prime focus of study and it is also the primary product of PAPL. Following is the revenue was product mix for PAPL:

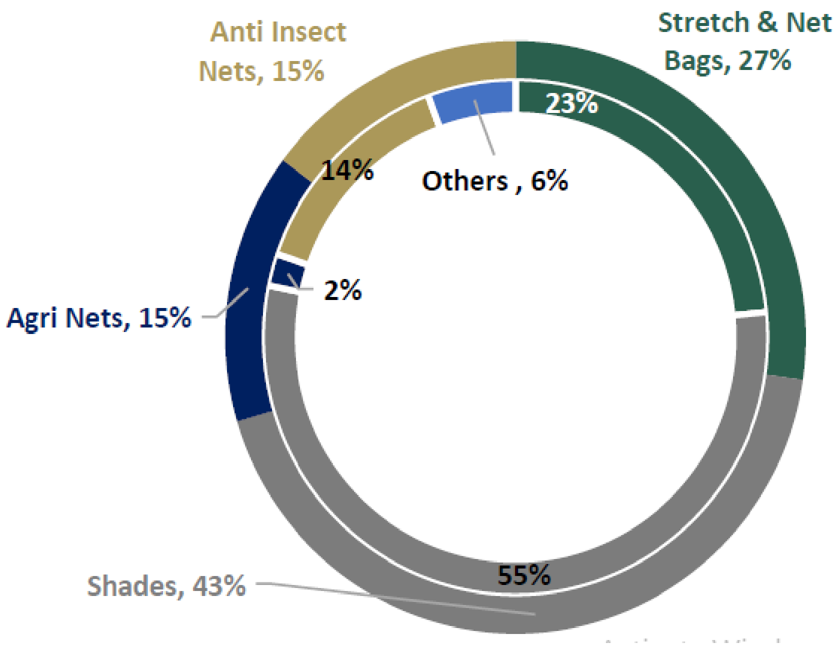

Figure 1.2.1: Revenue Mix for FY21 (Outside) and FY20 (Inside)
Source: Information Memorandum for Growth Enterprise Market Board Listing

Details of all other products are discussed in **Appendix C.**

1.3 GREENHOUSE SHADES

PAPL produces several varieties for Greenhouse shades in different breadths and lengths. Greenhouse Shades or Shading Nets is the prime business product of PAPL, and the company produces several varieties in different breadths and lengths:

1. Simple version made of flat yarn stripes.
2. Modern version made of round yarn.

Greenhouse shades serve several uses. Aside from farms and gardens, they are prevalent in many places that require shade, such as parking lots and outdoor waiting spaces. They come in two different forms and in a variety of colors, but Whole Green is the most popular. This product accounts for roughly 40% of the Company's sales.

Figure 1.3.1: Greenhouse Shades
Source: Information Memorandum for Growth Enterprise Market Board Listing

Greenhouse Shades Varieties: There are two types of greenhouse shades that are available to uses. **Round-Round Yarn Shade** also called RR-shade and **Flat Round Yarn Shade** also called FR-shade. Details of both these types of shades are given below:

Figure 1.3.2: FR Shade

- 1 Thread Round Yarn + 1 Thread Flat Yarn
- Available in 22kg, 25kg, 30kg, 40kg & 50kg.
- UV Stabilized to protect from sun heat and cold.
- Roll Dimensions usually 12’ x 50 meters but can be changed according to requirement.
- Shading Ratio is between 40 ~ 80% depending upon weight.
- Used widely for all shade applications.

Figure 1.3.3: RR Shade

- Both Threads of Round Yarn
- Available in 22kg, 30kg & 40kg.
- UV Stabilized to protect from sun heat and cold.
- Roll Dimensions usually 12’ x 50 meters but can be changed according to requirement.
- Shading Ratio is between 30 ~ 60% depending upon weight.
- Mostly used for nurseries.

Applications & Uses

Figure 1.3.4: Multiple Demand Verticals

1.4 PROBLEM STATEMENT

In the subsequent meetings with Mr. Tariq Javed (Executive Director) at PAPL's Head Office in Islamabad and Engr. Umar Daraz Khan (Production Manager) at PAPL's Hattar Plant, a number of problems that are being faced currently were highlighted.

PAPL is facing issues related to **fluctuating demand which peaks in the month of March, April, May & June.** The company's primary concern is **production capacity issues** as they are **facing product stock-outs,** especially during the peak months of March, April, May & June. PAPL wants to address the capacity issues by investing in an appropriate setup or machinery upgrade.

Related issue is with **ordering optimum amount of HDPE granule which is the primary raw material** to produce Greenhouse Shade. This issue arises especially during the peak season from March to June each year. PAPL would like to address this issue by developing an inventory management progression.

Lastly the company is also concerned that their **production process is out of control, and they are delivering excess products to the end customer**. PAPL would like to address this issue by evaluating the control limits, determining the sigma level of the production and the overall capability of the production processes.

From the basic concepts of operations & supply chain management, following solution methodology will be applied to propose solutions to the above-mentioned problem statement:

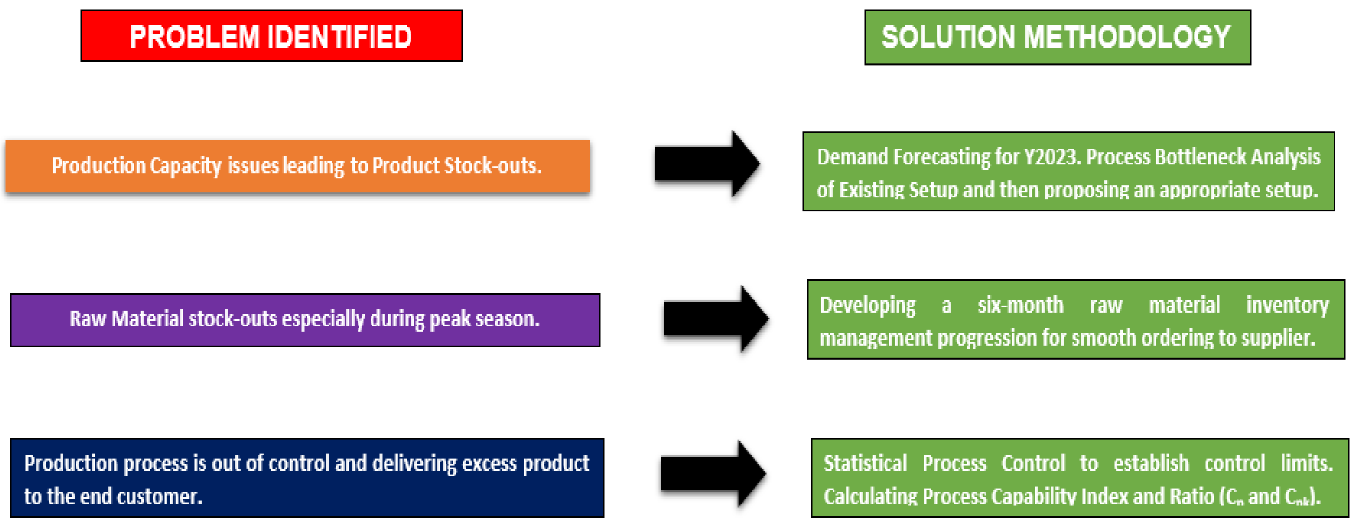

Figure 1.4.1: Project Solution Methodology

CHAPTER 2: PROCESS STUDY

To evaluate the production capacity of PAPL's Hattar plant the first thing to do is to understand the production operations of Greenhouse shade. For this study it is necessary to have a complete understanding of each production process individually. In this chapter a detailed study about the processes involved in the production of greenhouse shade is given so that process flowcharts for each production process are made. After visiting the factory there were three processes identified which are as follows:

a) **PROCESS 1 - YARN MANUFACTURING:** In the first phase of the production process yarn is being manufactured. There are two types of yarn that is being manufactured. A) Flat Yarn and B) Round Yarn. The series of steps involved in yarn manufacturing were studied, details of which are in the following sections of this chapter.
b) **PROCESS 2 - KNITTING OF GREENHOUSE SHADE:** In the second phase of the production yarn is being knitted into cloth by Raschel Knitting machine. There are two types of greenhouse shade that is being produced A) FR shade and B) R shade. Configurations of both these shades were studied, details of which are in the following sections of this chapter.
c) **PROCESS 3 - PACKAGING AND STORAGE:** The final phase of the production process is packaging and storage. After a series of quality checks, knitted greenhouse cloth is cut, wounded into rolls and then packaged for storage or onwards delivery to customer. Details of steps involved in this process were studied, details of which are in the following sections of this chapter.

2.1 PROCESS 1 - YARN MANUFACTURING

Yarn manufacturing is the first step of the production process. The main raw materials for yarn manufacturing are HDPE Monofilament Granules which is 100% Imported and Master Batch Green Color. The entire process consists of total six steps which are as follows:

d) **MIXING:** Automatic mixing of ingredients as hopper sucks material from mixer.

e) **HEATING**: Raw Material is heated to melt it using heaters. Temperature rises from 120^0C to 275^0C

f) **YARN CONVERSION & SUBSEQUENT COOLING:** Melted material is then converted to yarn through dies and the process is followed by cooling in cool water tank.

g) **ROLLING:** Pulling rollers are used to pull the yarn from dies.

h) **STRETCHING + DRYING:** Temperature of 1000C is maintained to stretch the yarn up to required thickness to ensure strength. Rollers are used to stretch the yarn in the hot water tank and then hot air is used to dry the wet yarn.

i) **CUTTING & WINDING:** Yarn is cut and wounded on beam and bobbins.

Pictures of each of the six sub processes involved in yarn manufacturing are given in **Appendix E.** Process flow chart is as follows:

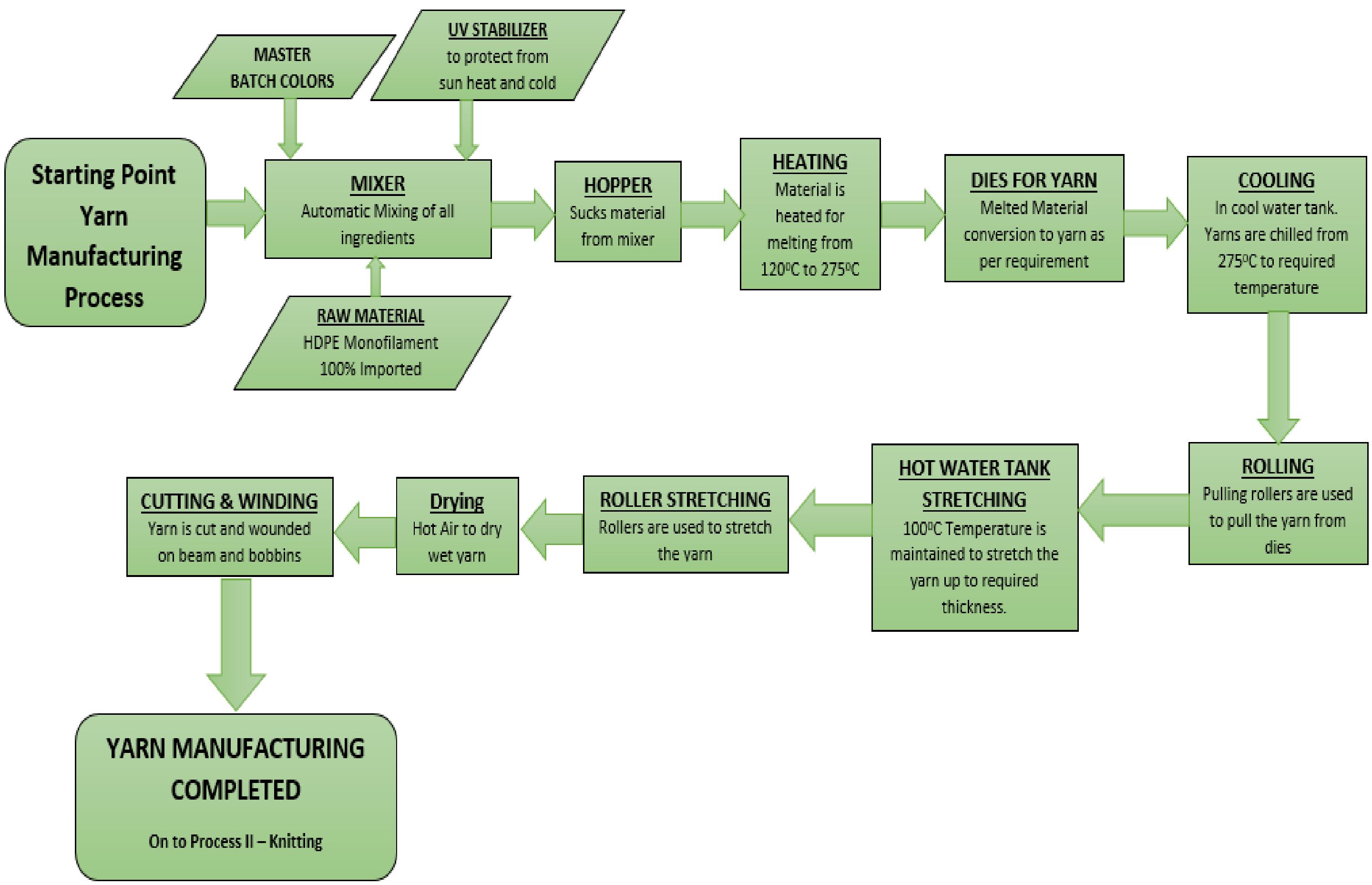

Figure 2.1.1: Process Flow Chart for Yarn Manufacturing

After following the above steps in series the final output of this process are two types of yarn which are:

a) Flat Yarn that is being wound on bobbins.
b) Round Yarn that is being wound on beams.

2.2 PROCESS 2 - KNITTING

Knitting of yarn produced in Process 1 is the next process to get Knitted Greenhouse Cloth. Knitting is done on Raschel Knitting Machine where the inputs are flat yarn and round yarn. The final output of this process is knitted greenhouse cloth on rollers which is of two types configuration of which are as follows:

a) FR greenhouse shade: One thread of round yarn and one thread of flat yarn. There are two inputs section to the machine. Round Yarn on beams is mounted on top of the knitting machine which is called Section A. Flat yarn on bobbins is mounted behind the knitting machine which is called section B. One thread of each section is being knitted to get the FR greenhouse shade.
b) RR greenhouse shade: Both threads of round yarn. Round Yarn on beams is mounted on top of the knitting machine which is the only input to the knitting machine.

Final output of this process is knitted greenhouse shade (either FR or RR). Pictures of the Knitting Process are given in **Appendix F** whereas Process flow chart is as follows:

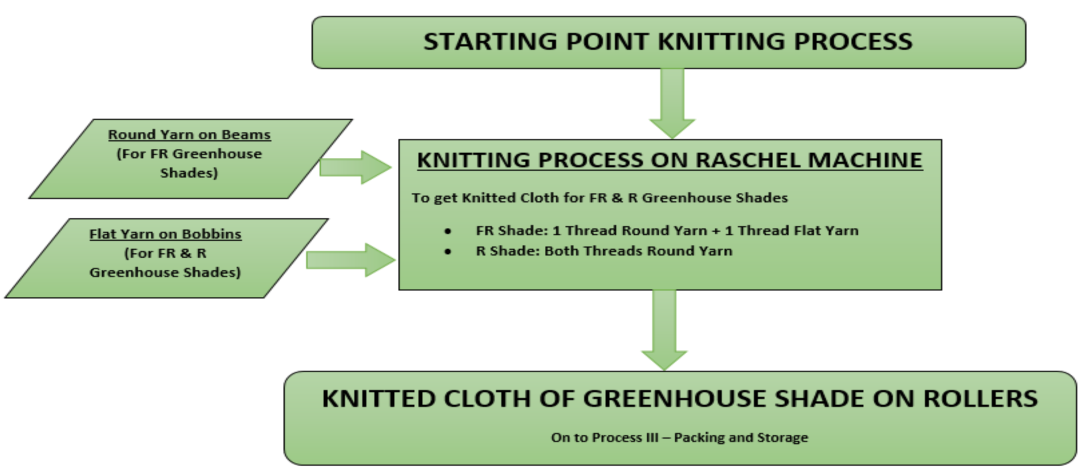

Figure 2.2.1: Process Flow Chart for Knitting

2.3 PROCESS 3 - PACKAGING AND STORAGE

The knitted cloth produced in Process 2 is then packaged and stored, which is the third process of production. Final output of this process is then delivered to the to customer. There are six sub-processes in this process which are as follows:

a) **Measuring of Knitted Cloth:** Spreading of Knitted Cloth under shed and measuring in batches of 50 meters.
b) **Quality Check:** Visual Inspection for thread breakage and manual stitching of areas where threads are broken.
c) **Cutting and Winding:** Winding usually in 50 meters of knitted cloth is done on the winding machine.
d) **Packing:** using a rolling machine. Knitted cloth is packaged in rolls.
e) **Weight Check:** on weighing machine and manual stitching of deficient cloth.
f) **Storage:** Storage in warehouse and ready for customer delivery.

Figure 0.2: Winding, Packing and Storage in Warehouse

Process Flow Chart is as follows:

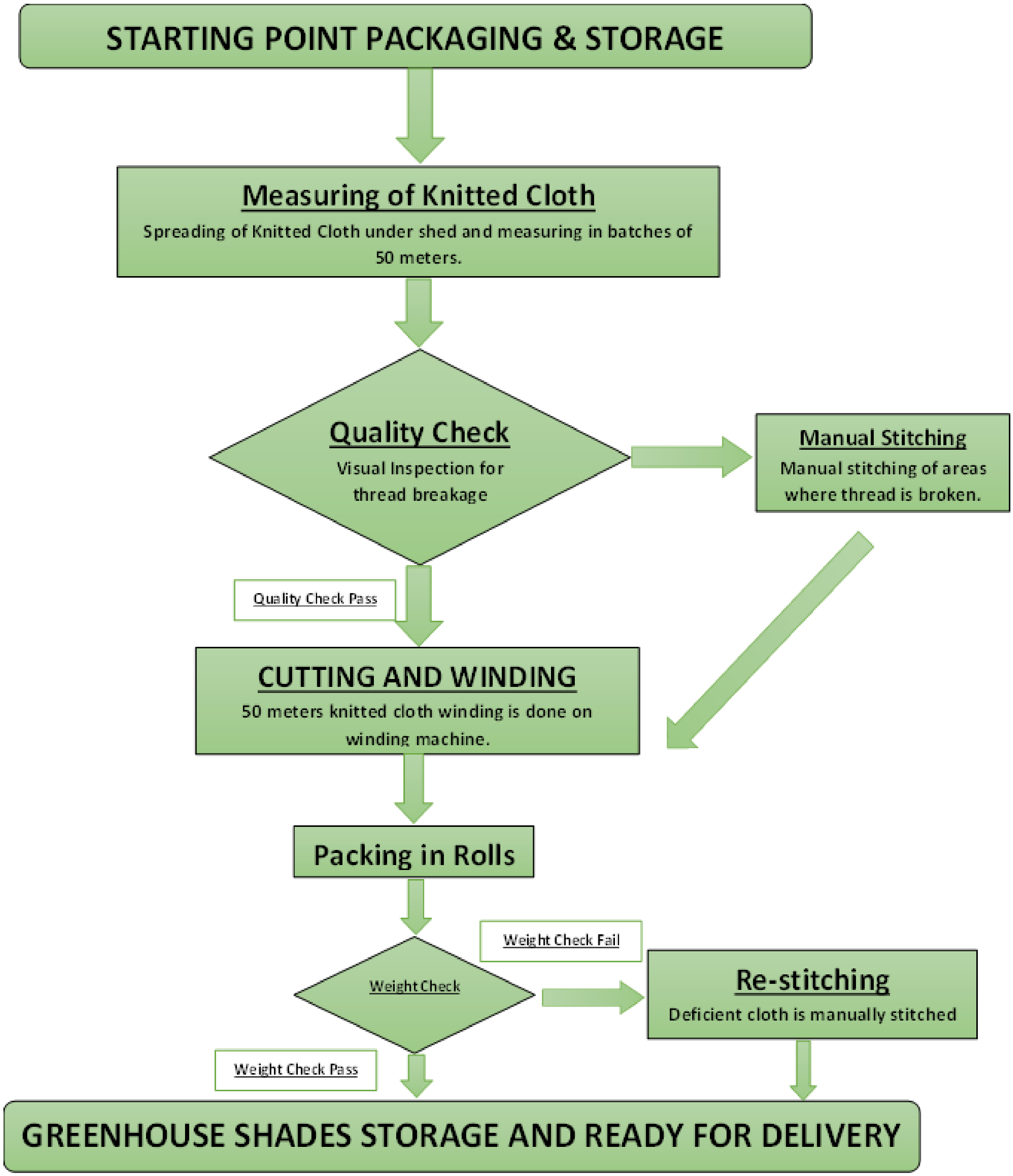

Figure 0.2: Process Flow Chart for Packaging and Storage

CHAPTER 3: ANALYSIS

This chapter is divided into five sections all of which are giving a detailed analysis. A brief summary as follows:

1) In the first section of this chapter monthly sales data of Greenhouse Shades from Y2019 to Y2022 was collected from the Sales and Marketing Department of PAPL. This data will be used so that an accurate forecast for Y2023 can be made. The data will be analyzed in detail and a seasonal index for each month will be calculated. A regression equation will then be developed to forecast the Yearly Demand of Y2023. Lastly month wise demand will be calculated so that PAPL can prepare a monthly production schedule of greenhouse shades. The forecast for Y2023 will serve as a basis for all further calculations in the preceding sections of this chapter.

2) In the second section of this chapter, process wise data was gathered from the factory's production department. This data includes the no. of machines involved in each process, their cycle time, available production minutes, labor involved and their average monthly wage rate. Then a process wise operational analysis of existing production setup will be done. The bottleneck process will be identified and based on that the annual production of the plant in kgs will be calculated. This figure will tell us if the existing production capacity is capable enough of meeting the forecasted demand of Y2023.

3) In the third section of this chapter a new setup will be proposed by introducing a new Raschel knitting machine. The production calculations will be done once again to if the Y2023's demand is being met or not. If yes, then calculations like additional cost incurred, incremental profit margin (annual) and payback period will be calculated.

4) In the fourth section of this chapter, raw material inventory data was collected from PAPL's Finance & Supply Chain Department. Data such as raw material required,

Insurance Premium per year, storage costs, warehouse labor costs, ordering costs, lead time from supplier and no. of operational plant days was collected. After a detailed analysis a raw material inventory management progression will be developed. Inventory management parameters like Economic Order Quantity, Total cost of managing inventory, No. of Orders per year, Time between each order and reorder point will be calculated. These parameters will then be plotted to show a six-month raw material inventory management cycle.

5) In the fifth section of this chapter process control and process capability issues will be addressed. Samples of 50kg Greenhouse Shade (Size: 12' x 50 Meters) were weighed randomly during 10HRS from the warehouse. A statistical process control analysis of the data will be done. Upper and Lower control limits of both X-Chart and R-Chart will be calculated and then both charts will be plotted to see if the entire production process is under control or not. Then to check the process capability, process capability ratio (C_p) and process capability index (C_{pk}) will be calculated.

3.1 DEMAND FORECASTING ANALYSIS FOR Y2023

Yarn manufacturing is the first step of the production process. The main raw materials for yarn manufacturing are HDPE Monofilament Granules which is 100% Imported and Master Batch Green Color. The entire process consists of total six steps which are as follows:

3.1.1 Data Gathering and Analysis for Demand Forecasting:

Following monthly sales data of greenhouse shades from Y2019 to Y2022 was gathered from the Sales and Marketing Department of PAPL so that demand for Y2023 can be forecasted.

Yearly Sales Data of Greenhouse Shades (in kgs) for PAPL				
Month	**Y2019**	**Y2020**	**Y2021**	**Y2022**
January	15,000	16,000	18,000	21,000
February	40,000	42,000	45,000	50,000
March	81,000	84,000	92,000	100,000
April	90,000	98,000	102,000	111,000
May	100,000	107,000	110,000	120,000
June	104,000	110,000	112,000	122,000
July	57,000	60,000	65,000	71,000
August	26,000	28,000	30,000	35,000
September	6,800	7,500	9,000	11,500
October	2,100	2,600	2,900	3,000
November	1,550	1,600	1,800	2,000
December	500	600	7,000	1,000
Totals (kgs)	**523,950**	**557,300**	**594,700**	**647,500**

Table 3.10: PAPL Yearly Sales Data (Y2019 to Y2022) for Greenhouse Shades (in kgs)
Source: Company's Sales Data File from PAPL's Sales & Marketing Department

From the data given in Table 3.1, we can easily notice that the demand is seasonal in the months of March, April May and June and after that the demand is considerably low. This seasonal demand is recurring each year from Y2019 to Y2022. Based on this data we plot the Sales in Kgs versus Month on a graph and then analyze the date. The plot is shown on Figure 3.1 whereas the analysis is done in Table 3.2.

	2019	**2020**	**2021**	**2022**
March Demand (kgs)	81,000	84,000	92,000	100,000
April Demand (kgs)	90,000	98,000	102,000	111,000
May Demand (kgs)	100,000	107,000	110,000	120,000
June Demand (kgs)	104,000	110,000	112,000	122,000
Total Demand from March to June (kgs)	375,000	399,000	416,000	453,000
% of Total Annual Demand	**71.57%%**	**71.60%**	**69.95%**	**69.96%**

Table 3.2: Sales Data Analysis

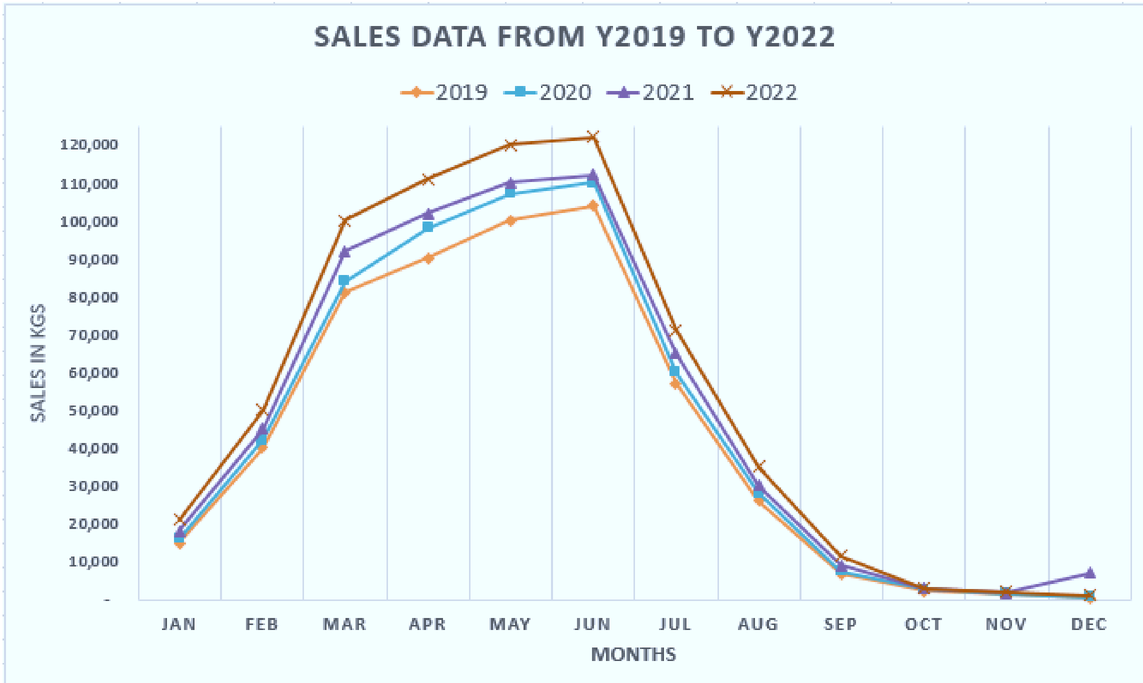

Figure 3.1.1: Plot of Sales in kgs vs Months (from Y2019 to Y2022)

Data Analysis:

Based on the plot of Figure 3.1 and results of Table 3.2 we can clearly see that almost 70% of the entire year sales occur in the months of March, April May & June and this trend is recurring each year. This conclusion clearly shows that Greenhouse shade is a seasonal product. We will now calculate the seasonal index for each month so that month wise production schedule can be forecasted.

3.1.2 Seasonal Index Calculation:

Month	**Demand (in kgs)**				**Average 2019-2022 (A)**	**Average of Average Monthly (B)**	**Seasonal Index = A/B**
	2019	**2020**	**2021**	**2022**			
Jan	15,000	16,000	18,000	21,000	17,500	48,405	0.362
Feb	40,000	42,000	45,000	50,000	44,250		0.914
Mar	81,000	84,000	92,000	100,000	89,250		1.844
Apr	90,000	98,000	102,000	111,000	100,250		2.071
May	100,000	107,000	110,000	120,000	109,250		2.257
Jun	104,000	110,000	112,000	122,000	112,000		2.314

Jul	57,000	60,000	65,000	71,000	63,250		1.307
Aug	26,000	28,000	30,000	35,000	29,750		0.615
Sep	6,800	7,500	9,000	11,500	8,700	48,405	0.180
Oct	2,100	2,600	2,900	3,000	2,650		0.055
Nov	1,550	1,600	1,800	2,000	1,738		0.036
Dec	500	600	7,000	1,000	2,275		0.047
Totals (kgs)	**523,950**	**557,300**	**594,700**	**647,500**			

Table 3.3: Seasonal Index Calculation

Seasonal Index Analysis: As seen in Table 3.2, the seasonal index is very high in the months of March, April, May and June clearly showing that the demand is seasonal. The next step in forecasting is developing a regression equation.

3.1.3 Regression Analysis:

As we have the cumulative annual demand from Y2019 to Y2022, we can create an input table for the regression analysis.

Year	**Period (x)**	**Annual Demand (y)**
	t	**St**
2019	1	523,950
2020	2	557,300
2021	3	594,700
2022	4	647,500

Table 3.4: Input Data for Regression Equation

The inputs of Table 3.4 are then used to run a regression in Microsoft Excel. Results are given in Table 3.5.

SUMMARY OUTPUT	

Regression Statistics	
Multiple R	**0.993987761**
R Square	**0.98801167**
Adjusted R Square	0.982017505
Standard Error	7106.92444
Observations	4

ANOVA

	df	SS	MS	F	Significance F
Regression	1	8325240125	8325240125	164.8289046	**0.006012239**
Residual	2	101016750	50508375		
Total	3	8426256875			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	**478850**	8704.16926	55.01386585	0.000330248	441398.9824	516301.0176
X Variable 1	**40805**	3178.313232	12.83857097	0.006012239	27129.8219	54480.1781

Table 3.5: Regression results on MS Excel

From Table 3.5: Slope = 40,805 & Intercept = 478,850. Therefore, we can create regression equation using the following format:

Dependent Variable (y) = Intercept + (Slope)*(Independent Variable(x))

The regression equation would then be:

Annual Demand = 478,850 + 40,805 (Time (Years))

Interpretation of results of Regression Analysis: From the values given in Table 3.5, we can deduce the following:

a) **R Value:** Coefficient of correlation of 0.99 which means that there is a strong positive association between the dependent variable (demand) and independent variable (time).

b) **R^2 Value:** Coefficient of determination is above 0.95 which means that the regression model is reliable and that 98.8% variance of dependent variable (demand) is explained by the independent variable (time).

c) **Significance F Value:** is the p-value of the regression model. As this value of 0.006 is less than 0.05 it means that the whole regression model is statistically significant.

The next step in forecasting is calculating the annual demand using the regression equation.

3.1.4 Forecasting Annual Demand:

For Y2023 will be done by inserting t = 5 in the above regression equation:

Annual Demand Forecast for Y2023 = 478,850 + 40,805 (5) = <u>682,875kgs</u>

The next step in forecasting is calculating the monthly demand using the seasonal index calculated in Table 3.3 so that PAPL's month wise production schedule can be prepared.

3.1.5 Forecasting Monthly Demand:

To calculate monthly demand of Y2023 we will use the seasonal index calculated in Table 3.3 and multiply it with the forecasted annual demand. Results are in Table 3.6:

Month	**Seasonal Index**	**Monthly Demand in kgs = (682,875 / 12) * Seasonal Index for each Month**
Jan	0.362	20,573
Feb	0.914	52,021
Mar	1.844	104,924
Apr	2.071	117,856
May	2.257	128,437
Jun	2.314	131,670
Jul	1.307	74,358
Aug	0.615	34,975
Sep	0.180	10,228
Oct	0.055	3,115
Nov	0.036	2,043
Dec	0.047	2,675
Totals (kgs)		**682,875**

Table 3.6: Monthly demand

Overall Results of Demand Forecasting Analysis:

We can deduce the following results from the demand forecasting analysis:

1. Demand of Greenhouse shade is seasonal. Almost 70% demand occurs in the months of March, April, May & June each year. Maximum demand is in the month of June after that the demand decreases. Demand is extremely low in the last quarter of the year.
2. Regression analysis is an accurate method to forecast the demand as the trend shows a linear relationship between the dependent and independent variable.
3. Forecasted demand for Y2023 is 682,875kgs of Greenhouse Shade.
4. Using the results of Table 3.6, a month-wise production schedule can be made by PAPL.

3.2 ANALYSIS OF EXISTING PRODUCTION SETUP

To analyze the existing production setup capacity, we have to study each production process separately. Data would then be analyzed to calculate the total production minutes, cycle time (in kg / min), total production in kgs per day and total labor cost per month in existing setup for each process. This will help us determine the bottleneck process which eventually is the plant's production capacity. Process Wise Data is gathered and then each process is analyzed individually. Results have been as follows:

3.2.1 Process 1 – Yarn Manufacturing Process Analysis in Existing Setup

Following Data for yarn manufacturing was gathered from factory's production department and physically witnessing each machine. Data has been tabulated in Table 3.7.

No. of Yarn Manufacturing Machines	4
Cycle Time (kg per hour)	25
Production minutes per shift = **480mins (8 Hours Shift) - 50 Minutes Lunch Break - 2 x 15 Mins Tea Breaks**	400
No. of shifts per day	3
No. of Operators Per Shift Per Machine	2
No. of Helpers Per Shift Per Machine	4

No. of Supervisors Per Shift	1
Avg. Monthly Wage Rate of Yarn Machine Operators	PKR 35,000
Avg. Monthly Wage Rate of Yarn Machine Helpers	PKR 24,000
Avg. Monthly Wage Rate of Yarn Machine Supervisors	PKR 70,000

Table 3.7: Yarn Manufacturing Data
Source: Record File of PAPL's Production Department

Based on the data of Table 3.7, analysis of Yarn Production in existing setup is being done in Table 3.8:

Analysis of Yarn Production in Existing Setup	
Cycle Time (kg per hour) (for 4 machines) = Cycle Time for one machine * No. of Machines = 25 x 4	100kg per hour
Cycle Time (kg per min) = kg per hour / 60mins = 100 / 60	1.67kg per min
Total Production Minutes per day = Production minutes per shift * No. of shifts per day = 400 * 3	1200minutes
Total Yarn Produced in kgs per day = Cycle Time (kg per min) * Total Production Minutes per day = 1200 * 1.67	**2000kgs per day**
Calculations of Labor Cost for Yarn Production Process in Existing Setup	
Labor Cost for Operators = No. of Operators * No. of Machines * No. of Shifts * Avg. Monthly Wage Rate of Operators = 2 * 4 * 3 * 35,000	PKR 840,000
Labor Cost for Helpers = No. of Helpers * No. of Machines * No. of Shifts * Avg. Monthly Wage Rate of Helpers = 4 * 4 * 3 * 24,000	PKR 1,152,000
Labor Cost for Supervisors = No. of Supervisors * No. of Shifts * Avg. Monthly Wage Rate of Supervisor = 1 * 3 * 70,000	PKR 210,000
Total Labor Cost = Labor Cost for Operators + Labor Cost for Helpers + Labor Cost for Supervisors = 840,000 + 1,152,000 + 210,000	**PKR 2,202,000**

Table 3.8: Analysis Yarn Production in Existing Setup

3.2.2 Process 2 – Knitting Process Analysis in Existing Setup

Following Data for Knitting Process was gathered from factory's production department and physically witnessing each Raschel Knitting machine. Data has been tabulated in Table 3.9.

No. of Knitting Machines	5
Cycle Time (kg per hour)	16
Production minutes per shift = **480mins (8 Hours Shift) - 25 Minutes Lunch Break - 1 x 15 Mins Tea Breaks**	440
No. of shifts per day	3
No. of Operators Per Shift Per Machine	1
No. of Helpers Per Shift Per Machine	2
No. of Supervisors Per Shift	1
Avg. Monthly Wage Rate of Knitting Machine Operators	PKR 35,000
Avg. Monthly Wage Rate of Knitting Machine Helpers	PKR 24,000
Avg. Monthly Wage Rate of Knitting Machine Supervisors	PKR 70,000

Table 3.9: Knitting Production Data
Source: Record File of PAPL's Production Department

Based on the data of Table 3.9, analysis of Knitted Greenhouse Cloth Production in existing setup is being done in Table 3.10:

Analysis of Knitted Cloth Production in Existing Setup	
Cycle Time (kg per hour) (for 5 machines) = Cycle Time for one machine * No. of Machines = 16 x 5	80kg per hour
Cycle Time (kg per min) = kg per hour / 60mins = 80 / 60	1.33kg per min
Total Production Minutes per day = Production minutes per shift * No. of shifts per day = 440 * 3	1320minutes
Total Knitted Cloth Produced in kgs per day = Cycle Time (kg per min) * Total Production Minutes per day = 1320 * 1.33	**1760kgs per day**
Calculations of Labor Cost in Knitting Process in Existing Setup	
Labor Cost for Operators = No. of Operators * No. of Machines * No. of Shifts * Avg. Monthly Wage Rate of Operators	PKR 525,000

= 1 * 5 * 3 * 35,000	
Labor Cost for Helpers = No. of Helpers * No. of Machines * No. of Shifts * Avg. Monthly Wage Rate of Helpers = 2 * 5 * 3 * 24,000	PKR 720,000
Labor Cost for Supervisors = No. of Supervisors * No. of Shifts * Avg. Monthly Wage Rate of Supervisor = 1 * 3 * 70,000	PKR 210,000
Total Labor Cost = Labor Cost for Operators + Labor Cost for Helpers + Labor Cost for Supervisors = 525,000 + 720,000 + 210,000	**PKR 1,455,000**

Table 3.10: Knitting Production Analysis in Existing Setup

3.2.3 Process 3 – Packaging and Storage Process Analysis in Existing Setup

Following Data for Packaging and Storage Process was gathered from warehouse and factory's production department and physically witnessing each Packing machine. Data has been tabulated in Table 3.11.

No. of Packing Machines	1
Cycle Time (kg per hour)	150
Production minutes per shift = **540mins (9 Hours Shift) - 30 Minutes Lunch Break - 2 x 15 Mins Tea Breaks**	480
No. of shifts per day	2
No. of Operators Per Shift Per Machine	-
No. of Helpers Per Shift Per Machine	15
No. of Supervisors Per Shift	1
Avg. Monthly Wage Rate of Packaging Machine & Storage Helpers	PKR 24,000
Avg. Monthly Wage Rate of Packaging & Storage Supervisor	PKR 70,000
No. of Packing Machines	1

Table 3.11: Packaging and Storage Production Data
Source: Record File of PAPL's Production Department & Warehouse

Based on the data of Table 3.11, analysis of packaged and stored greenhouse shade is being done in Table 3.12:

Analysis of Packaged and Stored Greenhouse Shade in Existing Setup	
Cycle Time (kg per min) = kg per hour / 60 mins = 150 / 60	2.5kg per min
Total Packaging and Storage Minutes per day = Packaging & Storage minutes per shift * No. of shifts per day = 480 * 2	960minutes
Total Packaged and Stored Cloth in kgs per day = Cycle Time (kg per min) * Total Production Minutes per day = 960 * 1.33	2400kgs per day
Calculations of Labor Cost in Packaging and Storage Process in Existing Setup	
Labor Cost for Helpers = No. of Helpers * No. of Machines * No. of Shifts * Avg. Monthly Wage Rate of Helpers = 15 * 1 * 2 * 24,000	PKR 720,000
Labor Cost for Supervisors = No. of Supervisors * No. of Shifts * Avg. Monthly Wage Rate of Supervisor = 1 * 2 * 70,000	PKR 140,000
Total Labor Cost = Labor Cost for Operators + Labor Cost for Helpers + Labor Cost for Supervisors = 525,000 + 720,000 + 210,000	PKR 860,000

Table 3.12: Packaging and Storage Process Analysis in Existing Setup

3.2.4 Overall Analysis of Existing Production Setup

A summarized Results of Each Production Process in Existing Setup has been tabulated in Table 3.13.

Summarized Results of Each Production Process in Existing Setup		
Process Name	**Production Capacity Per Day**	**Labor Cost**
Process 1 – Yarn Manufacturing	2000kgs	PKR 2,202,000
Process 2 – Knitting	1760kgs	PKR 1,455,000
Process 3 – Packaging and Storage	2400kgs	PKR 860,000

Table 3.13: Summarized Results of Each Production Process in Existing Setup

Process Wise Analysis of Existing Production Setup: From the process wise calculations above and the results in Table 3.13 we can clearly see that the bottleneck process is Process 2: Knitting. This process determines the overall plant's production capacity. Hence we can say that existing production setup has a capacity of producing 1760kgs per day of Greenhouse Shade.

We will now conduct an analysis of the current production capacity versus the annual forecasted demand of Y2023 calculated in Section 3.1. Also the Total Annual Labor Cost will be calculated. The results have been tabulated in Table 3.14.

No. of Plant Operational Days = 365 - 18 Days Downtime	**347**
Annual Production of Greenhouse Shades in Existing Setup = Total Production per day * No. of Plant Operational Days = 1760 * 347	**610,720kgs**
Difference in Annual Production and Forecasted Demand for Y2023 = Annual Production of Greenhouse Shades in Existing Setup - Forecasted Annual Demand of Greenhouse Shades for Y2023 (From Table 4.5) = 610,720 – 682,875	**72,155kgs**
Additional Production required per day = Difference in Annual Production and Forecasted Demand for Y2023 / No. of Plant Operational Days = 72,155 / 347	**208kgs per day**
Annual Labor Cost in Existing Setup = (Total Labor Cost for Yarn Production + Total Labor Cost for Knitting Process + Total Labor Cost for Packaging and Storage Process) * 12 = (PKR 2,202,000 + PKR 1,455,000 + PKR 860,000) * 12	**PKR 54,204,000**

Table 3.14: Analysis of Current Production vs Forecasted Demand in Existing Setup & Annual Labor Cost Calculations

Overall Results of Existing Production Setup Analysis: We can deduce the following results from the existing production setup analysis:

1. Bottleneck process of production is Process 2: Knitting. This process determines the plant's overall production capacity.
2. Plant's current production capacity of Greenhouse Shade is 1760kgs per day or 610,720kgs per year.
3. Production shortfall of 72,155kgs will be witnessed by PAPL in Y2023 and for that production capacity should be increased by 208kgs per day to 1968kgs per day.

This capacity will only then be able to meet the forecasted annual demand of 682,875kgs for Y2023.

4. The Annual Labor Cost in Existing Setup is PKR54.2Million.

3.3 ANALYSIS OF PROPOSED PRODUCTION SETUP

We have identified the bottleneck to be the Knitting process as it restricts the production of Greenhouse shade to 1760kgs per day. We will try to elevate this constraint and check the production capacity again. To meet the production target of 1968kgs per day an addition of new Raschel Knitting Machine is proposed. We will calculate the new production capacity and its payback period in years after the sixth Knitting Machine is added.

3.3.1 Process 2 – Knitting Production Analysis in Proposed Setup

Calculations of Knitted Cloth Production Process in Proposed Setup	
Cycle Time (kg per hour) (for 5 machines) = Cycle Time for one machine * No. of Machines = 16 x 6	96kg per hour
Cycle Time (kg per min) = kg per hour / 60mins = 96 / 60	1.60kg per min
Total Knitted Cloth Produced in kgs per day = Cycle Time (kg per min) * Total Production Minutes per day = 1320 * 1.60	**2112kgs per day**
Calculations of Labor Cost in Knitting Process in Proposed Setup	
Labor Cost for Operators = No. of Operators * No. of Machines * No. of Shifts * Avg. Monthly Wage Rate of Operators = 1 * 6 * 3 * 35,000	PKR 630,000
Labor Cost for Helpers = No. of Helpers * No. of Machines * No. of Shifts * Avg. Monthly Wage Rate of Helpers = 2 * 6 * 3 * 24,000	PKR 864,000
Labor Cost for Supervisors = No. of Supervisors * No. of Shifts * Avg. Monthly Wage Rate of Supervisor = 1 * 3 * 70,000	PKR 210,000

Total Labor Cost = Labor Cost for Operators + Labor Cost for Helpers + Labor Cost for Supervisors = 525,000 + 720,000 + 210,000	**PKR 1,704,000**

Table 3.15: Knitting Production Analysis in Proposed Setup

A summarized Results of Each Production Process in Proposed Setup has been tabulated again in Table 3.16.

Summarized Results of Each Production Process in Proposed Setup		
Process Name	**Production Capacity Per Day**	**Labor Cost**
Process 1 – Yarn Manufacturing	2000kgs	PKR 2,202,000
Process 2 – Knitting	2112kgs	PKR 1,704,000
Process 3 – Packaging and Storage	2400kgs	PKR 860,000

Table 3.16: Summarized Results of Each Production Process in Proposed Setup

Process Wise Analysis of Proposed Production Setup: With the addition of sixth Raschel Knitting Machine we can see that the capacity of Knitting Process has increased to 2112kgs per day. From the above data we can clearly see that the new bottleneck process is Process 1: Yarn Production. Therefore, the plant's capacity of Producing Greenhouse Shade is 2000kgs per day with the proposed setup.

3.3.2 Process 2 – Analysis of Proposed Production Setup

We will now calculate the proposed production capacity, new annual labor cost, total additional cost involved and lastly. payback period. Results have been tabulated in Table 3.17.

Proposed Production Setup Capacity and Labor Cost Calculations	
Annual Production of Greenhouse Shades in Proposed Setup = Total Production per day * No. of Plant Operational Days = 2000 * 347	**694,000kgs**
Extra Production in Proposed Setup: Annual Production of Greenhouse Shades in Proposed Setup - Forecasted Annual Demand of Greenhouse Shades for Y2023 = 694,000 – 682,875	**11,125kgs**

Annual Labor Cost in Proposed Setup = (Total Labor Cost for Yarn Production + Total Labor Cost for Knitting Process + Total Labor Cost for Packaging and Storage Process) * 12 = (PKR 2,202,000 + PKR 1,704,000 + PKR 860,000) * 12	**PKR 57,192,000**
With the addition of sixth Raschel Knitting Machine, PAPL will be able to meet the forecasted demand of 682,875kgs and also keep a buffer stock 11,125kgs. Plant's production capacity with the proposed setup would be 2000kgs per day or 694,000 kgs per year. Now that the production issue is resolved, we will now calculate the total cost involved with the proposed setup and the payback period.	
Period Payback Calculations for Proposed Setup	
Annual Incremental Change in Production = Incremental Change in Production per day * Plant Operational Days = (2000-1760) * 347 = 240 * 347	83,280kgs
Initial Investment - Cost of Raschel Knitting Machine (Fixed Cost) = (CFR $ Price + 18% GST) * Exchange Rate = $44,000 * 1.18 * 280	PKR 14,537,600
Variable Cost will be calculated for the additional Greenhouse Shade produced by adding the Direct Material, Direct Labor and Overhead Cost	
Direct Material Cost (Raw Material Cost) 1. Raw Material 1 Cost per kg: HDPE Granule Cost (Imported) = $425 per Ton (CFR $ Price) = $425 * 1.18 * 280 / 1000 = PKR 140.42 per kg 2. **Raw Material 2 Cost per kg:** Masterbatch Green Color = $120 per kg (DDP Price) Total Direct Material Cost = {Raw Material 1 Cost per kg * 1.25 (1kg of Greenhouse requires 1.25kg of HDPE Granule) + Raw Material 2 Cost per kg} * Annual Incremental Change in Production = {PKR 140.42 * 1.25 + PKR 120} * 83,280	PKR 24,611,322
Direct Labor Cost = Annual Labor Cost in Proposed Setup - Annual Labor Cost in Existing Setup = PKR 57,192,000 – PKR 54,204,000	PKR 2,988,000
Overhead Cost = Overhead cost per kg * Annual Incremental Change in Production = PKR 80 * 83,280kgs	PKR 6,662,400
Total Variable Cost for additional Greenhouse shade produced = Direct Material Cost + Direct Labor Cost + Overhead Cost = PKR 24,611,322 + PKR 2,988,000 + PKR 6,662,400	PKR 34,261,722
Total Selling Price for additional Greenhouse shade produced = Selling price per kg * Annual Incremental Change in Production = PKR 450 * 83,280kgs	PKR 37,476,000

Total Annual Profit or Annual Cash flow generated for additional Greenhouse shade produced **= Total Selling Price - Total Cost Price** = PKR 37,476,000 - PKR 34,261,722	**PKR 3,214,278**
Payback Period (Years) = Initial Investment / Annual Cash flow generated = PKR 14,537,600 / PKR 3,214,278	**4.52 years**

Table 3.17: Payback Period Analysis of Proposed Production Setup

Overall Results of Proposed Production Setup Analysis:

We can deduce the following results from the existing production setup analysis:

1. To meet the forecasted demand of Y2023 i.e. 682,875kgs, PAPL will have to get a sixth Raschel Knitting Machine.
2. Plant's production capacity of the proposed setup will be 240kgs per day or 694,000kgs per year. This means a buffer stock of 11.125Tons can be kept also.
3. The total initial investment of the proposed setup would be PKR14.53Million. The total incremental profit would be PKR 3.21 Million and the payback period would be almost 4.5 years.

3.4 RAW MATERIAL INVENTORY MANAGEMENT ANALYSIS

HDPE Granule is the primary raw material for Greenhouse Shade which is 100% imported. An inventory management progression is required for PAPL so that raw material availability is ensured especially during the peak seasons from March to June. Inventory management parameters like Economic Order Quantity (EOQ), Total cost of managing inventory, time between orders and reorder point will be calculated an then a six-month inventory cycle will be plotted.

Following raw material inventory data was gathered from the PAPL's Finance & Supply Chain Department further analysis and formulation of raw material inventory management cycle.

HDPE Required for 1kg of Greenhouse Shade	1.25kg
Insurance Premium per year	PKR 720,000
Storage Costs per year (own warehouse)	PKR 300,000
Labor Cost of Warehouse per year = Monthly wage * 3 workers * 12 months = 30,000 * 3 * 12	PKR 1,080,000
Ordering Cost per order	PKR 6,500
Lead Time (Days)	15
Plant Operational Days	347

Table 3.18: Raw Material Inventory Management Data
Source: Record File of Raw Material Ordering in PAPL's Finance and Supply Chain Department

Based on the data collected in Table 3.18, inventory management parameters are calculated and results are tabulated in Table 3.19.

Annual Raw Material Required - D (For 1kg Greenhouse Shade, 1.25kg of HDPE Required) = Annual Demand of Y2023 x 1.25 = 682,875 x 1.25	853,594kgs
Holding Cost per kg per year - H = (Insurance Premium per year + Storage Costs per year + Labor Cost of Warehouse per year) / D = 720,000 + 300,000 + 1,080,000 / 853,594	PKR 2.46
Ordering Cost per order - S	PKR 6,500
Economic Order Quantity – Q* $= \sqrt{(\frac{2 * D * S}{H})}$ $= \sqrt{(\frac{2 * 853{,}594 * 6500}{2.46})}$	**67,160kgs**
Average Inventory – Q* / 2 = 67,160 / 2	33,580kgs
Annual Inventory Holding Cost = Q*/2 * H = 30,035 * 2.46	PKR 82,614
No. of Orders Each Year - N = D/Q* = 853,594 / 67,160	12.71

Annual Inventory Ordering Cost = N * S = 12.71 * 6500	PKR 82,614
Total Cost of Managing the inventory = Annual Holding Cost + Annual Ordering Cost = 82,614 + 82,614	**PKR 165,227**
Time between Orders (days) – T T = Plant Operational Days / N = 347 / 12.71	**27days**
Demand per day– d = D / Plant Operational Days = 853,594 / 347	2460kgs
Reorder Point - ROP = d x Lead Time in Days = 2460 * 15	36,900kgs
Safety Stock (kgs) (10% of ROP) – SS = 10% * 36,900	3,690kgs
Reorder point with Safety Stock = ROP + SS = 36,899 + 3690	**40,590**

Table 3.19: Raw Material Inventory Management Analysis

To plot an inventory management progression for six months based on the parameters calculated in Table 3.19, an inputs table can be created which is as follows:

Time (Days)	Inventory	Re-Order Level	Average Inventory	Max Inventory
0	67,160	40,589	33,580	67,160
27	-			
27	67,160			
55	-			
55	67,160			
82	-			
82	67,160			
109	-			
109	67,160			
137	-			
153	67,160			
180	-			

Table 3.20: Inputs for Six Months Inventory Cycle

Based on the results of Table 3.20 we can plot an inventory management cycle for six months which is as follows:

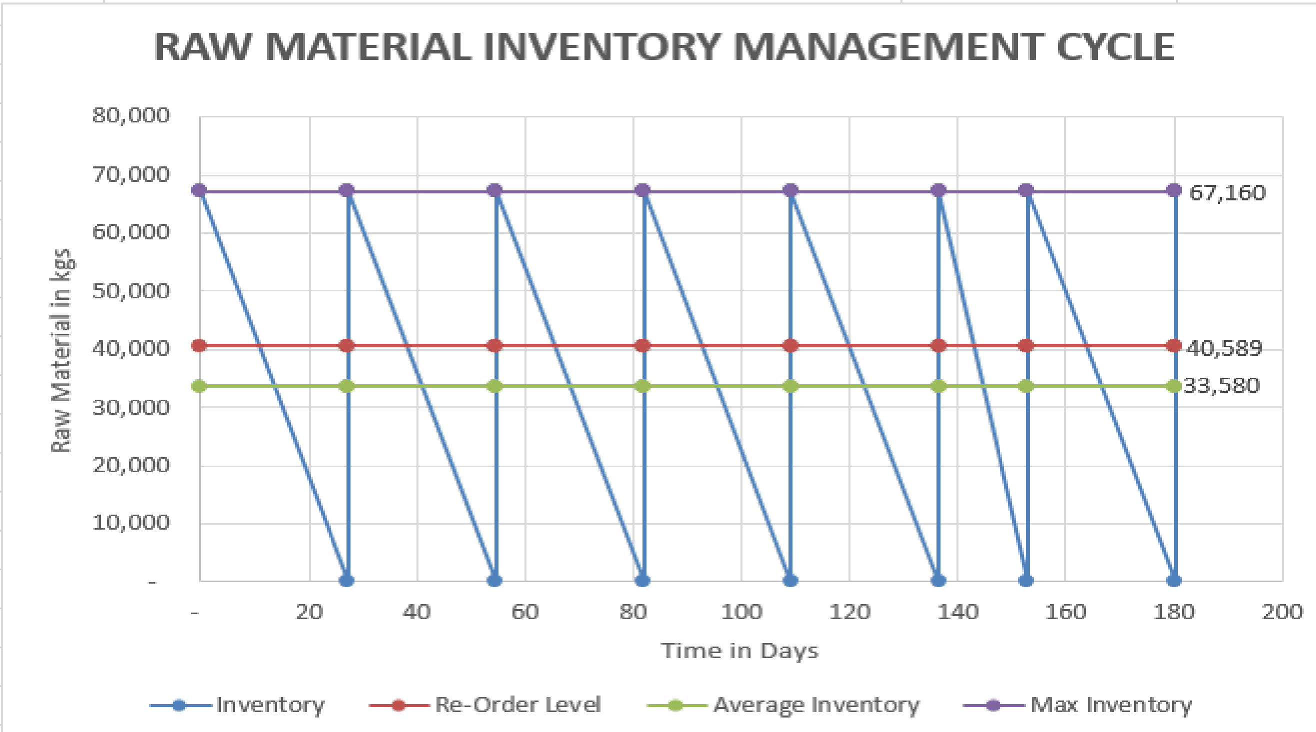

Figure 3.4.1: Raw Material Inventory Management Cycle

Inventory Management Analysis: PAPL should consider managing the inventory according to the following plan:

1. When the Raw Material Inventory Level reaches 40,590kgs management should place order to the supplier given that the lead time is 15 days. This will ensure smooth production.
2. The time between each order should be 27days.
3. Each order quantity should be 67,160kgs as it is the EOQ.
4. The total cost of managing the inventory is PKR 165,227.

3.5 PROCESS CONTROL & PROCESS CAPABILITY ANALYSIS

From PAPL's warehouse samples of 50kg Greenhouse Shade (Size: 12' x 50 Meters) were weighed during 10HRS to check if the entire production process is under control or not. Three samples rolls per hour were randomly sampled. Results are tabulated in Table 3.21:

Hour	Weight of Sample 1 (kg)	Weight of Sample 2 (kg)	Weight of Sample 3 (kg)
1	50.65	51.95	50.70
2	51.05	50.65	50.80
3	50.95	51.25	50.05
4	51.20	50.75	51.00
5	51.40	50.70	50.95
6	51.85	50.65	50.05
7	50.20	52.00	51.00
8	50.75	51.25	51.75
9	51.90	50.65	51.20
10	51.30	50.70	51.40

Table 3.21: Weights of Samples for SPC & PC

To check the control of the production of process we will use the basic quality tool of Statistical Process Control (SPC) analysis whereas process capability parameters of C_p and C_{pk} will be calculated to check the overall process capability. We will start off with SPC analysis which will be followed by the Process capability analysis.

3.5.1 Statistical Process Control (SPC) Analysis

From Table 3.21, we will calculate mean $\bar{\mathbf{X}}$ of the weight of Samples 1, 2 & 3 for each hour. Dispersion R will be calculated by subtracting the highest weight value with the smallest. Then values of $\bar{\bar{\mathbf{X}}}$ and $\bar{\mathbf{R}}$ will be calculated by taking mean of $\bar{\mathbf{X}}$ and R values. Results in Table 3.22:

Hour	Weight of Sample 1 – Column A (kg)	Weight of Sample 2 – Column B (kg)	Weight of Sample 3 – Column C (kg)	$\bar{\mathbf{X}}$ (Average of samples)	R (Dispersion in samples)
1	50.65	51.95	50.70	51.10	1.30
2	51.05	50.65	50.80	50.83	0.40
3	50.95	51.25	50.05	50.75	1.20
4	51.20	50.75	51.00	50.98	0.45
5	51.40	50.70	50.95	51.02	0.70

6	51.85	50.65	50.05	50.85	1.80
7	50.20	52.00	51.00	51.07	1.80
8	50.75	51.25	51.75	51.25	1.00
9	51.90	50.65	51.20	51.25	1.25
10	51.30	50.70	51.40	51.13	0.70
Averages				$\bar{\bar{X}}$ = 51.02	$\bar{R}$ = 1.06

Table 3.22: Calculating $\bar{\bar{X}}$ and $\bar{R}$ for SPC Analysis

The formula sheet for computing upper and lower control limits for X-Charts and R-Charts is given in **Appendix H** whereas the factors for computing limits is given in **Appendix I.**

3.5.1.1 X Chart Analysis: To check the central tendency of the process, firstly control limits for X-Chart are calculated. Then the input table is made and finally the results are plotted on an X-Chart.

Upper Control Limit for X-Chart = $\bar{\bar{X}} + A_2 \bar{R}$ (where A_2 = 1.023 from Appendix H & Appendix I) = 51.02 + 1.023*1.06	52.11
Lower Control Limit for X-Chart = $\bar{\bar{X}} - A_2 \bar{R}$ (where A_2 = 1.023 from Appendix H & Appendix I) = 51.02 - 1.023*1.06	49.94

Hour	$\bar{X}$	$\bar{\bar{X}}$	Upper Control Limit	Lower Control Limit
1	51.10	51.02	52.11	49.94
2	50.83			
3	50.75			
4	50.98			
5	51.02			
6	50.85			
7	51.07			
8	51.25			
9	51.25			
10	51.13			

Table 3.23: Upper, Lower Control Limits and Inputs for X-Chart

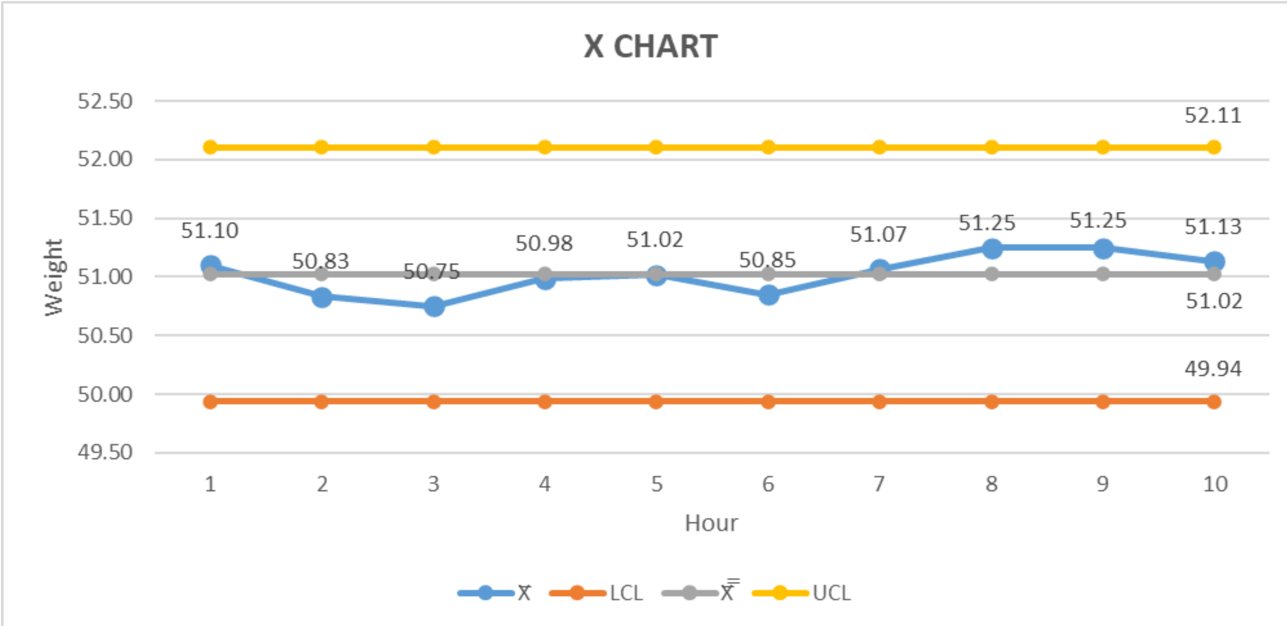

Figure 3.5.1.1: X-Chart

X-Chart Analysis: As all values of X chart are within the control limits so the process is under control for X-Chart.

3.5.1.2 R Chart Analysis: To check the dispersion of the process, firstly control limits for R-Chart are calculated. Then the input table is made and finally the results are plotted on an R-Chart.

Upper Control Limit for R-Chart = $D_4\,\overline{R}$ (where D_4 = 2.574 from Appendix H & Appendix I) = 2.574 * 1.06	2.73
Lower Control Limit for R-Chart = $D_3\,\overline{R}$ (where D_3 = 0 from Appendix H & Appendix I) = 0 * 1.06	0

Inputs for R Chart				
Hour	**R**	**$\overline{R}$**	**Upper Control Limit**	**Lower Control Limit**
1	1.30	1.06	2.73	0
2	0.40			
3	1.20			
4	0.45			
5	0.70			

6	1.80			
7	1.80			
8	1.00			
9	1.25			
10	0.70			

Table 3.24: Upper, Lower Control Limits and Inputs for R-Chart

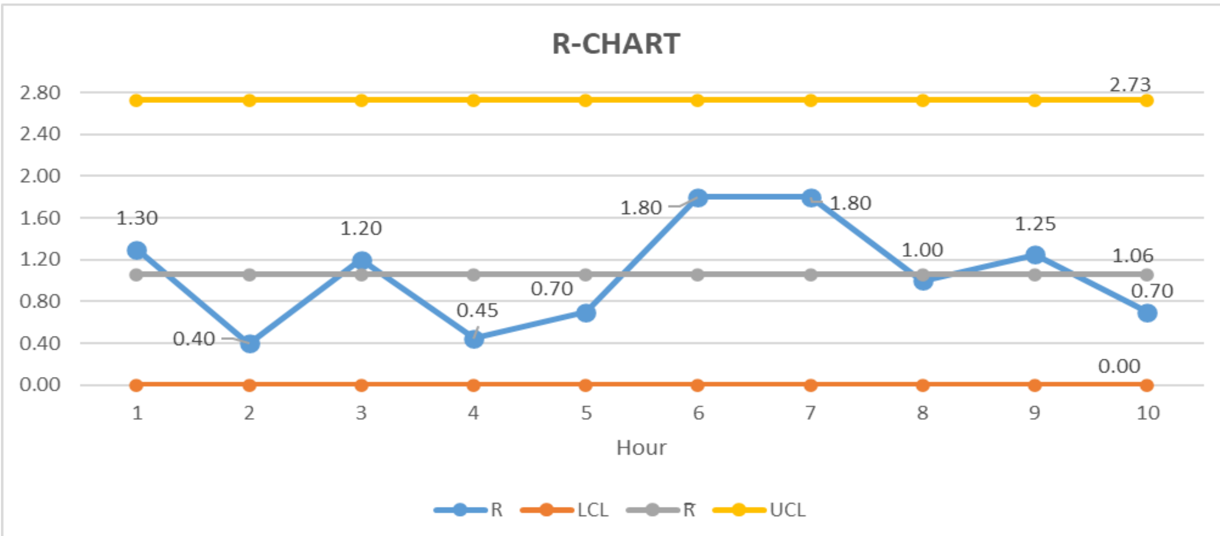

Figure 3.5.1.2: R-Chart

R-Chart Analysis: As all values of R chart are within the control limits the process is under for R-Chart.

Overall SPC Analysis: As all values in both X Charts and R Charts are within the control limits so the entire production process is under control.

Even though the process is under control we have to check the capability of the process and for that we have to perform the process capability analysis.

3.5.2 Process Capability Analysis:

Process capability is defined as the ability to meet design specifications. It has two basic parameters C_p & C_{pk} and both of them will be individually calculated.

3.5.2.1 Process Capability Ratio (C_p): is the ratio of the specification limits to the process variation. It basically shows the spread in the process. C_p is calculated by the following formula:

$$\mathbf{Cp} = \frac{Upper\ Specification - Lower\ Specification}{6\sigma}$$

We have already calculated the upper and lower control limits (of X-Chart) in Table 3.23.

To calculate standard deviation σ, we use =STDEV.P(all process values mentioned in Column A, B & C of Table 3.22) in MS Excel. The sigma value is calculated, σ = 0.516.

We can therefore now calculate C_p a follows:

$$\mathbf{Cp} = \frac{52.11 - 49.94}{6\ (0.516)}$$

$$\mathbf{Cp} = 0.701$$

Process Capability Ratio C_p Results: A C_p value of 0.701 indicates that production process is compliant to 2 σ methodology and corresponds to a 69.1% yield of good results. As this value is less than 1.0 the production process shows a high spread.

3.5.2.2 Process Capability Index (C_{pk}): gives an indication of the ability of a process to consistently provide output which is within required specifications or in other words a proportion of variation (3σ) between the center of the process and the nearest specification limit. C_{pk} basically shows the centering of the process around the mean. is calculated by the following formula:

$$\mathbf{Cpk} = Minimum\ of\ \{\frac{Upper\ Spec\ Limit - Desired\ Spec\ Limit}{3\sigma}, \frac{Desired\ Spec\ Limit - Lower\ Spec\ Limit}{3\sigma}\}$$

For a 50kg roll of greenhouse shade, the desired specification limit would be 50kg. Therefore, we can calculate Cpk value as follows:

$$\mathbf{Cpk} = Min\ \{\frac{52.11 - 50}{3(0.516)}, \frac{50 - 49.94}{3(0.516)}\}$$

$$\mathbf{Cpk} = Min\{4.31, 0.12\}$$

$$\mathbf{Cpk} = 0.12$$

Process Capability Index Cpk Results: A C_{pk} value of 0.12 indicates that production process is incapable and process is defective. Also as this value is less than 1.0 it shows that the production process has a low centering.

From Table 3.22 An $\bar{\bar{\mathbf{X}}}$ value of 51.02 indicates that PAPL is supplying an excess of 1.02kgs for each roll of 50kgs greenhouse shade produced. If this is the case, this means that for Y2023's forecast of 682,875kgs:

Greenhouse Shade additionally delivered in kgs = (682,875 / 50) x 1.02 = **13,657.5kgs**

OR

In PKR = 13,657.5 kgs x 450(PKR / kg) = **PKR 6,145,875** without even charging for it.

Overall Results of Process Control and Process Capability Analysis: We can deduce the following results from SPC and Process Capability analysis:

1. Production Process is under control according to Statistical Process Control Analysis as all points lie within the control limits of X and R charts.
2. Production Process follows 2 σ methodology that corresponds to a 69.1% yield.
3. Production Process is incapable, and the output is found to be defective. An $\bar{\bar{\mathbf{X}}}$ value of 51.02 indicates that PAPL is supplying an excess of 1.02kgs for each roll of 50kgs produced. This means an additional 13.65Tons of greenhouse shade worth of PKR6.15M will be delivered to customer in Y2023 free of cost.
4. The production process has a high spread and a low centering as both values of C_p and C_{pk} are less than 1.0.

CHAPTER 4: CONCLUSION

This chapter will be a conclusion chapter that is divided into three parts. Firstly, the results of the operational analysis done in Chapter 3 will be summarized. In the next section current challenges that are being faced by PAPL will be discussed and in the last section recommendations and way forward will be given.

4.1 CONCLUSIONS BASED ON ANALYSIS

Based on the operational analysis of PAPL done in Chapter 3, we can conclude the following:

1. Process Flow Charts for Yarn Manufacturing, Knitting and Packaging / Storage are developed. Copies of these flow charts are to be displayed in all production areas of the plant so that there is better understanding, quality control and training of employees. These flow charts will be used as a model to standardize the production processes so that each process is repeated every time. Lastly for optimal efficiency these flow charts can determine bottlenecks, unnecessary steps and other inefficiencies.

2. A seasonal demand is noticed. Almost 70% of the annual demand for Greenhouse Shades are noticed in the months of March, April, May and June.

3. The forecasted demand of Greenhouse Shade for Y2023 is 682,875kgs.

4. In the existing production setup:
    a. 610,720kgs of Greenhouse shade are being produced annually.
    b. The total annual labor cost is PKR 54.2M.
    c. The bottleneck production process is Knitting.

d. The forecasted demand for Y2023 will not be met. Annual shortfall of 72,155kgs will occur which means the plant's capacity has to be increased by 208kgs per day.

5. A new production setup is proposed in which a sixth Raschel Knitting machine is added Conclusions are:
   a. 694,000kgs of Greenhouse shade will be produced annually. This will not only meet the forecasted demand of Y2023 but an extra buffer stock of 11.25Tons can also be kept.
   b. The total initial investment of the proposed setup would be PKR14.53Million. The total incremental profit would be PKR3.21 Million and the payback period would be almost 4.5 years.

6. After taking random samples of 50kgs rolls of greenhouse shade and weighing them for 10hours (3 samples each in an hour), it was noticed that the entire production process is under control. The production process is following a 2 σ methodology that corresponds to a 69.1% good results. Production Process is incapable and the output is found to be defective. Also Production process has a high spread and a low centering as both values of C_p and C_{pk} are less than 1.0.PAPL is supplying an excess of 1.02kgs for each roll of 50kgs produced. This means additional **13.65Tons** of greenhouse shade worth of **PKR6.15M** will be delivered to customer in Y2023 free of cost.

7. A raw material inventory management was developed. Following are the conclusions:
   a. 1 kg of Greenhouse shade requires 1.25kg of raw material HDPE granule which is 100% imported.
   b. Economic Order Quantity for each order placed to supplier should be of 67,160kgs. The reorder point in the inventory level should be 40,590kgs as lead time from supplier is 15 days.
   c. The time between each order should be 27 days.

d. The total cost of managing the inventory is PKR 165,227.

4.2 CHALLENGES AHEAD

After a detailed discussion with the factory production manager, a number of challenges are being faced by PAPL currently which are as follows:

1. Electricity tripping is a very common issue in Hattar Industrial Estate (HIE) where PAPL's production plant is located. The main reason cited for this is increased load on the grid by the surrounding industries. First preference of provision of smooth electricity is always provided to bigger industries like steel manufacturing. Secondly as HIE was declared a 10-year tax free zone in 2016, a recent rise in number of steel industries is noticed as many of them are relocated from I-9 / I-10 Industrial Area Islamabad. As a result, an increased load on the grid is seen which causes tripping.

2. Because of electricity jerks entire Production Process is highly disturbed. If there is an unscheduled utility outage or tripping during production, the material inside the machinery has to go through the entire process once utility is restored. This material would be classified as wastage and its cost is eventually added into the production. Also there is a loss of production time. Typical Wastage is around 30%.

3. Raw material HDPE granule is purely a petroleum by-product. As a result of recent surge in petroleum prices the raw material price has considerably increased. Secondly as the raw Material is 100% imported, there is a high price fluctuation because of the depreciation of local currency. Eventually both these price differentials are added to the production cost which affects the overall net profit.

4. Peak Demand is during the four months from March to June only. Remaining year, the market demand is extremely low. Seeing the overall trend of inventory, raw

material availability with the supplier is low in January and February which causes production shortfall in peak season from March to June.

5. Company is exposed to a number of risks which are as follows:

MARKET RISK	Financial performance of PAPL is dependent on agriculture industry and prevailing market dynamics.
PROJECT RISK	As most funds raised are earmarked for expansion CAPEX, where no agreement is currently executed, the risks associated with project implementation remain.
OPERATIONAL RISK	Operational risk is defined as the risk of loss resulting from inadequate or failed internal processes, people and systems or external events. This includes legal risk as well as the reputational consequences of failures in operational risk management.
TAX & TARIFF RISK	PAPL remains exposed to import based competition where any material deviations from stated policy of promoting localization in favor of imports could limit demand catalysts.
REGULATORY RISK	Any change in the regulatory framework, particularly agriculture sector incentives, can have an adverse impact on the performance of the Company.
LIQUIDITY RISK	Liquidity risk is the potential inability to meet contractual and contingent financial obligations, either on or off-balance sheet, as they become due. This is mitigated by strong cash flow management regularly practiced by the Company.
CLIMATE RISK	Numerous climatic factors including hydro-meteorological hazards could reduce cultivatable land area and dampen sector dynamics.
EXCHANGE RATE RISK	With a significant portion of raw materials imported, the Company is exposed to FX volatility, which it mitigates by efficient procurement policies.

Figure 4.2.1: Key Risks for PAPL

Source: Company's Information Memorandum for Growth Enterprise Market Board Listing

4.3 RECOMMENDATIONS AND WAY FORWARD

Besides a number of challenges and threats looming to PAPL, the management is 100% confident that it will be able to survive the competitive environment. An example of this is the incident of December 2019 when an unfortunate fire accident destroyed around Rs 141 million worth of company's assets. This was the only time the company incurred a loss in the past eighteen years. On the verge of a shutdown there was a dramatic recovery in FY20/21 and the company's revenue soared to PKR402.5M – the highest ever recorded. PAPL is the market leader for Greenhouse Shades capturing almost 40% market share: A number of reasons attribute to PAPL's success which are as follows:

a) Quality: High Quality Imported Raw Material is always used. Raw Material is never reused in the production cycle after wastage and because of that wastage is always high (around 30%). Recycled raw material is used by most competitors and hence the quality is questionable.
b) Prudent Decision Making by Experienced Management.
c) Labor / Workforce Commitment
d) Niche Market
e) Proven track record of capitalizing on first mover advantage – to be extended to Fishing nets
f) Healthy cash-flow generation
g) Tax incentives for agricultural support programs

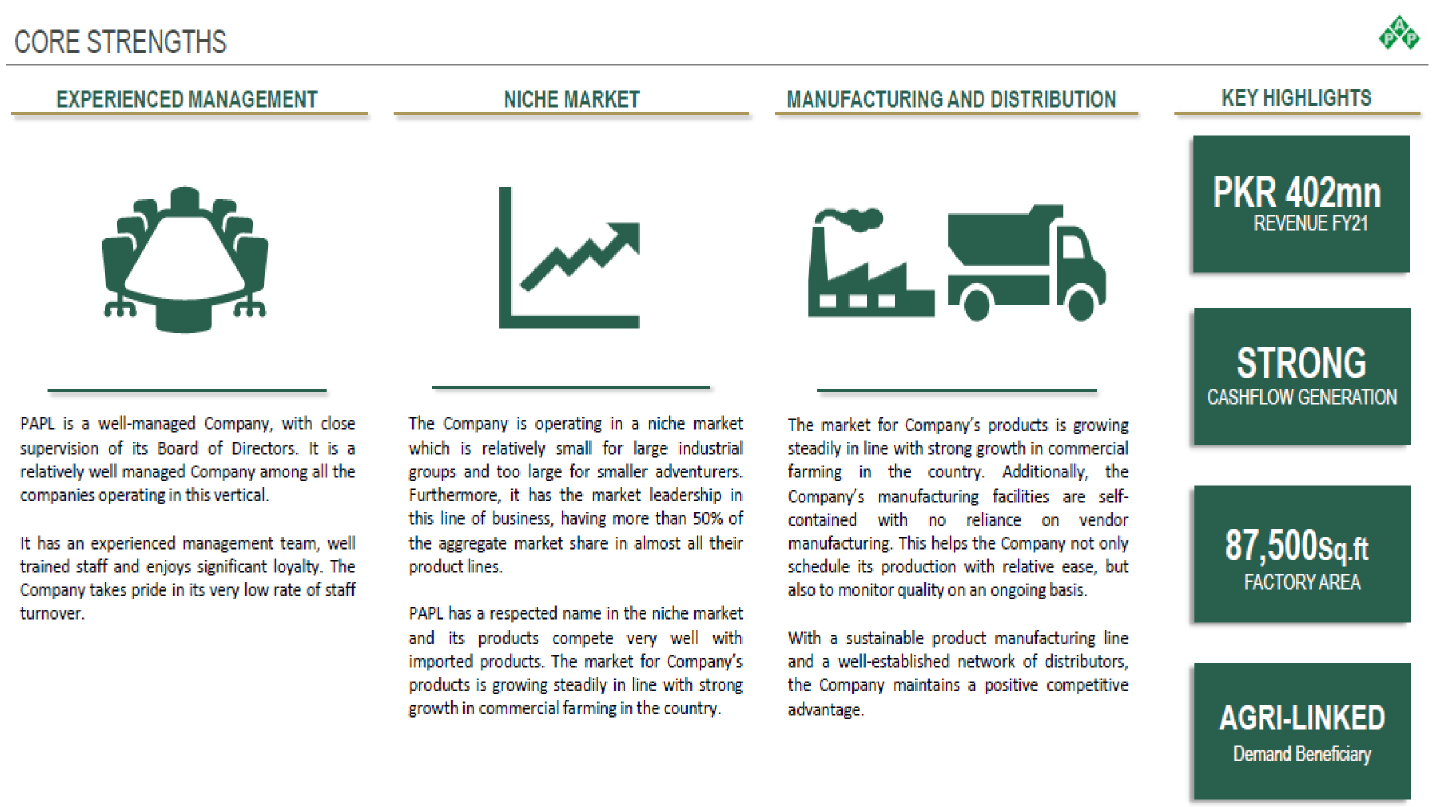

Figure 4.3.1: Core Strengths of PAPL
Source: Company's Information Memorandum for Growth Enterprise Market Board Listing

Following are the recommendations to PAPL to the issues highlighted in Section 4.2:

1) Each year an operational and production analysis (similar to this report) should be conducted so that a shortfall in meeting the market demand does not occur. Secondly it is suggested that this study shall be conducted for a longer time period rather for one year only so that changes in existing setup or machinery upgrade can be anticipated beforehand.
2) Enlistment in the GEM board will help PAPL to raise capital especially for its power requirements. Feasibility on alternate energy resources like solar plant should be developed. This will reduce PAPL's reliance on grid and there would be an overall reduction in the electricity bills.
3) Hedging techniques like forwards / future contracts can be used to mitigate price risk because of FOREX fluctuation and soaring petroleum prices.
4) Following the inventory management cycle developed in Section 3.5 and with close coordination with the supplier the risk of raw material availability can be mitigated. There should be smooth flow of information from the Buyer to Supplier and an ordering plan of at least six months should be provided to the supplier so that no production shortfall is seen.
5) Using quality tools is a very easy and economical method of improving the overall production process. Quality tools will help quickly identify the problem, find the root cause of the problem and will help to reduce the number of defects. By raising awareness and educating the workers with the significance of the quality tools the overall productivity of an organization can be increased as it does not require huge capital.

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APPENDIX A: TIMELINE OF MAJOR EVENTS

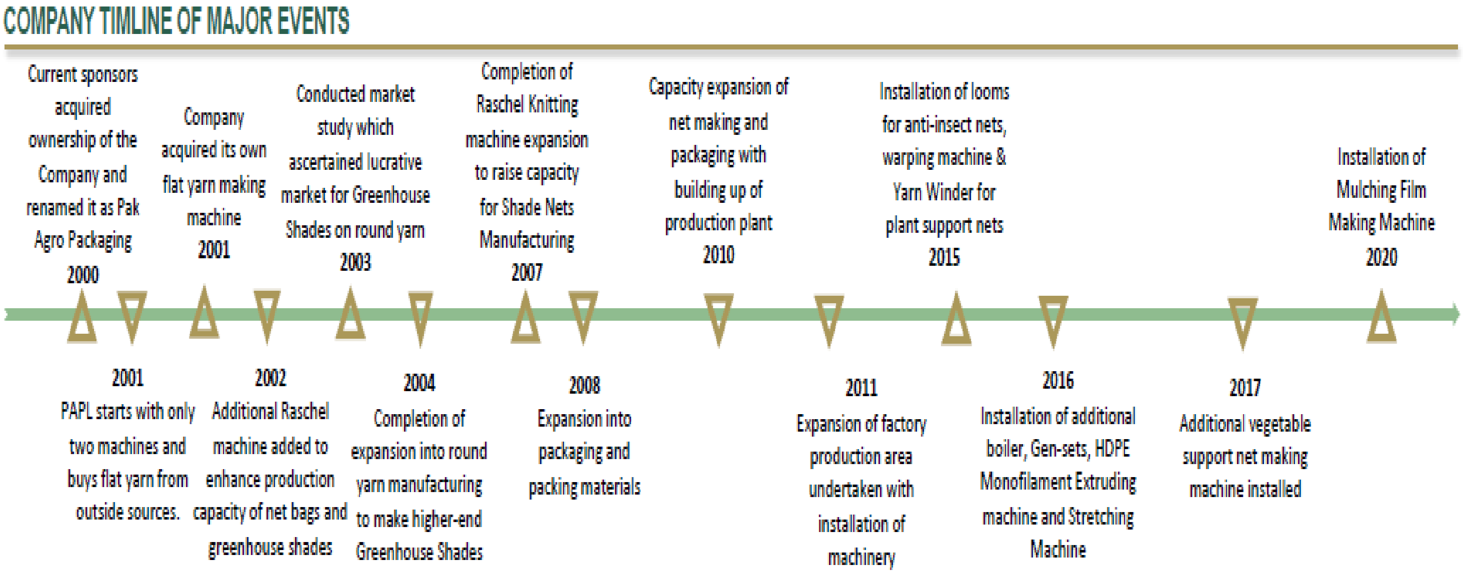

Figure A1: PAPL's timeline of major events

Source: Company's Information Memorandum for Growth Enterprise Market Board Listing

APPENDIX B: COMPANY'S ORGANOGRAM

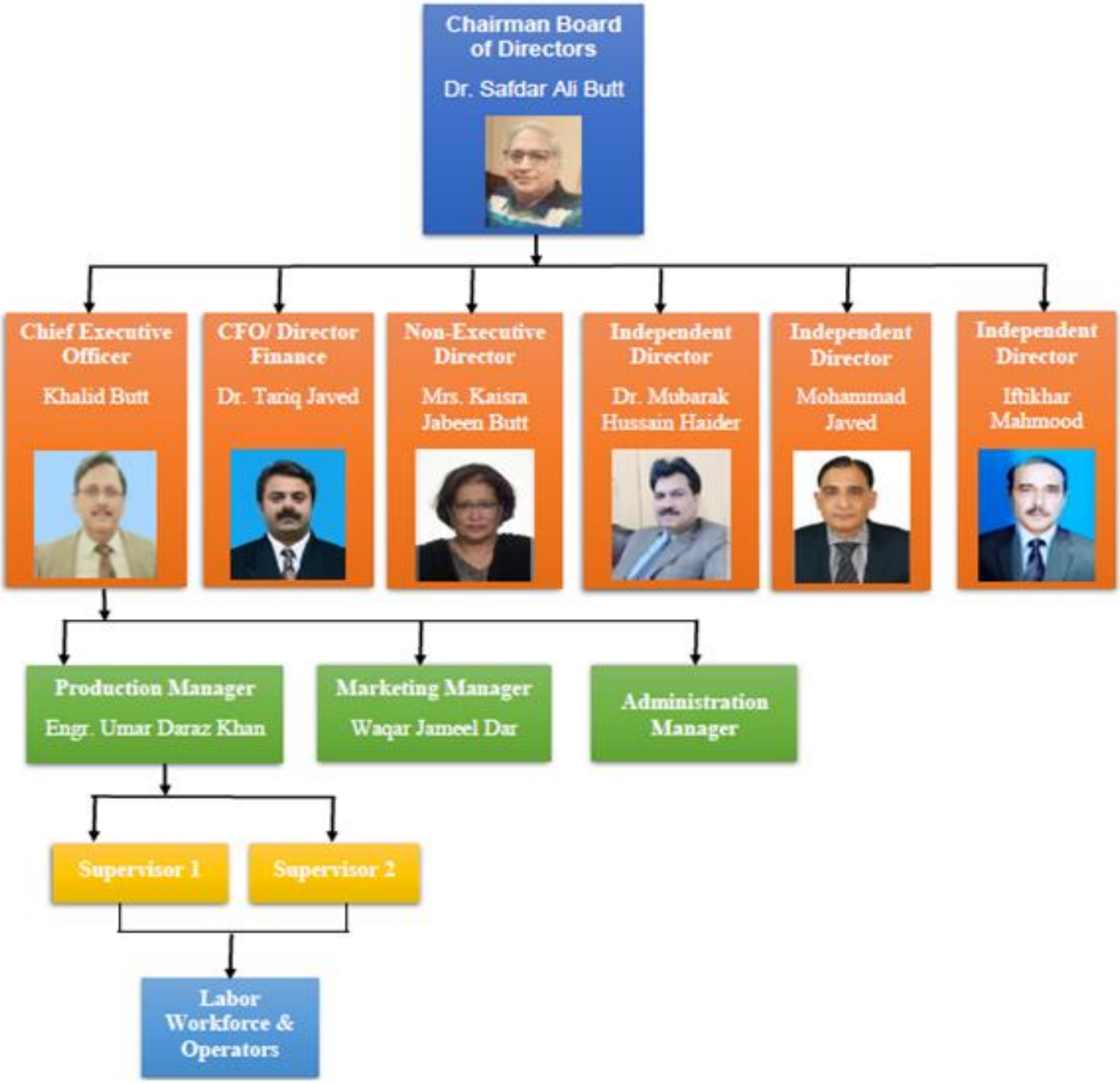

Figure B1: PAPL's Company Organogram

APPENDIX C: SWOT ANALYSIS

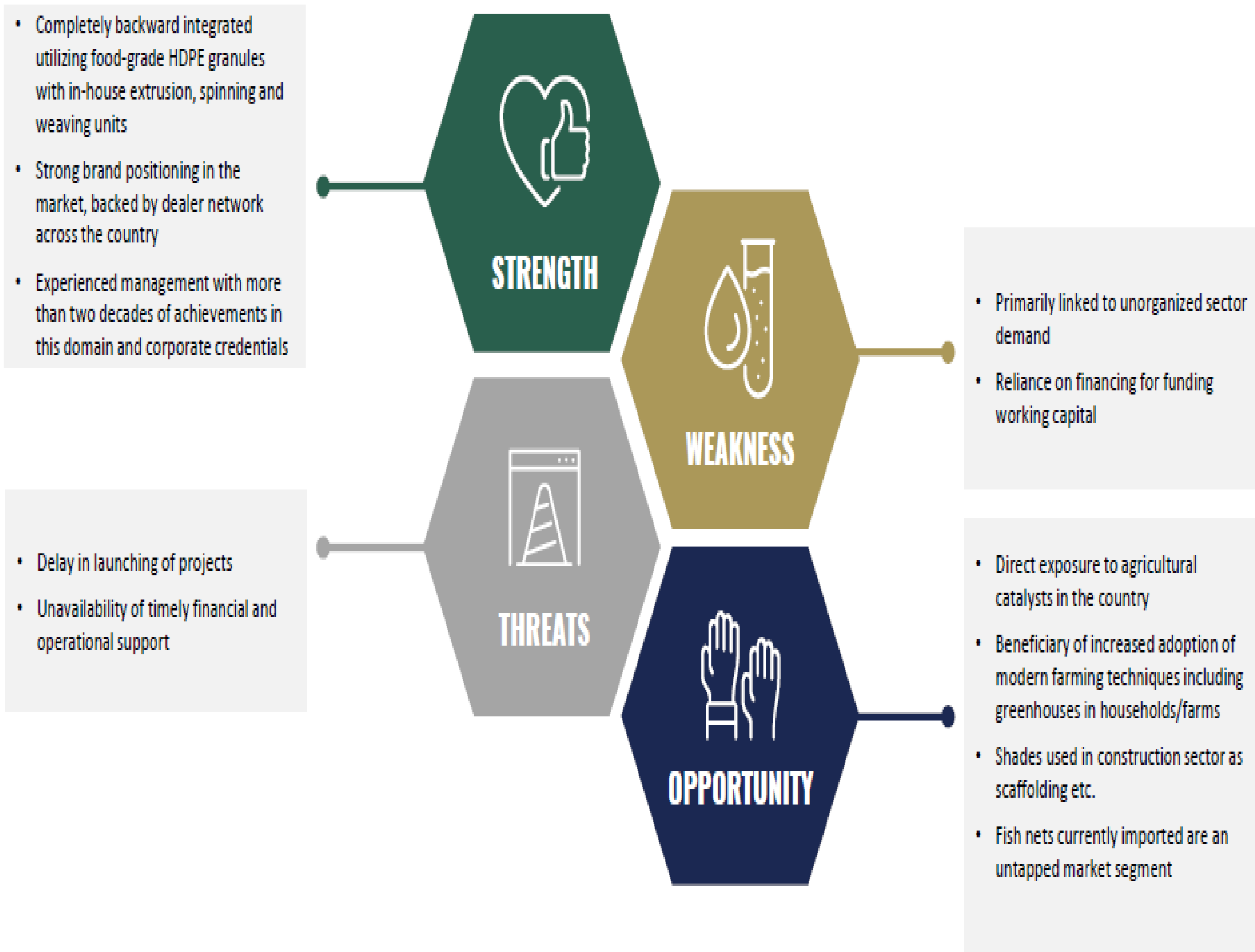

Figure C1: PAPL's SWOT Analysis
Source: Company's Information Memorandum for Growth Enterprise Market Board Listing

APPENDIX D: PRODUCT LINE

SOURCE: COMPANY WEBSITE: *https://www.pakagro.com/*

a) Plant Support Nets

Figure D1: Plant Support Nets

Plant Support Nets are used to support fragile plants and vines like gourd, bitter gourd, cucumber, etc. Commercial farmers of vegetables require these nets on a regular basis. PAPL is the only local Company manufacturing these support nets.

b) SPECIALIZED NET SHADES:

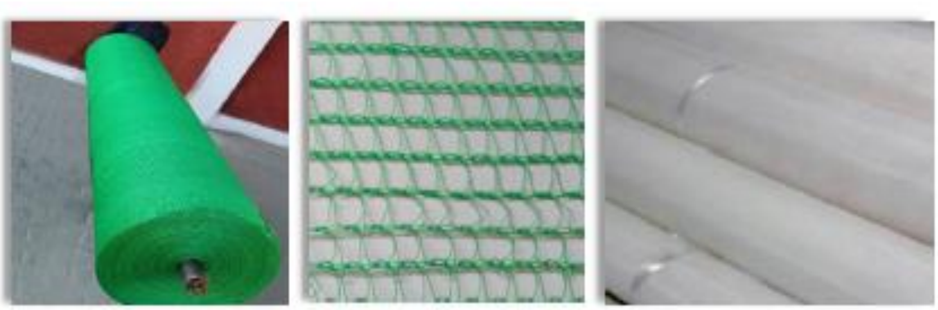

Figure D2: Specialized Net Shades

These include anti-bird, anti-hail and anti-insect nets. They provide plants with uniform shadow, optimal ventilation and resistance to Agro chemicals and insects.

c) NET BAGS (Extruded, Knitted, Woven)

Extruded nets bags are produced by a single process from HDPE granules into a tubular form of nets, which are cut to size according to needs by the user. Knitted net bags are made in two stages. In the first stage, flat yarn is manufactured from food grade HDPE granules. In the second stage, Raschel Machines knit the flat yarn into net bags of suitable sizes. Woven net bags are made on weaving looms using the same flat yarn.

Figure D3: Net Bags

d) OTHERS (Net Products)

Figure D4: Bale Nets and Filters

In addition to above main lines of products, the Company also manufactures certain other products in relatively smaller quantities. These include Bale Nets and Filters.

APPENDIX E: YARN MANUFACTURING

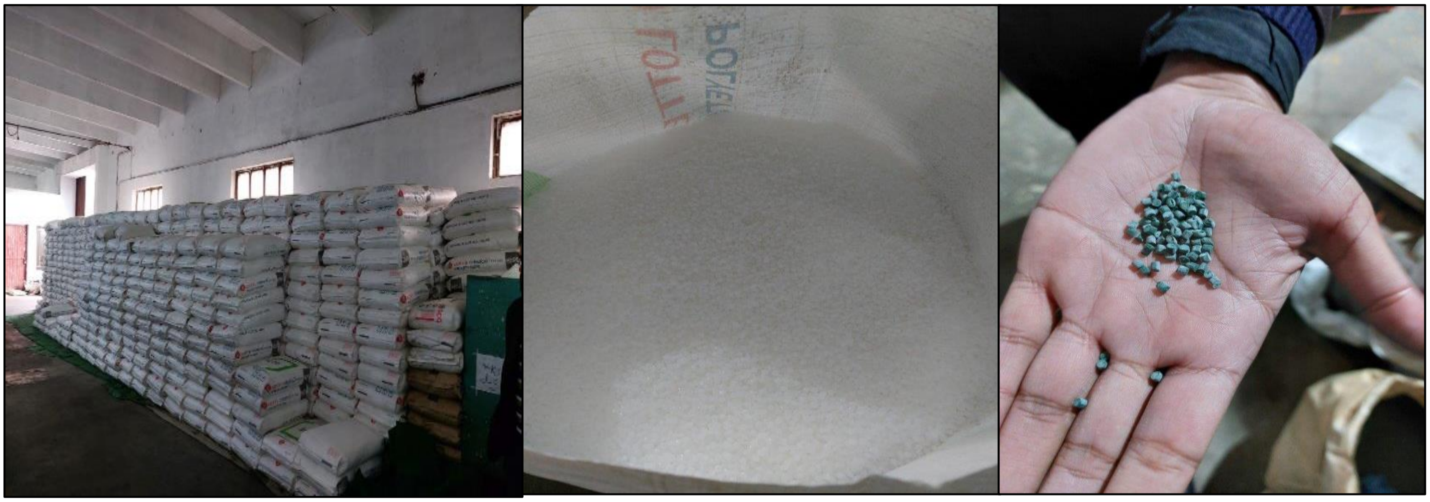

Figure E1: Raw Material for Yarn Manufacturing

1. MIXING

Figure E2: Automatic Mixing through Hopper

2. HEATING

Figure E3: Heaters for melting of mixed Raw Materials

3. YARN CONVERSION & SUBSEQUENT COOLING

Figure E4: Conversions to yarn through dies and cooling in cool water tank.

4. ROLLING

Figure E5: Rollers used for yarn Pulling.

5. STRETCHING & DRYING

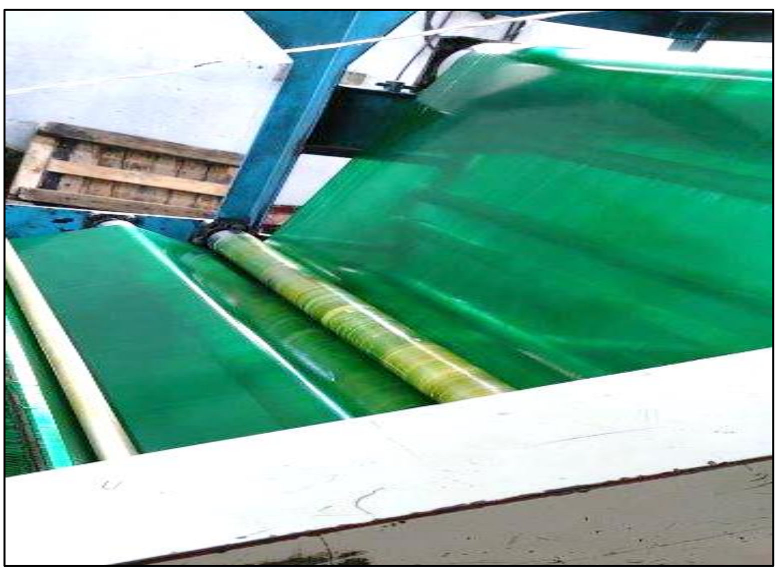

Figure E6: Stretching of yarn using rollers and then drying

6. CUTTING & WINDING: Yarn is cut and wounded on beam and bobbins.

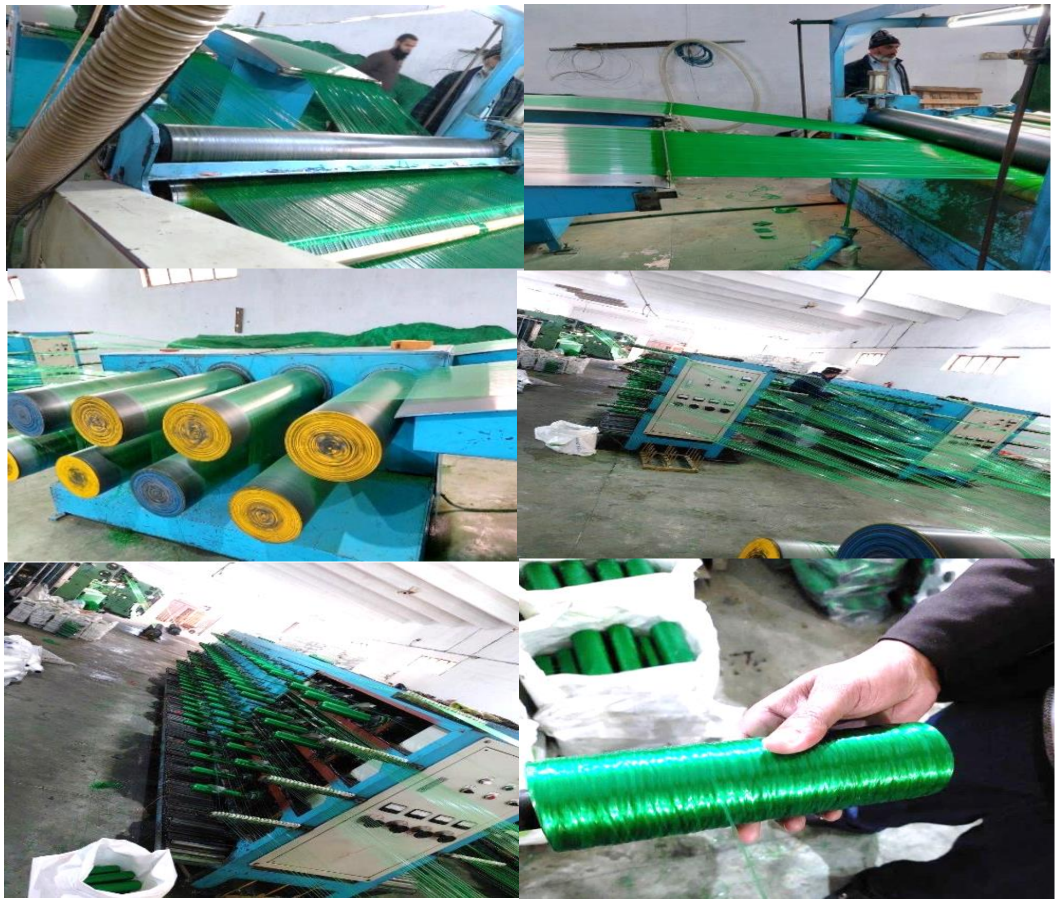

Figure E7: Cutting and Winding on beams and bobbins

APPENDIX F: KNITTING

Figure F1: Knitting of Greenhouse Shade Cloth on Raschel Knitting Machine

APPENDIX G: FORMULA SHEETS FOR X CHARTS & R-CHARTS

X Chart Control Limits:

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R}$$

and:

$$LCL_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R}$$

where $\bar{R} = \frac{\sum_{i=1}^{k} R_i}{k}$ = average range of all the samples; R_i = range for sample i

A_2 = value found in Table S6.1 $\quad$ k = total number of samples

$\bar{\bar{x}}$ = mean of the sample means

R Chart Control Limits:

$$UCL_R = D_4\bar{R}$$

$$LCL_R = D_3\bar{R}$$

where

UCL_R = upper control chart limit for the range

LCL_R = lower control chart limit for the range

APPENDIX H: FACTORS FOR COMPUTING CONTROL CHART

SAMPLE SIZE, n	MEAN FACTOR, A_2	UPPER RANGE, D_4	LOWER RANGE, D_3
2	1.880	3.268	0
3	1.023	2.574	0
4	.729	2.282	0
5	.577	2.115	0
6	.483	2.004	0
7	.419	1.924	0.076
8	.373	1.864	0.136
9	.337	1.816	0.184
10	.308	1.777	0.223
12	.266	1.716	0.284

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Table H1: Factors For Computing Control Chart Limits (3 Sigma)