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School of Mechanical and Industrial Engineering

Industrial Engineering Stream

MSc. Research Thesis on:

Assembly Operation Productivity Improvement for Garment Production Industry through the Integration of Lean and Work-Study

A Case study in Bahir Dar Textile Share Company, in Garment

By: Mequanent Ewnetu

A Thesis Submitted to

School of Mechanical and Industrial Engineering

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Advisor

Dr. Ermias Tesfaye

Co-Advisor

Mr. Fitsum Getachew

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SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

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Assembly Operation Productivity Improvement for Garment Production Industry through the Integration of Lean and Work-Study

(*With Special Reference to Bahir Dar Textile Share Company, in Garment*)

By: Mequanent Ewnetu

Approved by the board of examiners:

Director of postgraduate program______________Signature________Date 02/ 11/ 2021

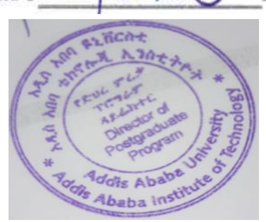
Advisor Ermias Tesfaye (Ph.D.) Signature ______ Date 01 / 11 / 2021

Co – Advisor Fitsum Getachew Signature ______ Date 02 / 11 / 2021

Internal examiner Kassu Jilcha (PhD) Signature ______ Date 01 / 11 / 2021

External examiner Dr. Temesgen Garoma Signature ______ Date 01 / 11 / 2021

School dean Yitma T. (PhD) Signature ______ Date 02 / 11 / 2021



DECLARATION

I hereby declare that the work which is being presented in this thesis entitled “Assembly operation productivity improvement for garment production industry through the integration of lean and work-study: with special reference to Bahir Dar Textile Share Company, Garment’s” is original work of my own, has not been presented for a degree of any other university and all the resource of materials used for this thesis have been duly acknowledged.

____________________ 01 / 11 / 2021

Mequanent Ewnetu Date

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

____________________ 01 / 11 / 2021

Advisor: Dr. Ermias Tesfaye Date

____________________ 02 / 11 / 2021

Co-Advisor: Mr. Fitsum Getachew Date

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ABSTRACT

Productivity improvement is a very important issue for manufacturing industries to survive in the global competition. A nation's effort on productivity-improving is mandatory and its achievement of productivity is one of the major weapons to attain cost, time, and quality advantages for competition. Ethiopian garment industries are not competitive in the global market share. The primary reason is low productivity.

This study tries to investigate both internal & external productivity factors of the garment industry and proposed genuine solutions using integrated techniques of lean & work-study. So, this paper aims to provide the users are understanding easily the main productivity factors of the garment industry and present the way how to develop a solution using these integrated techniques.

The main objective of the research is to enhancing productivity using integrated techniques of lean & work-study for the Ethiopian garment industry, specifically in the case company. To accomplish this objective a literature review has been conducted to get a realistic understanding. The existing productivity status, improvement practices, experience, and productivity factors of the garment industry have been assessed using open interviews and secondary data from the sector.

To make this study practical and realistic, a case study has been conducted on the Bahir-dar textile share company in, garment. And the data was collected using interviews, direct observation, recording, measuring, questionnaires, and secondary data. The existing result indicates that the productivity of the Ethiopian garment industry and the case garments is much lower than the government plan and their production targets as well as compared with other best practice garment industries. Due to this, the garment industry has been faced multidimensional productivity factors related to human, method, control, process, and product.

To enhancing the overall productivity improvement of the garment industry that has been using the combined techniques & tools of lean and work-study, due to, the nature of garment industry productivity factors are multidimensional as a result a single tool or model hasn't boosted a significant change. Consequently, to solve the garment industry productivity factors that should be used an integrated techniques & tools for enhancing a significant productivity improvement of the case company and these integrated techniques has been answered the research question.

Keywords: Productivity, LM, work-study, time & method study, waste, line balancing, defects

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LIST OF ACRONYMS

GATT………General Agreement on Tariff and Trade

VER………...Voluntary Export Restraint

STA…………Short Term Arrangement

SLT……….....Long Term Arrangement

MFL…………Multi-fiber Arrangement

AGOA………African Growth Opportunity Act

CBTA……….Caribbean Basin Trade Agreement

WOT………..World Organization trade

NIC…………Newly Industrial Countries

ASME………American Society of Mechanical Flow

ETIDI……….Ethiopian Textile Industry Development Institute

BDTSC……...Bahir Dar Textile Share Company

ILO………….International Labor Organization

OT…………..Observed Time

AF…………...Allowance Factor

SMV………...Standard Minute Value

ECSA………..Ethiopian central statistical agency

SPC…………Statistical Process Chart

UCL…………Upper Control Limit

CL…………...Control Limit

LCL………….Lower Control Limit

GTP………….Growth and Transformation Plan

M/c…………..Machine

Min…………..Minute

LM…………...Lean Manufacturing

CL……………Cycle Time

SPSS............... Statistical Packages for Social Sciences

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Today's pace of globalization and the forces driving it have created new market conditions. These rapid market shares create globalized economic competitiveness between the developed and developing countries (Monga, 2013). The major determinants of the manufacturing industry are highly competitive markets are no longer the relative cost advantage. More and more, it is based on quality, speed, technical superiority, and product variation (Tadesse, 2011). So, in the global manufacturing industry, whether at the international, national, industrial, or firm level, raising productivity is a major determinant for competitiveness and leads the company to survive in a global market share (Monga, 2013).

Textile is a manufacturing industry that is closely linked with the industrial revolution in England and the US in the seventh and eighth century respectively. The garment industry took one more century, to develop after the growth of the textile industry (Bheda, 2003). Now a day's garment is one of the three basic needs of mankind. Hence, textile and garment manufacturing has retained an important place in human life starting from the historical era to today's modern world & one of the truly global industry market places (Ewnetu, 2016). So, over the world textile and garment are one of the biggest consumer goods categories with a global market estimated to worth well over one million Euros. It indicated that the global competitions in this sector product become very intensive (Habtemariam, 2018). Due to, the contest of this sector can be categories into three. Textile and garment manufacturing in developed, developing, and under developing countries (Mahmud, 2015). Based on, the well-documented fact that the textile and garment industries have been the driving force for all developing countries. Todays, such countries have targeted this apparel industry as means to supply jobs, raise their standard of living and make economic wealth. The main reasons are the industry continues to be labor-intensive, and barriers to entry are relatively low (Bheda, 2003). In developing countries, garment industries are more intensive on sourcing raw material and minimizing delivery costs than labor productivity, due to the availability of cheap labor. So, labor productivity in developing countries is lower than within developed ones (Mostafizur Rahman Sobuj, 2015).

The modern garments industry in Ethiopia started with the establishment of the Addis garment factory by three Italians in 1958. Bahir Dar Textile mills S.C., established in 1961 from the fund of Italian war reparation with 563 Ethiopian. In 1992, Ethiopian largest garment factory, Nazareth garment, became operational (ETIDI, 2010). According to Pols, (2015) report state that Ethiopian textile and garment business began to grow were less than 20 firms in 1991, which increased to above 80 in 2012 and nearly 110 in 2013, 130 in 2016, and reaching around 200 in 2019/20 medium- and large-scale factories. Currently, from these factories, there are above 90 large & medium garment industries in Ethiopia. Entirely, the sector creates a job opportunity for 96,120 employees (which is only 47% of the GTP-II plan job opportunity to achieved) and from those employees, 63% of job opportunities are covered by garment industries & 76% female workers (ETIDI, 2019). The government of Ethiopia has a planned projection of getting 1 billion USD from the export of garment and textile-related products in 2020, which is 40 times as much as it earned during 2013/14 (25 million USD from garment export) (Kastro, 2013). Hence, Ethiopian garment industries experience growing pressure to improve quality & productivity, reduce cycle time, eliminate errors, improve customer satisfaction and reduce cost (Martinovic, 2007).

However, the Ethiopian garment industries including the case garment (BDTSC, garment) are not competitive in the global marketplace, mainly due to low productivity. Therefore, this garment industry needs attention to improving productivity to meet the competition on relevant cost, quality, time, and flexibility issues and to meet their customer demand (Haffman, 2009).

In general, to improve garment productivity many researchers try to use several techniques towards continuous productivity improvement separately, but one of each technique doesn't improve productivity comprehensively (Eshetu, 2017). This limitation helps the study to find more comprehensive improvement techniques that enhancing the overall productivity improvement of the garment industry. Thus, one approach of this study is to use an integrated technique that to form a comprehensive & reliable set of manufacturing practices, their synergy is supportive & contributes hopefully to continuous productivity improvement (Habtemariam, 2018). Therefore, the application of these integrated improvement tools & techniques of lean and work-study contribute significant improvement efforts to solve the productivity problems of Ethiopian garment industries. Because, lean manufacturing techniques mainly focus on identifying and eliminating seven activities of waste, whereas the work-study technique focuses on reducing the production time and eliminating non-productive processes (Choomlucksana, 2018). And also, work-study is used in the examination of human work in all its contexts, which leads systematically to the investigation of all the factors which affect the efficiency and economy that affect improvement (Sujay Biswas, 2016; Pancholi, 2018). While, LM mainly focuses on eliminating all kinds of non-value-adding activities and processes which are considered as waste and create no value for customers (Firozabadi, 2015).

Therefore, this study focuses on identifying all the internal & external productivity factors of the Ethiopian garment industry including the case company and tries to solve these factors using integrated improvement tools and techniques of lean & work-study that to enhance a significant change in productivity improvement.

1.2. Statement of the Problem

The textile and garment production industry in Ethiopia has been linking in the global markets for long years ago but until now the exports of this sector were not sufficient even though several industries that established throughout the country (Habtemariam, 2018). So, these industries lack competitiveness both locally & internationally, due to several productivity problems that existed and which leads to these industries were low productivity. But, only a few firms can achieve the highest stage of producing and exporting finished garments (Matebu, 2009). And these garment industries made a significant contribution to the national economy (Tadesse, 2011).

However, currently, most Ethiopian garment industries are not effective & competent in the global market share. According to Ethiopia's Textile Industry Development Institute (ETIDI) has predicted $ one billion in yearly revenue from this sector exports during the second phase of the growth and transformation plan (GTP-II: 2015-2020) (Habtemariam, 2018). But, at the end of the GTP II period, the performance of the Ethiopian garment exports was only $347 million (the plan achieved only 34.7%), which is much below that of the government had plan ($1 billion) under the GTPs and during this period the Ethiopian government expected from this sector was to get 22% & 0.15% country and world total export values; but not more than 6% & 0.01%.

The efficiency of Ethiopian garment production during the GTPs is slow as 40-45 % in production (ETIDI, 2018). And the average production capacity utilization of the Ethiopian garment industry at the end of the GTP II plan is expected to reach 80%, but now it is below 58% (Kumera, 2018). Therefore, this value indicated that the Ethiopian garment industries are not competent in the marketplace. Due to, low productivity and several productivity factors exist.

These factors are grouped as human, method, control, process, and product that require an organized and sustainable productivity improvement program.

Bahir Dar Textile share company, Garment (BDTSC, garment) is one of the long experienced garment industries in Ethiopian and this garment industry has the following productivity problems: Production under capacity, long lead time, low skill workers, poor work culture, old machine & equipment, low managerial capability, poor system integration, low wage, low export price, limited & low-quality inputs, unbalanced work load, high non- productivity time (idleness, down & setup time) of workers & machines, poor space and resources utilization, inappropriate working method & production process, high defects & rework.

Detail justification intended for low productivity of the case company, based on their effective capacity: currently, the major export production process can't run at the effective capacity which is 800 pieces/ shift. But the actual output is below 470 pieces/ shift, it is approximately 59% only to be achieved. This indicated that the company cannot perform the production targets. Subsequently, it requires a detailed investigation of the causes of the problem.

At present, the case company uses an incompetent problem-solving approach which is not effective for productivity improvement. Due to, lack of understanding of where to start its improvement, identifying critical success factors, addressing the possible productivity factors, and lack of knowledge that to select appropriate productivity improvement techniques and tools. It is believed in this study that productivity improvement is a critical measure for the competitiveness and success of the case company. Without productivity, a company will not be able to compete and continue to exist in a long-term perspective. Therefore, in this study by considering the existing situation of the case company, an integrated of lean and work-study techniques is used that to supports productivity improvement of BDTSC, Garment.

1.3. Research Question

i. What are the critical factors that hinder the productivity of Ethiopian garment industries (in the case of BDTSC, Garments)?
ii. How to integrate work-study and lean techniques for enhancing productivity improvement?
iii. What are the intervention areas for the export production improvement of the case garment?
iv. How to develop a proposed solution using the integration of lean and work-study techniques?

1.4. Objectives of the Study

1.4.1. General Objective

The main objective of this study is to increase productivity through the combination of lean and work-study techniques, in the case of Bahir Dar Textile Share Company, in Garment.

1.4.2. Specific Objective

- ☞ To investigate those factors that influence the productivity of the case garments and their indicator.
- ☞ Identify the combination variables of work-study and lean for productivity improvement.
- ☞ To assess the intervention areas for uninterrupted productivity improvement.
- ☞ To propose a solution by using the most critical tools of lean and work-study.

1.5. Significance of the Study

The study outcome benefits Bahir Dar Textile Share Company, Garment's as well as other Ethiopian garment industry firms through the adoption of nonstop productivity improvement techniques that help to progress the status of productivity factors that exist in the company. And the study gives as a guideline how an integrated of work-study and lean manufacturing techniques to support productivity improvement of the garments. In addition, the improvement techniques bring a significant change in the garment production process and create better working conditions for both the case and Ethiopia garment industry.

The other benefit of the study is that it provides empirical knowledge about this integrated approach which is helpful to improve production efficiency, performance, and capacity utilization of the garment production process. Hence, the overall effect of the study is that improving garment productivity, to enhancing customer & workers satisfaction for both the case company and the Ethiopian garment industry. The findings of the study were used as input for academicians, researchers, an organization like ETIDI, governments, other factories under this sub-sector with no or little modifications, and for any interested party who has paid attention to integrated productivity improvement technique and tools.

1.6. Scope of the Study

The study has been done for the Ethiopian garment industry with a special reference to BDTSC, Garment. This garment industry was selected by reviewing a well-written document fact and visiting some extent, other garment industries, i.e. Almeda garment & MAA garment industry p.l.c (written document); Yirgalem Addis garment p.l.c. Haile garment industry, and BDTSC, garment's (directly observe) to conduct. Because, some of them are used in part the lean principles and work-study techniques independently to solve the challenges of Ethiopian garment production, but not achieved their targets. This study is dedicated to the progress of productivity improvement of the garment industry using the integration of LM and work-study techniques at the firm level. The main intervention areas of the case study are particularly focused on the main export garment production of the case company, which are Quilt cover (140 x 220 cm) and Flat sheet production process (150 x 260 cm size) is discussing. The study uses the data collected from various literature, organizations (ETIDI), and the case company using qualitative & quantitative methods.

1.7. Limitation of the Study

The study was limited to productivity improvement for the Ethiopian garment production process. Concerning the productivity, there are many issues or problems that should be avoided, but this study mainly focused on identifying the selected garment productivity problems (both internal & external) are careful and those production types mainly focused on the major export garment production. But not addressing all Ethiopian garment industries, due to lack of adequate time and data. And also it was hard to convince the respondents about the aim of the study, besides this, the negative impact of Covid-19 was a hard situation during collecting external data (qualitative) using questionnaires and interview methods like the company stop working for some weeks. But, when the company start their work, then the data was collected using the protecting materials of covid.

1.8. Organization of the Study

This research has been organized into six chapters. The first chapter gives an overview of the introduction part of the study. The second deals with the literature review that states the study matter. The third focuses on the methodology of the study. The fourth deals with the overview of the textile & garment industry in the world, and the Ethiopian context. Chapter five provides the data collected from the case garment for analysis, & interpretation and proposes the solution to the problem. Finally, it covers the conclusion, recommendation, and future research work.

CHAPTER TWO

2. LITERATURE REVIEW

The literature review of the study has been organized into eight main parts, namely concepts of productivity, productivity factors, productivity measurement, productivity improvement, LM, work-study, integration of lean, & work-study, and summary & gaps of the literature.

2.1. Concept of Productivity

The word productivity is not new over the earlier centuries. Usually, productivity is viewed mainly as an efficiency concept. Today productivity is a measure of system performance, system efficiency, resource utilization, and the relationship between real output & input (Tadesse, 2011). As stated by Kulkarni et al, (2014), productivity is well-defined as the ratio of output to the unit of all of the input resources that are used to produce this output. Usually, it deviates from production, which concerns an increment in output over a given period, which means the ratio of output to an input (Kulkarni et al, 2014; Sahni, 2016). It is achieved by enhancing the value-added content of products/ services, or by decreasing the unit cost, or a combination of both, at present the view of productivity is to decrease the non-value adding activities to give optimized output to the possible extent. It is a total concept that addresses the key features of competition (innovation, cost, quality, and delivery) (Shah et al, 2015; Chandra, 2013). An enterprise or a sector of the economy as a whole defines the term "productivity" to be used to assess or measure the extent to which a certain output can be removed from a given input (Cengiz Duran, 2015). The efficiency of the production process is used as an indicator of the level of effectiveness in using production resources (raw materials, manpower, land, building, machine, equipment, and energy). The economic growth of a country is usually measured by its increase in production, which comes from two sources: a larger quantity of production factors used (inputs) and/or an increase in productivity. Hence, productivity is considered a component of growth (Cengiz Duran, 2015). Productivity is well-thought-out to be a growth of profit (Moktadir et. al, 2017). According to (Eshetu, 2017), to explain that productivity is the actual utilization of resources to achieve set objectives. Due to this, a lot of management approach is planned to attend to the factors that affect productivity (Habtemariam, 2018). Productivity is one of the major determinants that enable mfg industries to compete in the global market & it is important to factor that increases the competitive capacity of companies is to use their production bases most effectively. Then, to minimize loss of the factors related to labor, machine and material provide an opportunity to increase productivity. And also it is an extremely important measure in mfg operations, besides turnover and profit, because it provides insight into the efficiency and effectiveness of the operations (Mahmut Kayar, 2014). In general, the manufacturing input and outputs are the two pillars that define productivity. A simple firm model that relates inputs, constraints, outputs, and its indicators is shown in Figure 2.1.

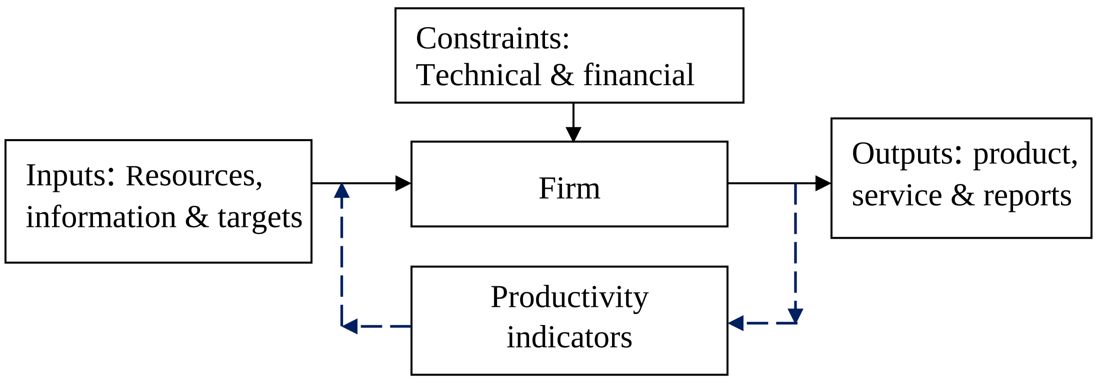


Figure 2. 1 The simple firm model

Productivity is defined by different organizations, sectors, and individuals as:

The European Productivity Agency (EPA) has defined productivity as an attitude of mind. It is a mentality of the progress of the constant improvement and the certainty of being able to do better today than yesterday & continuously by applying new techniques & methods. The nation: productivity would broadly mean the optimized use of real resources to obtain the output of goods & services needed by the community. Manufacturing company: the output of manufactured goods sold (the effective use resources, employees of all ranks, materials, and capital assets). Individual: The saleable value of work achieved in return for a reward, the use of personal resources, and those provided for personal use (Tessema, 2007). It is a measure of the degree of effectiveness & efficiency of any service and manufacturing organization in generating output, given the resources available (Tesfu Berhane, 2017). Defining the inputs and outputs is very crucial and mandatory. Inputs represent material, labor, capital, equipment, energy, and data; and outputs as completed products, information (report), and data that can develop processes (Tadesse, 2011). Attia et al. (2006) present the inputs of a manufacturing (mfg) company as materials, machines, manpower, method, technology, land, building, money, market, management tools, and information. The following Figure represented its conceptual model.

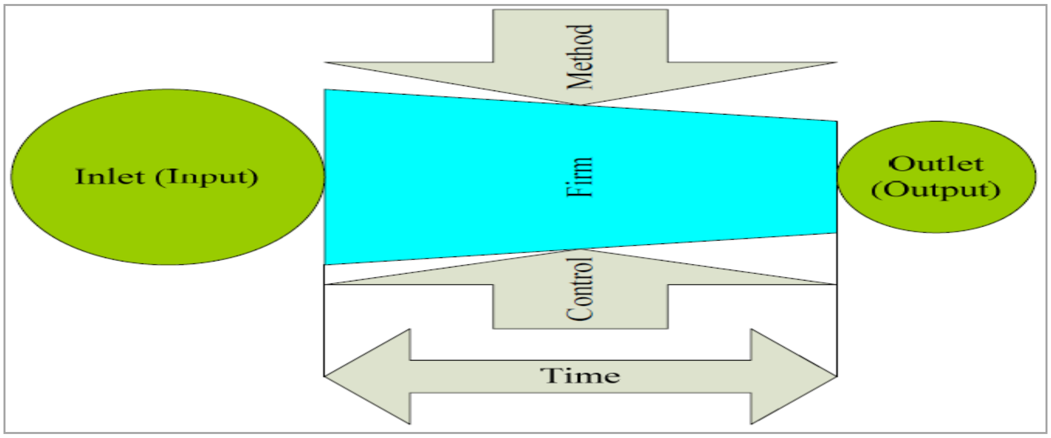


Figure 2. 2 The conceptual model of productivity

Source: (Tadesse, 2011)

The theoretical model is represented as a frustum to show all the input cannot be changed to output and there is a waste. Waste increases along the length of the frustum. The basic thing while thinking productivity improvement is minimizing the waste. Waste is represented by the difference in the volume of the cylinder and frustum. As a review, the inputs of the firm considered are human, capital, material, energy, and miscellaneous inputs. The outputs considered are finished and partial products for sale and internal use. Method is a means applied to do activities in a better way. Control deals with regulating activities and parameters within an acceptable limit. All operation and non-operation times are considered. Waste is the part of the resources that have no purpose or value to the firm and customers (Tadesse, 2011; Sahni, 2016).

Therefore, as summary productivity is defined as the effective and efficient utilization of resources used to produce products/services that meet customer requirements continuously by applying appropriate methods, time and by controlling the parameters of constraints that help any industry or service organization can survive in a global market share.

❖ ***Importance of Productivity***

High productivity enhances customer satisfaction, reduces time & cost, is profitable to firms, produces & delivers products on time. Productivity has a strong & significant relationship to performance measurement for process utilization, process output, product cost, and work-in-process inventory levels, and on-time delivery (Sujay Biswas, 2016).

Therefore, its improvement is used in the form of elimination, correction, or repair of ineffective processing, optimizing the system, reducing variation, simplifying the process, maximize the throughput, reducing cost, increasing quality/ responsiveness, and reducing set-up time.

2.2. Productivity Factors

Identifying the possible productivity factors is one of the basic elements for productivity improvement. The productivity factors can be either boost or hinder productivity. The productivity factors surveyed from kinds of literature are presented as follows.

According to ETIDI, (2010), identify the constraints of Ethiopian garment sectors: access to inputs at a competitive price, access to market, low margin operation, high transport & transaction cost, bureaucratic hurdles, undercapitalization, & the threat of foreclosure from banks.

Kumar et al. (2008), presents controllable (internal) factors and uncontrollable (external) factors that influence productivity. Product factors, plant and equipment, technology, material & energy, human factors, work methods, and management style are controllable. Structural adjustment, natural resources, government, and infrastructure are uncontrollable factors (Grunberg, 2007).

Belgin (2008), classifies productivity factors into internal and external factors. The internal factors are categorized into materialistic and non-materialistic. Materialistic internal factor involves product, plant and equipment, technology, material and energy; and non-materialistic internal factor includes human, organization, work methods, and management. The external factors are categorized into structure, natural resources, and governmental issues. A structure factor involves ergonomics and social situation; natural resources factor included land, energy, and raw material; and governmental issues involves - corporate mechanisms and politics (Yilmaz, 2009). According to Grunberg (2007), classifies factors influencing the performance of operations into four: namely processes, control, product, and resource. Factors related to the process are lead-times, bottlenecks, material flow, volumes, development, inventory, integration, losses layout, measurement, cycle-times, and transport; ABC analysis, overproduction, subcontracting, financing, total quality, outsourcing, cost, and articles; administration, location, routines, suppliers, planning, customer, factors related to the resource are an organization, measurement, efficiency, work methods, capacity, communication, motivation, satisfaction, accidents, resetting, utilization, maintenance, scheduling, absenteeism, competence, ergonomics, new technology, losses and downtimes; and factors related to products are development, design for assembly, product variants, standardization (Tadesse, 2011). The matters for insufficient productivity are poor material flow control, high absenteeism, poor workers' skills, and the unwillingness of workers to change workplaces (Dragoslav Slović, 2017). Hence, productivity is the better utilization of existing resources (Mahmut Kayar, 2014). So, the factors of productivity are many and vary.

In general productivity factors in Ethiopia garment industries (both internal and external factors) are grouped into five, including process, method, control, human, and product. According to ETIDI, (2018) report indicates that at present time the major productivity factors of this sector are limited inputs, low salary standard, long lead time, poor work culture, workers skill gap, inappropriate work method, and poor system integration both internally and externally. So, reducing these productivity factors are helps us to improve productivity. And productivity can be increased by several methods: like modernization, automation, and technological improvements, but this involves substantial capital investment.

2.3. Productivity Measurement

Productivity measures efforts to high spot improvements in the physical use of resources, that is, to motivate and evaluate attempts to produce more outputs with fewer inputs while maintaining quality (Tadesse, 2011). Which, is important for any kind of industry; includes effective relationship to performance measure for method utilization, method output, product prices, and work in process inventory levels and on-time delivery (Farhatun Nabi, 2015). Among the central philosophies of productivity improvement is the values of productivity in the existing process should be measured in as much detail as possible before any effort is made to improve (Eshetu, 2017). Productivity can be measured by the following productivity measurement indicators: total productivity, partial productivity, and surrogate productivity (measure surrogate factors) which are not measured directly as the ratio of output to input (Habtemariam, 2018).

According to Tadesse, (2011), productivity broadly classifies into total, partial, total factor, and multifactor productivity. The total productivity is measured by the ratio of the total output to the sum of all inputs. Partial productivity is measured by the ratio of output to one class of input. Multifactor productivity is the ratio of output to a bundle of inputs. Total factor productivity is calculated as the ratio of net output to the sum of associated labor and capital inputs. These are used for productivity measurement indicators. According to Dragoslav Slović, (2017), states that productivity was measured as a ratio of industrial production and the number of employee indices (productivity/ employee). Productivity can be measured at the international, national, industrial, and company levels (Tadesse, 2011).

As a result, productivity measurement is essential to know the production performance, production capacity, efficiency, and resources utilization of any industry. And it helps to compare their production capacity level with other competitors.

2.4. Productivity Improvement

Since the 1950s, struggle among companies has increased as markets have become increasingly global. This augmented competition creates an even greater need for first-rate improvement approaches that can sustain competitiveness. Because, improving productivity has a positive impact on the direct costs of the products, as the same output is produced with less input or as the same inputs are producing more output (Mapfaira, 2015). It can create new opportunities and improve the competitiveness of the manufacturing operations. Low productivity indicates that an enterprise is wasting its resources and it affects international competitiveness. Accordingly improving productivity is especially important for export-oriented industries since it is the only viable option for competing in the long term (Tadesse, 2011; Eshetu, 2017). The productivity improvements can be understood at different levels. The productivity of individuals may be reflected in employment rates, wage rates, the stability of employment, and job satisfaction across industries (Gebrehiweta, 2017). It has to do with how effectively people combine different resources to manufacture parts and services others dream to purchase. With the rapid increase in demand for production, mfg industries need to increase their potentials in production & effectiveness to compete against their competitors. Hence the route to simplify the problem regarding the production is of paramount importance, to solve the problems & governing productivity (Prathamesh P. Kulkarni, 2014). According to Mishra, (2013), productivity improvement focuses on: doing the “right things” by continuously reviewing and identifying the changing customer and societal needs. The rate at which a company produces goods or services about the number of materials and number of employees needed (Input: Material, machine, man-hours, methods, land, and output: parts & product, services, wastage, pollutants of any type) (Sahni, 2016; Abdul Moktadir, 2017). Hence, productivity improvement can be done by sorting of elimination, reducing variation, repairing of ineffective process, simplifying the method, optimizing the system, maximizing turnout up quality or responsiveness, and reducing set-up time (Sahni, 2016). According to Abdul Moktadir, (2017) states that productivity improvement is the continuous improvement process of any type of activity. Improving productivity means increasing the efficiency and effectiveness of the conversion of inputs into outputs, which means the elimination of waste (Dragoslav Slović, 2017). Hence, it is carefully planned and executed, the particular investment is the initial cost & effort, and the reward is a great result. To achieve this continuous productivity improvement through the utilization of improvement tools, that to solve all barriers are being used in the industry includes lean, Just-in-time, 5S, standardized work, value stream analysis, Pareto chart, cause-effect diagram, cost/benefit analysis, continuous flow, Heijunka, Jidoka, etc. (Mapfaira, 2015). One of the core strategies towards mfg excellence is improving productivity and it is necessary to achieve good financial and operational performance. The two important functions of productivity management that help to increase productivity are the installation of the most effective method of operating and the control of resources (i.e. plant and labor). This is a total thought that addresses the key elements of competition are: innovation, cost, quality, and time (Sujay Biswas, 2016). The importance of productivity improvement is to satisfy the customer, reduce time and cost, produce and deliver products on time (Farhatun Nabi, 2015).

In a summary, productivity improvement is one of the most important factors for any industry, to increasing efficiency and effectiveness of the transformation of input into outputs, especially for the textile and garment sectors to survive in this global upward competition. Because globalization has given rise to new standards by increasing the value-added content of products, decreasing the unit cost & work content of the production, line balancing of the methods, or by a combination of all using appropriate techniques, tools, and approaches.

2.5. Concept of Lean Manufacturing (LM)

The concept of lean was originally developed in Japan by Toyota for their automobile manufacturing replacing mass production Womack and Jones (1990). According to Womack, the primary focus of lean is to maintain the value of the product with less work (Yerasi, 2011). Lean has been increasingly applied by leading manufacturing companies throughout the world and a core concept is pulling production in which the flow on the factory floor is driven by demand from downstream pulling production upstream (Nadia Akter Swarna, 2018). Lean mfg is an efficient method that to finding and eliminating wastes through continuous improvement and flow the product at the pull of the customer in pursuit of perfection (Mazedul Islam, 2013; Swapnil Firake, 2014). Lean describes a system that produces what the customer wants and when they want it, with minimum waste and it's the concept lean arises when a company wants to make the process more efficient, without delays and with less capital and to use in automobile, garment, aerospace, chemical engineering or any manufacturing (Legese, 2014; Rashmi Kumari, 2015). Thus, lean is a working idea designed to produce better products by using less income to obtain more profit and has been applied to a vast variety of manufacturing sectors (Vikram, 2017). And also, it is a management approach for processes improvement with a methodology that is focused on comparing value-added steps versus non-value-added (Eshetu, 2017). Lean also denoted as lean management, lean manufacturing, lean enterprise, or lean production, is a set of principles, tools, and techniques that many industrial companies go for to implement. LM has emerged relatively recently as an approach that integrates different tools to focus on the elimination of waste and produce products that meet customer expectations and helps in the reduction of resources (Senthil Kumar, 2012; Swapnil Firake, 2014). LM has a comprehensive set of rules, elements, and tools which focus on the elimination of waste and the creation of value. Hence the main points of LM are to eliminate non-value adding activity, build quality into the production, reduce costs and create & formulate tools that will add value to the organization's functional performance (Firozabadi, 2015; Mohammed Saidul Huq, 2018). One of the key aspects of LM is including the never-ending quest for perfection, continuous search to eliminate waste, and the recognition and importance of employee contributions (Pramadona, 2013). Lean technology is the most effective & efficient mfg thought, and it is used to improve productivity with high quality (Sahebagowda, 2017). The main idea that was considered to lean mfg has been to maximize customer values, while, minimizing all the wastes that come with that value (Effah-Kesse, 2017). As stated by Kulkarni et al. (2014), LM reduces the operation time, increases maneuverability, improves the corresponding attributes and to optimizes customer significance, minimizes wastes, thereby achieving manufacturing excellence through the creation of more value with fewer or no capital investments (Sahni, 2016). Lean is a manufacturing philosophy that shortens the time between the customer order and the product build/shipment by eliminating the source of waste (Legese, 2014; Dr.Askın Ozdagoglu, 2016). The primary aim of lean mfg is to attain the same output with less input-less time, less space, less human effort, less machinery, less material, less cost (Legese, 2014). Thus, LM helps to identify productively (value-adding) & non-productive (non-value-adding) activities (Mazedul Islam, 2013). The use of lean production is now being practiced by organizations that aim to increase productivity, improve product quality and reduce manufacturing cycle time, reduce inventory, reduce lead time and eliminate manufacturing waste, by using the following lean tools like Kaizen, Kanban, 5S, Just in Time (JIT), Value Stream Mapping, etc. (Amorado, 2015). One of the main concerns of LM is the elimination of waste in every production area including customer relations, product design, supplier networks, and factory management. And also, it is highly responsive to customer demand through producing top-quality products most

efficiently and economically (Rojasra, 2013; Rashmi Kumari, 2015). The fundamental objective of lean management is to have a continuous improvement system, which eliminates wastes to its minimum, and to make sure that all activities and processes that take place in any part of the organization add value to the final customer (Effah-Kesse, 2017). The organizational benefit of lean are: better management, reduce waste in human effort, production space and less rework, improved quality, faster delivery time, improved visual management, increase worker efficiency, easier to manage work areas, total involvement, problem elimination, increased space utilization, safer work environment and improved employee morale (Mohammed Saidul Huq, 2018). The benefits of lean in the process industry are less process waste, reduce lead time, less rework, financial savings, increased process understanding, and reduced inventory (Dr.Askın Ozdagoglu, 2016). Disadvantages of implementing lean practices: depends deeply on suppliers due to small amount of inventory, high cost of implementation; rejection of employees and stressful workplace, focus on waste elimination and lack of attention to other parameters, such as workers safety, environmental risk, and pollution are not considered as waste in LM (Firozabadi, 2015).
Therefore, the lean mfg technique is one of the systematic approaches that, used to identifying and eliminating wastes through continuous improvement, and the flow of the production at the pull of the customer is in search of perfection in any garment industry for enhancing productivity.

2.5.1. Lean Manufacturing Tools and Techniques

Learn tools and techniques are good industrial engineering practices that can be applied to companies in many contexts and without a lot of difficulties. These tools have been derived from the research of many people throughout history (Prathamesh P. Kulkarni, 2014). And those tools are used to accomplish what LM stands for: waste elimination, cost reduction, improved quality, and decrease lead time, inventory, and equipment downtime (Wulff, 2014). There are several LM tools when used in proper ways will give the best results for productivity improvement in manufacturing sectors (Rashmi Kumari, 2015). Since the birth of the Toyota production system, many of the tools and techniques of LM (like: (JIT), cellular manufacturing, total productive maintenance, single-minute exchange of dies, production smoothing) have been extensively used (Swapnil Firake, 2014). And also, several different lean tools and techniques are used in mgf industries and the same tools can also be applied in the service sector, which is developed from the adaption of the manufacturing sector (Mahmood, 2014). These lean tools are why very complex & interdependent and one can find similarities in one another. Currently, in practice, there are approximately 25 lean tools, out of which, these five tools are considered to be the most critical, which are: Bottleneck analysis, waste, 5S, standard work, and set up reduction (Prathamesh P. Kulkarni, 2014). The most widely used lean tools are value stream mapping (VSM), 5S, total productive maintenance (TPM), single minute exchange of dies (SMED), JIT, and kaizen (Biman Das, 2013). The most frequently used LM tools are listed as 5S, VSM, work standardization, setup-reduction, cellular manufacturing, line balancing, quick changeover (SMED), JIT, kanban, small-lot production & continuous, flow production, leveling (Heijunka), TQM, TPM, continuous improvement (kaizen), Autorotation via Poka-yoke (Rubayet, 2013; Mohammed Saidul Huq, 2018). These lean improvement tools and techniques are applied to any company which helps to identify areas of opportunity for waste reduction and improve the efficiency of production processes (Balaji Rathod, 2016; Sahebagowda, 2017). The common LM improvement methodologies are VSM, 5'S (Housekeeping), Visual Management, Standard Work, and Mistake Proofing (Poke-Yoka) (Yerasi, 2011). As stated by Mihir K. Shah, (2015), some of the lean tools and techniques with their practical applications are shown in Figure (2.3).

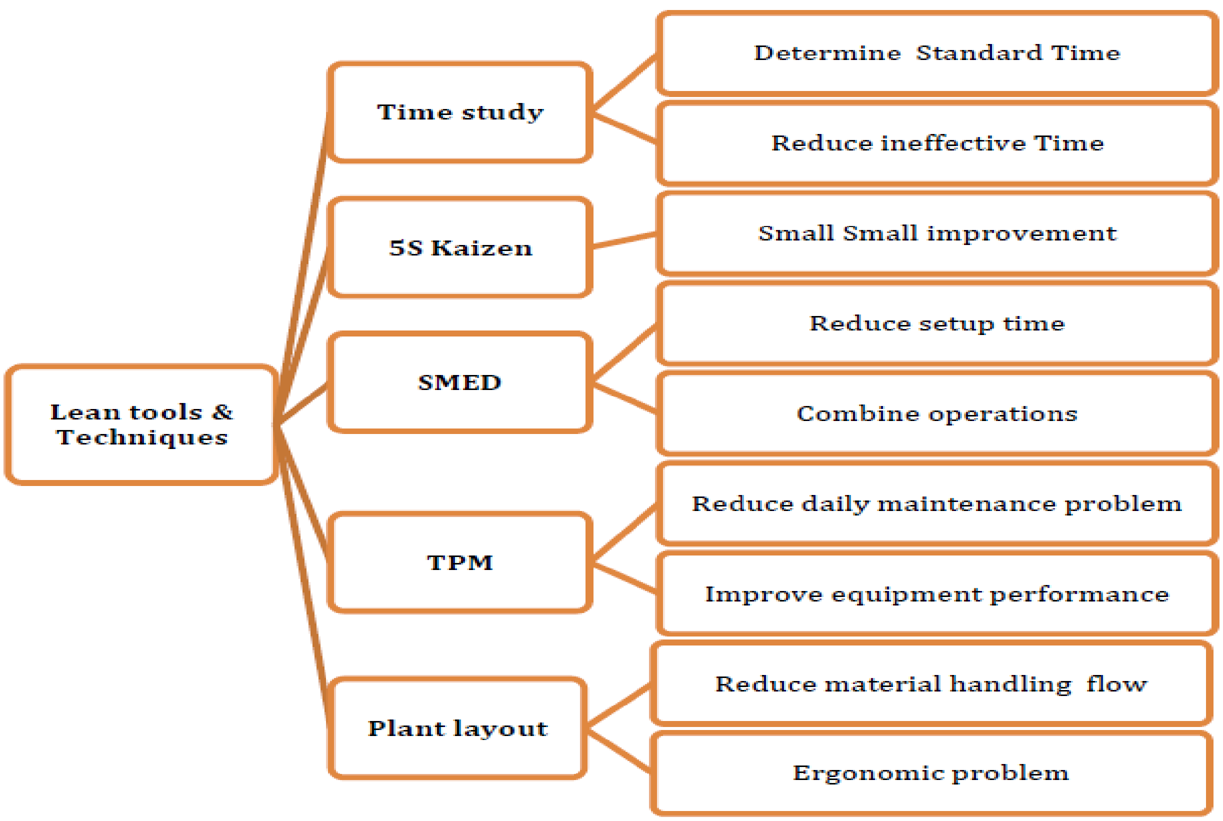


Figure 2. 3 Different lean tools & their applications

Therefore, based on various literature, there are above 30 types of lean tools to identify. Based on their practical use of lean tools they can be grouped as process & work method, time, management & control, quality, and human safety.

Table 2. 1 The most commonly known lean manufacturing tools

Lean Manufacturing Tools and Techniques		
5S	Six-Sigma	Multi-function employees
VSM	Muda (waste)	Cycle time
Cell Layout	PDCA (plan-Do-Check and Act)	Teamwork & training
Kaizen	Standardize work	Ergonomics work
Poka-Yoke (error proofing)	Bottleneck analysis/ line balancing	Ishikawa Diagram
JIT	Kanban (pull system)	Visual display & control
TPM	Heijunka - level scheduling	Supplier management
TQM	Visual Management	Small lot size
SMED & Point of use system	Set up Reduction	Uniform workload
cellular manufacturing	Jidoka- Automation	Flow production

Basic concepts of some lean tools and techniques

Table 2. 2 The summary of lean tools & techniques with their basic concepts & their focuses

Lean Tools and Techniques	Basic Concepts	It focused on
VSM	It is used to map the flow production and shows the current & future state of processes for further improvement	Avoid the existing wastes & provides a road map for the new state.
5S	Organize the work area by 5S pillars	Eliminates wastes, time, and non-value-adding activities.
Kaizen	Change for the better/ a step-by-step process improvement/ gradual CI.	reducing fatigues and eliminate non-value adding activities
TPM	Optimize the equipment’s effectiveness	Reduce maintenance problems
TQM	The art of managing the whole to achieve excellence	Improving the management involvement & reduced errors
Kanban/ Pull system	Using automatic replenishment signal cards for smoothing production flow.	Less inventory, lead time & effective resource utilization
SDW	It makes the fastest & most effective method to carry out a job in the less time	Eliminate non-value adding activities and time
SMED	Mainly focused on machine setup reduction	Reducing setup time, combine operation, and less lead time

Production leveling	To leveling a fluctuation demand of the customer & it avoids peaks and valleys in the production flow schedule.	Reduces lead time and inventory.
JIT	To produce the right items with the right quality and quantity in the right place at the right time	Reducing inventory improves cash flow and reduces space requirements
Poka-Yoke	Design error detection and prevention into production processes to achieve zero defect	Reducing product defects during the assembly/ design phases.
Cellular manufacturing	Separate production of a specific product in one line and gathered all necessary tools and materials in place.	Eliminating production time, improving material utilization reducing operators fatigues
Six-Sigma	It seeks to identify & remove the causes of defects and errors in mfg processes.	Eliminate product defects, scraps, and reworks.
Cellular layout	Arranging a group of m/c or processes based on the design of the product being made for its production.	Eliminate unnecessary material & operator movements and time
Muda (waste)	Anything that does not add value from the customers' point of view.	Elimination of all Muda wastes & is a lean objective
Set up reduction	Reducing non-production time & issues	Improve equipment performance
Line balancing	Reducing bottlenecks & obstacles	Eliminate non-value adding activities, & reduce lead time
Visual display and control	To visual and manage the production process using different technologies	To reduce the complexity of the production system errors
Ergonomics work	To create a good working environment	Reducing risks, fatigues, & time
Flow production	The mfg process where WIP smoothly flows through production with minimal barriers.	Eliminates waste: inventory, transport, and waiting time.
Small lot size	Small lots reduce variability in the system and smooth production. Lot size directly affects inventory & scheduling	Enhancing quality, simplifying scheduling & reducing inventory
Ishikawa diagram	Used to shows the causes of an event	Identify root causes of a problem
Cycle time	The total time required to produce a specific product.	Reducing lead time
Uniform workload	To provide a good work distribution	Improve workers motivations
Root cause analysis	A method to deeply figured out the problems in the process along with their causes that reach the root of a problems	Eliminate non-value-added activities and reduced defects.

2.5.2. Waste of Lean and Conceptual Models

Anything that doesn't add- any value in the mfg process, known as waste, means it is nothing but any process for which the customer does not pay the company (Prathamesh Kulkarni, 2014; Habtemariam, 2018). Waste is generally caused due to unnecessary delays, processes, costs, and errors (Yerasi, 2011). And it is generated due to: poor layout, long setup time, incapable processes, poor maintenance practices, poor work methods, lack of training, large batches, ineffective production planning/ scheduling, lack of workplace organization, etc. (Mazedul Islam, 2013). The waste (Muda) as in Japanese can be grouped in seven different forms: defaults, overproduction, waiting, conveyance, processing, inventory, and motion. Each of these types of waste has its causes and solutions and when eliminated, provides multiple benefits (Mohammed Saidul Huq, 2018). Waste in LM can be categorized into seven types which are commonly referred to as the "Seven Wastes" (Mazedul Islam, 2013). Taiichi Ohno suggests that these account for up to 95% of all costs in non – LM environments. According to Ramune. E.t al., (2012), divides the seven wastes into three categories: Men, Machines, and Materials, but, not consider energy. See in the following Figure (2.5).

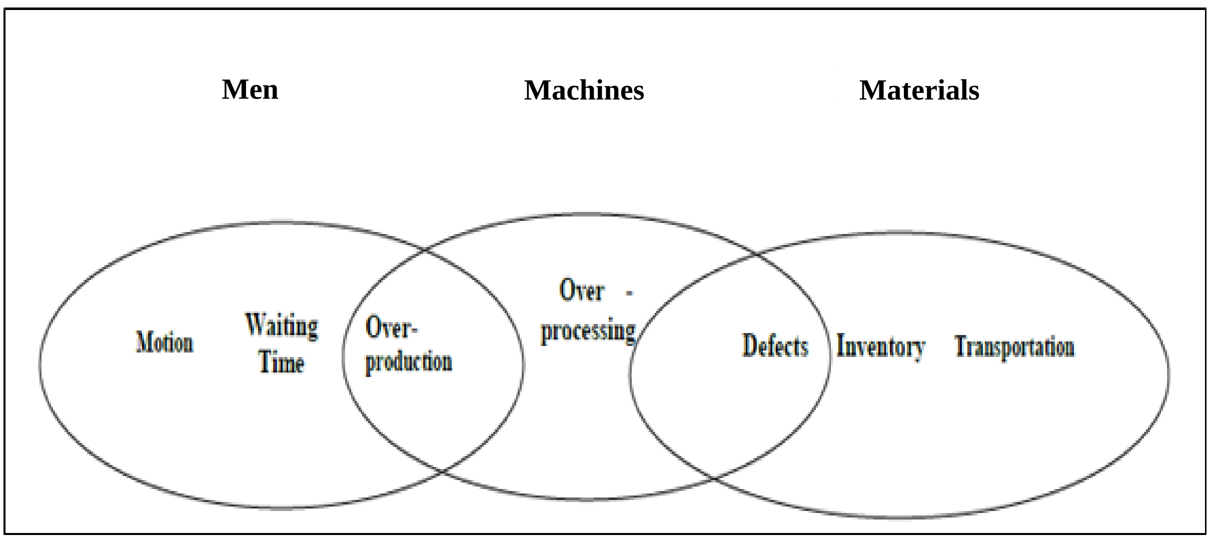


Figure 2. 4 The three categories of the seven lean wastes
Source: (Firozabadi, 2015).

- Currently, in practice there are eight LM wastes, these are over-processing, waiting for time, unnecessary (motion, transportation, and inventory), over-processing, un-used skills, and defects. These lean wastes are discussed in detail as:

1. **Overproduction**: producing more than the customer demand is one of the obstructs to smooth flow of materials & degrades quality & productivity (Mazedul Islam, 2013; Effah-Kesse, 2017). **2**. **Waiting**: whenever goods are not being moved or being processed, waste, waiting occurs. Usually, more than 99% of the product's life cycle time in old-style mass production is spent idling, waiting for material, labor, information, equipment, etc. When time is not used effectively, it leads to a waste of waiting, and it results in higher lead time, customer dissatisfaction, and competitiveness (Effah-Kesse, 2017). **3**. **Excess Motion**: any motion that an employee has to perform which does not add value to the product is an unnecessary motion (Mostafizur Rahman Sobuj, 2015). This is caused by poor workflow, poor layout, and inconsistent or undocumented work methods (Mazedul Islam, 2013; Prathamesh P. Kulkarni, 2014). **4**. **Transportation**: moving products between processes do not add value to the product. Excessive movements and handlings can cause damages and can lead to a reduction in quality (Mohammed Saidul Huq, 2018). Lean requires the material to be shipped directly from the vendor to the location in the assembly line where it will be used, its call point-of-use storage (Mazedul Islam, 2013). **5**. **Over-processing**: is taking unneeded steps to the production process. The most common examples are: reworking, inspecting, rechecking, etc., due to poor layout, poor tools, and poor product design, unnecessary motion, and producing defects (Sahni, 2016). **6**. **Excess Inventory**: waste caused by keeping of unnecessary stock (Effah-Kesse, 2017). It uses valuable floor space and hides the problems related to process capabilities. It leads to longer lead time, seamless flow of work, increases space, prevent rapid identification of items, obsolescence, damaged goods, transportation and storage costs, and delay (Mazedul Islam, 2013; Effah-Kesse, 2017). **7**. **Defects**: is categorized as either production defects or service errors and this results in a tremendous cost to organizations (Prathamesh P. Kulkarni, 2014). Time, money, materials, and energy are wasted every time this type of waste happens, due to, reworks which results are double costs, unsatisfied customers, or total loss of customers (Effah-Kesse, 2017). Rework, replacement production, and inspection means wasteful handling time, and effort (Mazedul Islam, 2013). **8**. **Underutilized employee creativity**: This means more people on the job, but fewer people. The failure to make full use of employees' knowledge, abilities, and skills are required to use their creative brainpower, to inspire to their highest potentials, and their point of view needs to be recognized (Effah-Kesse, 2017). Thus, all those lean wastes should be reducing/eliminate in any mfg industry, including the textile & garment industries of Ethiopia using integrated tools for enhancing the productivity of the sector.

2.5.3. Summary of lean Manufacturing

Conceptual model of LM that stated by Shah et al., and Mahmood, (2007; 2014)

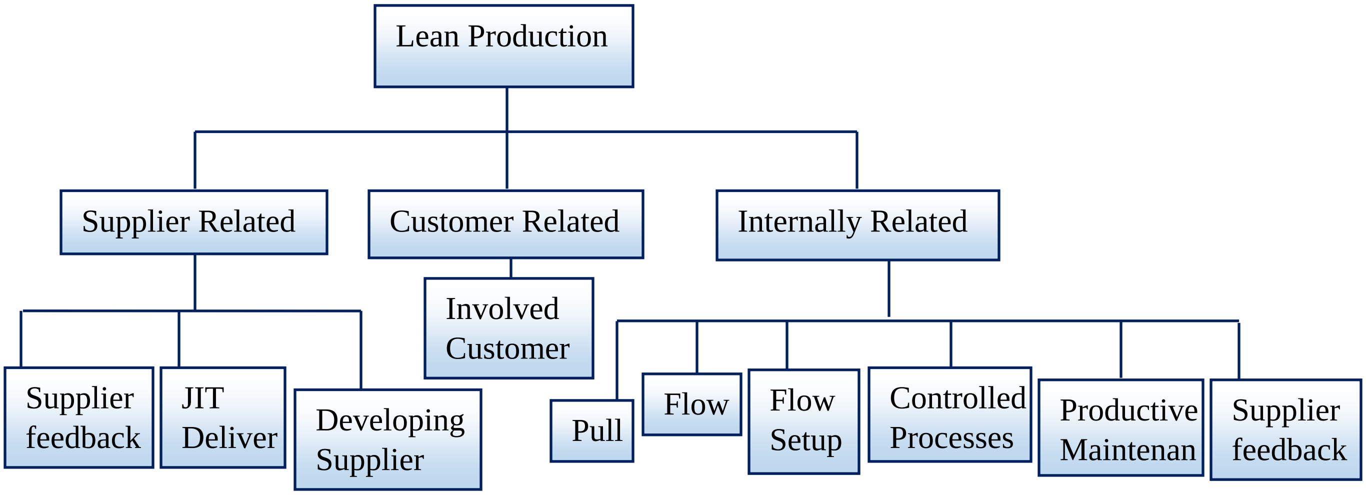


Figure 2. 5 Lean conceptual model

The main concept of lean mfg is to eliminate those wastes in the production process, improving quality, reduce costs & formulate tools that will add value to the industry's functional performance (Firozabadi, 2015; Mohammed SaidulHuq, 2018). Lean aims at reducing cost by eliminating waste and wasteful steps within a process and producing at a faster rate using different tools and techniques (Habtemariam, 2018). The most commonly used LM tools are JIT, Cellular Manufacturing, 5S, Value Stream Mapping, SMED, Kaizen, and TPM. These lean tools are used for the garments industry, to eliminate waste, have better inventory control, product quality, and good overall financial and operational procedure (Rubayet, 2013). By eliminating wastes in the overall process, through continuous improvements (CI) the product's lead time can be reduced remarkably and can obtain operational benefits (enhancement of productivity, reduction in WIP inventory, improve quality, reduction of space utilization, and better workplace organization) & administrative benefits (reduction of order errors, streamlining of customer service functions) (Mazedul Islam, 2013). Sewing is a subdivision of the garment sector and it is a nuclease of among different garment sub-operations because major value-added activities are done. Some lean mfg tools are difficult to adopt in the garments industry. Hence, it is necessary to identify which tools are appropriate for the specified garments industry. Because, it creates an opportunity to eliminate or reduce, wastes, that did not add value to customers and the company (Mahmood, 2014). Thus, LM is all about eliminating waste & creating flow through CI as illustrated in the following Figure.

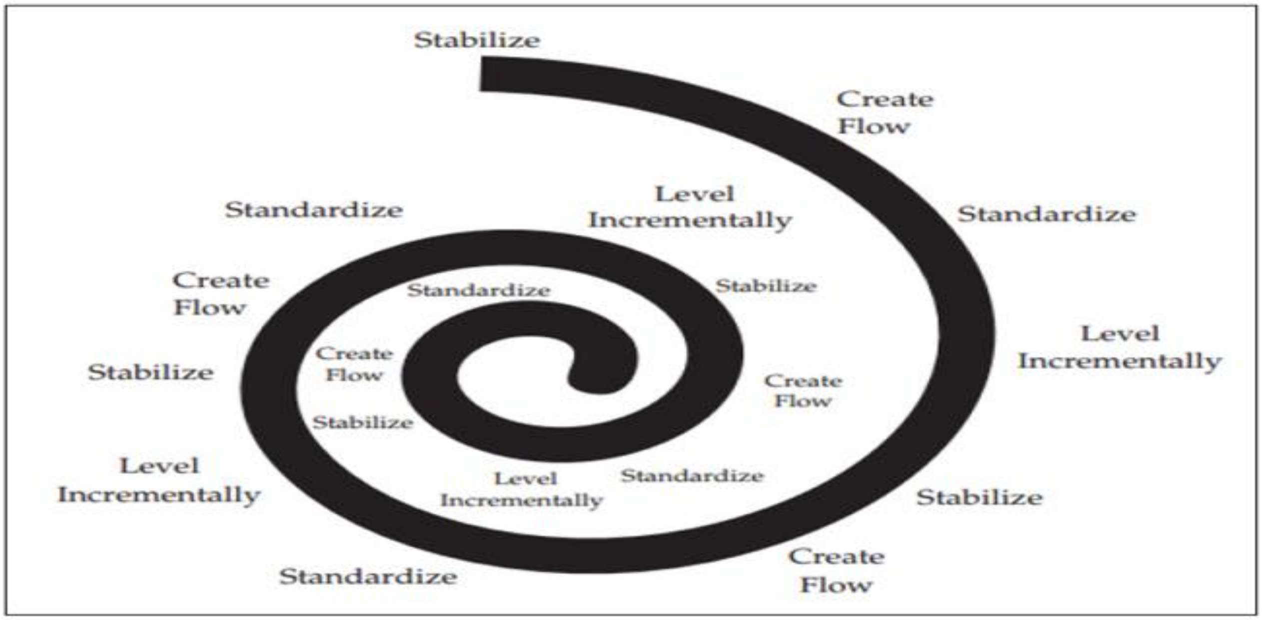


Figure 2. 6 Continuous improvement spiral flow

Source: (Vartdal, 2016).

Figure (2.8) illustrates that improvement work never ends. By improving a process by creating flow and standardizing the procedures a new potential for flow increases. The flow created may not give the same results as the first improvement, but, it is an improvement. According to Niklas Modig (2016), lean is a journey where flow efficiency is prioritized before resource efficiency (see Figure 2.9). So, by placing a company, or shop floor in the efficiency matrix one can see whether the management focuses on flow or resource efficiency to become more lean manufacturing.

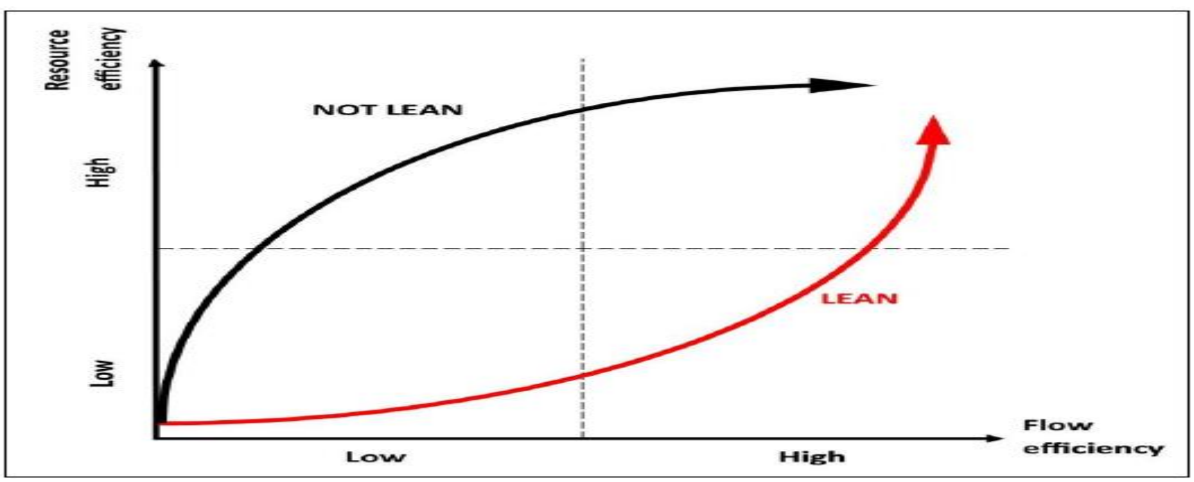


Figure 2. 7 Efficiency matrix flow

Source: (Vartdal, 2016).

2.6. Concept of Work-Study

Work-Study constituted much of the pre-WWII industrial engineering (IE). IEs significance was recognized by Henry Ford through the specialization of engineers. The Ford is presented industrial engineers, whose task was to, through the application of work-study, simplify and standardize work, so it can be performed by unqualified workers (Dragoslav Slović, 2017). This is the basic term that is used in the examination of human work in all its contexts, which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, to effect improvement (Sujay Biswas, 2016; Eshetu, 2017; Pancholi, 2018). It is mainly focused on investigating the way of an activity that is being carried out, simplifying or modifying the method of operation to reduce non-value adding activities in terms of rework, wastage, and finally fixing the standard time for an activity, to attain the best possible use of the resources are available in the building at present (Prathamesh P. Kulkarni, 2014; Abdul Moktadir and Dragoslav Slović, 2017). The technique of work-study is very much required for management to understand its actual application not only from the angle of productivity/ financial improvement or proper utilization of resources but also it should address critically the soft side of workers psychology (Sujay Biswas, 2016). The new dimension of the work-study technique helps to produce goods at a faster and more reasonable cost, through changes in the methods, procedures & some work habits and also used to increase the amount produced from a given quantity of resources without further capital investment (Dr.P. Singh, 2016; Chisosa, 2018).

In general, work-study is the most important technique in any industry, because it can be applied with less investment or no investment that to enhancing the production efficiency and benefit, reduce the cost, and strengthen the competitive ability through improving the operating process & method, fully utilizing the human, material and financial resources inner the firm (Cengiz Duran, 2015). The two classifications of work-study are shown in the following Figure (Chandra, 2013).

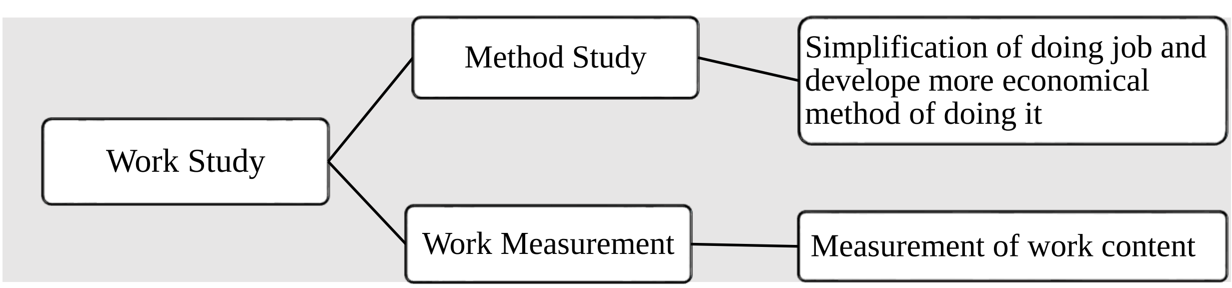


Figure 2. 8 Components of work-study

The main aim of work-study is finding the best and the most efficient way of utilizing the available resources to achieve the best possible quality of work in minimum possible time and cause the least possible fatigue to the worker (Ravikumar Kamble, 2014). Thus, one of the importance of this technique is to enhance the production efficiency & to identify non-value adding operations by investigating all the factors affecting the job and also, used to establish time standards, etc.

2.6.1. Principle, Purpose, Benefits, Procedures, Roles of work-study

❖ **Principles of work-study stated by Moroliya,** (2018):

- Work-study must come from the top-level management.
- People were made aware of the objectives and the need the exercising such study.
- Method study must precede work measurement.

❖ **Purpose of Work-Study**

To establish the most economical way of doing the work, establish the time required for a job at a defined level of performance, increase productivity and profitability, increase job security, make work easier, establish fair tasks for everyone, check achievements against standards, and to install the work method as standard practice (Dragoslav Slović, 2017; Habtemariam, 2018).

❖ **Benefits of work-study** (Ewnetu, 2016):

- Increasing productivity, operational efficiency, and better working conditions for employees
- Reduced manufacturing costs and improved workplace layout
- Better manpower planning, capacity planning, and fair wages to employees
- Improved workflow and reduced material handling costs
- Proved a standard of measure labor efficiency & Better employee morale.
- Better employment prospects, set standards of performance, the base for incentive standardize the method, materials, and equipment used in the production process (Eshetu, 2017).

❖ **Steps involved in work-study** (Dragoslav Slović, 2017):

Select: the job or process to be studied; record: all the details of the job using various recording techniques; examine: recorded facts critically by asking questions like; who, what, when why; develop: most economical methods; measure: the amount of work involved and set standard time to do a job; define: new method and standard time; install: the new method as a standard practice and maintain: the new standard practice by proper control procedures.

❖ **Role work-study to increase productivity:**

There are six possible lines of attack on productivity problems, these classified as:

Improve basic processes by research and development, improving existing processes and provide better plant and equipment, simplify the product, reduce and standardize the range, improve the planning of work and the use of manpower, improve existing methods of plant operation, and increase the effectiveness of all employees (Habtemariam, 2018). So, work-study plays an important role to increase productivity by solving those problems in the production processes.

2.6.2. Techniques of Work-Study

This technique is mainly classified into two, which are method study and work measurement. Method study mainly on searching efficiency working method, whereas work measurement is to determine the scientific and reasonable working time quota of each operating (Cengiz Duran, 2015). And this detailed classification had shown in the following Figure.

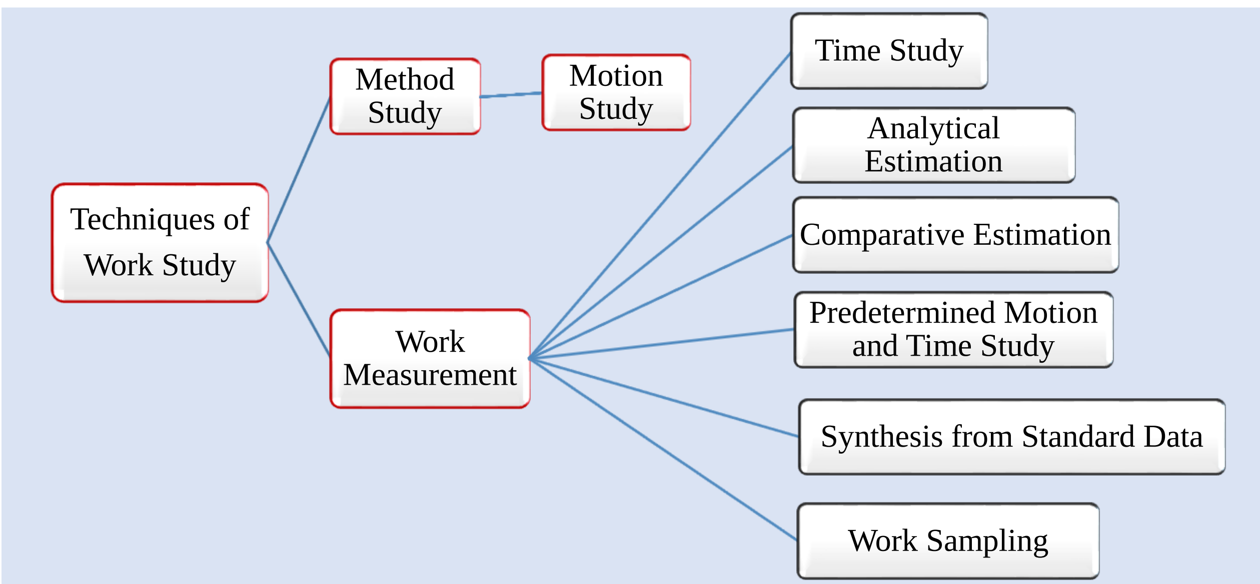


Figure 2. 9 Work-study techniques

1. ***Method Study***

The philosophy of method study is that "there is always a better way of doing a job" and the tools are designed to systematically arrive at a job without any need for investment (Mahmut Kayar, 2014). In most developing countries the managers pay attention to several products rather than paying attention to how these products are produced. This indicates that there is a skill gap for managers to use an appropriate technique like method study for improving the productivity of their company (Chandra, 2013). Method study is the most effective the use of the plant, equipment, human effort & work and also it increases the efficiency by eliminating unnecessary operations, avoidable delays, and other waste (Cengiz Duran, 2015). Thus, it is a scientific technique of observing, recording, and critically examining the present method of performing a task/ job to improve the present method and develop a new and cheaper method (Gyanendra Prasad Bagri and Ravikumar Kamble, 2014; M.Ashiq Hyder, 2016). Because, a better method helps to optimum use of the best materials and appropriate manpower so that work is performed in a well-organized manner leading to increased resource utilization, better quality, and lower costs (Ewnetu, 2016; Moroliya, 2018). To improve the efficiency using method study is achieved through improved layout, workplace design, efficient work procedures, effective utilization of human, machinery, and material resources (Chisosa, 2018). Method study mostly applies to the repetitive type of work (Mahmut Kayar, 2014). Consequently, in the garment industry, certain repetitive activities could be reduced through method study. Method Study procedures/ steps are shown in Figures (2.12)

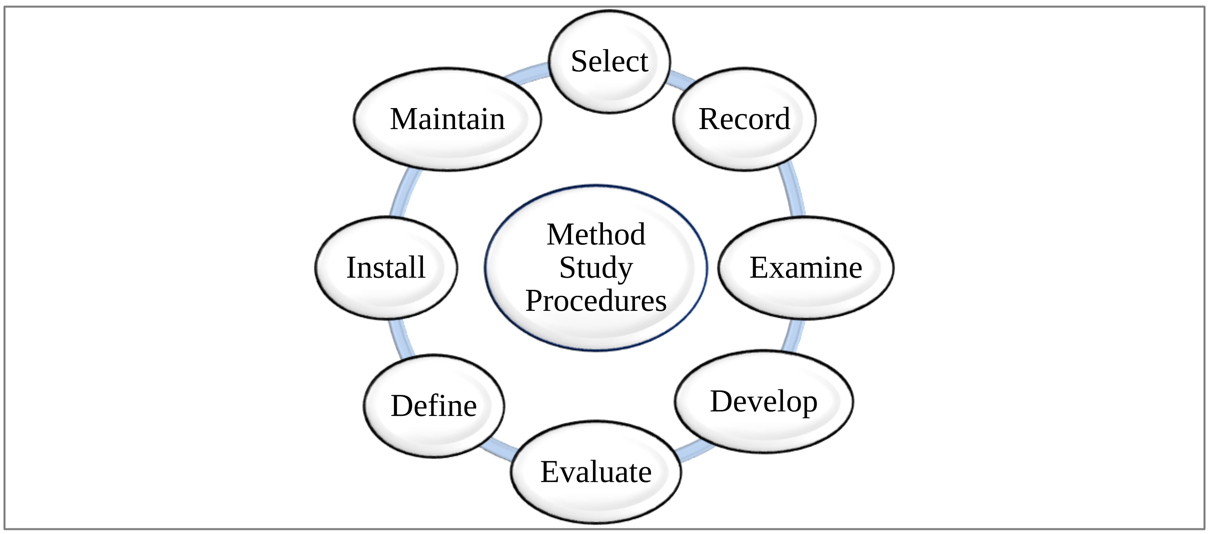


Figure 2. 10 The procedures of method study

Source: (Prathamesh P. Kulkarni et al, 2014)

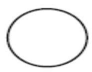
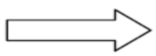
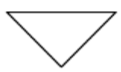
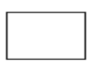
The procedures of method study stated by (Ewnetu, 2016; Hailemariam, 2018):

1. Select: the work or operation to be studied and define its boundary. **2. Record**: all relevant facts about the job or operation using suitable charts, techniques, and diagrams, like flow & operation process charts, flow diagrams, string diagrams. **3. Examine**: critically all the recorded facts, questioning the purpose, place, sequence, & persons. **4. Develop** the most practical, economic, and effective method. **5. Evaluate**: take the different alternatives to develop a new method comparing the cost-effectiveness of the selected improved method with the current method of performance.

6. Define - the improved method, the consequence, is clear, and present it. **7. Install** - the new method is applied as standard practice & train the persons involved to implement it. **8. Maintain** - the new method for the job or process or operation.

The common method study symbols are listed below stated by ASME and (Tessema, 2007).

Table 2. 3 The main flow process symbols

Symbol	Name	Meaning
	Operation	A complex action or process (possibly described elsewhere), often changing something.
	Transport	Movement of people or things. May be accompanied by a distance measurement.
	Delay	Idle time of people or machines, or temporary storage of materials.
	Storage	It occurs when an object is kept under control such that its withdrawal requires authorization. Longer-term storage of materials or other items.
	Inspection	Checking/ examining of items and comparing with standard to ensure correct quality or quantity.

Source: (The American Society of Mechanical Engineers)

2. *Motion Study*

This technique is used to analyzing the body motions working in doing a task to eliminate or decrease ineffective movements and facilitates effective movements (Pancholi, 2018). It is a more detailed investigation of the individual operator, the layout of machines, tools, jigs, and fixtures, the movements of the body to perform the work (Tessema, 2007). Chart used for motion study is operation process & flow process chart, multiple activities, travel, and two-handed process chart (Farhatun Nabi, 2015). The main principles of motion study are the use of the human body, the arrangement of the work, and the design of tools, and equipment (Ewnetu, 2016).

❖ Procedure for motion study

Break up the operation of the job; question each detail of the job; develop a new method; installing the new method and maintain the new method. This step helps to eliminate all useless motions and unwanted waste (Pancholi, 2018).

3. *Work Measurement*

Work measurement applies different types of techniques to determine the required time to complete one operation and which can be performed by one operator. It provides a fair way of estimating the time to do a skillful operator with plentiful work supply & proper equipment (Farhatun Nabi, 2015). It is an application of the technique to measure and establish the time required to complete the job by a qualified worker at a definite rate of working (Gyanendra Prasad Bagri, and Ravikumar Kamble, 2014). So, which is used to estimating of standard time and which is defined as the time utilized by an average experienced skillful operator for the job with provisions for delays beyond the operator’s control (Eshetu, 2017). Now a day’s standard time is used as a tool for balancing, production control, and the elimination of efficiency and helps for accurate pricing (Chisosa, 2018). There are about six types of work measurement techniques used by sewing floor managers, among them, stopwatch or time study is the most popular work measurement technique (Mahmut Kayar, 2014; Farhatun Nabi, 2015). Hence, it is the most effective tool to measure each production time for the garment production process.

Purpose of work measurement stated by Prathamesh P. Kulkarni et.al, (2014):

- To find out an ineffective time in the production process
- To set standards for output level & to evaluate worker’s performance
- To determine available capacity & to facilitate operations scheduling.

4. *Time Study*

Originally it is proposed by Frederic W. Taylor in 1881. The classical stopwatch study is still the most wildly used time study method (Chisosa, 2018). According to ANSI in 1982 Institute of Industrial Engineers state time study as, "a work measurement technique consisting of careful time measurement of the task with a time-measuring instrument, adjusted for any observed variance from normal effort and to allow adequate time for such items as, unavoidable or machine delays, rest to overcome fatigue, and personal needs” (Chandra, 2013; Jadhav, 2017). It is measured to find out the scope for improvement & it elaborates about the best way to do the job, the time required to complete the task, and the way to measure production rates (Jadhav, 2017). Thus, time study is the most popular and used method for line balancing and solving bottlenecks. One problem of time study is the Hawthorne effect where it is found that employees change their behavior when they know that they're being measured (Farhatun Nabi, 2015). Which is the solid tool used for balancing the sewing line as well as solving the bottlenecks in the garment industry. If standard set, performance improved to an average of 85%. Then, performance increased by 42% (Cengiz Duran, 2015). One of the hot issues in front of the garment manufacturers and management is to produce quality garments as per customer demand at minimum time and cost-efficiently. So, this technique is the most effective tool for improving the existing situations and attractive for the productivity of sewing lines (Dhanashree Rajput, 2018). Because, it is used to record the actual capacity for each worker or process line that to enhancing optimum individual efficiency and productivity (Jadhav, 2017). The measurement of time was completed by direct supervision and prearranged using the synthesis and analytical estimating by applying for personal allowance helps to calculate a standard time (Sujay Biswas, 2016). Standard time used for determined to (Cengiz Duran, 2015): to establish reasonable productivity targets for experienced workers, provide productivity goals for training purposes, eliminate waste, reduce variability, improve quality & make processes more consistent. The key objectives of a time study are (Yerasi, 2011):

- Efficient plant layout; to increase productivity & balance the workforce with resources.
- To determine the production capacities; to determine standard time & costs of a product.
- Effective production planning and control.

Procedures of time study (Prathamesh P. Kulkarni, 2014; Dr.P. Singh, 2016)

1. Select - the job to be timed; **2. Define** - the elements, break the job into elements, convenient for timing; **3. Obtain & record** - details regarding the method, operator, job, time, and working condition; **4. Extend** - observed time into the basic time; Normal time = OT * Performance rating (%)/100; **5. Measure time** - duration for each element & asses the rating; **6. Determine** - allowances, add the amount of time that allowed for personal, basic fatigue, and unavoidable delays; **7. Compute**- set **a** standard time for the defined job; **8. Determine** - relaxation and personal allowances. SAM or (Standard Allowed Minute) is widely used by industrial engineers and production people in the garment manufacturing industry, which is used to measure the task or work content of the garment operations (Habtemariam, 2018). It is the amount of time required to complete a specific job or operation under existing conditions, using the specified & standard method at a standard pace when there is plenty of repetitive work. Standard time = (Average observed time X rating %) + Allowance %. Cycle time is the total time taken to do all works to complete one operation, i.e. time from pick up the part of the first piece to the next piece of the product (Farhatun Nabi, 2015).

$$\text{Cycle Time} = \frac{\text{Total operating time}}{\text{Quantity of production produced}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Takt time: refers to how often the part or product is required or the rate at which the product is required (customer based). It computed as (Balaji Rathod, 2016):

Performance rating (PR) is divided into three categories (Ewnetu, 2016). Rating: it refers to the assessment of the worker's performance rate of working relative to the observer's concept of the rate corresponding to standard pace (Abdul Moktadir et.al, 2017).

Slower performance rate: a rating in which a worker produces fewer pieces per hour, due to higher setup time, higher tool exchanges, defects, etc.

Normal performance rate: it is the rate of output which qualified workers will achieve without overexertion over the working day shifts provided they know and adhere to the specified method and provided they are motivated to apply themselves to the work and faster performance rate: is a rating that produces more pieces per hour. In general when: PR = 1.0 denotes normal worker; PR > 1.0 denotes a faster worker and PR < 1.0 denotes a slower worker performances.

$$\text{Rating factor} = \frac{\text{Observed Performance}}{\text{Normal Performance}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Allowance: As a human being it is impossible to work throughout the day even though the most practicable, effective method has been developed. Even under the best working conditions, the job will still demand the expenditure of human effort and some allowances must therefore be made for recovery to different types of allowances are allowed in the garment (sewing) production floor. Thus, allowances can be calcified as (Harshna Gupta, 2018).

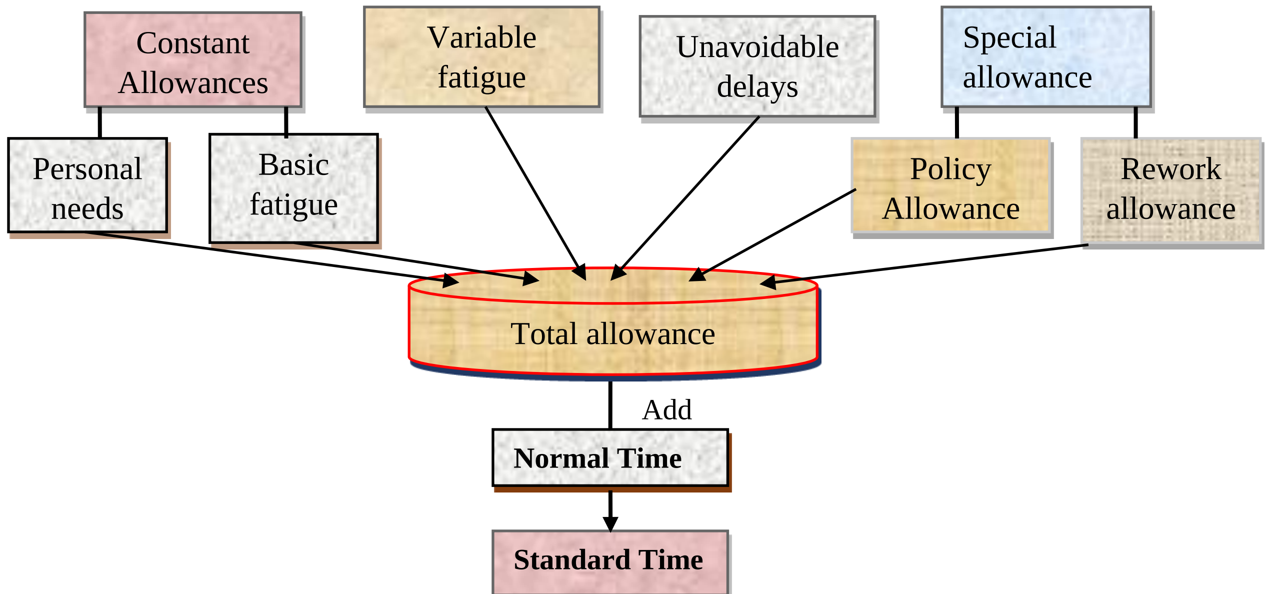


Figure 2. 11 Types of allowance

Different types of allowances are allowed in the apparel production process (Farhatun Nabi, 2015). The basic fatigue allowance - is given to the operator that to compensate for the energy expended for carrying out the work, and 4% of normal time is treated as a constant allowance (Chandra, 2013). Personal allowance: an allowance intended to compensate the operator for the time crucial to leave the workplace, to attend to personal needs (drinking, smoking, washing, etc.). It is considered as; for women 7% & for men 5% of normal time (Harshna Gupta, 2018). Unavoidable delay allowance: is given to an operator for unavoidable delays and interruptions that the operator experiences every day during work (Harshna Gupta, 2018). Special allowance: which are normally not part of the operation cycle but are essential for satisfactory performance of work, including items: start-up, cleaning, shut down set up, reject, excess work, training allowance, and tool changing (Ewnetu, 2016). The relaxation & fatigue allowances are providing to allow the workers to recover from the effort of doing his/her work, and to allow for attention to personal needs. Recommended allowances for personal and fatigue allowances in the sewing trade are set at 11% for sitting jobs and 13% for standing (Chandra, 2013), and contingency allowance should not be greater than 5% (Ewnetu, 2016).

2.6.3. Summary of the relationship between work-study and productivity

Work-study has received an important for clothing industry acclaim due to its effect on productivity, quality and competitiveness of an entry and it provides to increase companies productivity using labeling the production efficiency, job engineering and standardization of the job in a correct way. See in Figure (2.14) the relation between work-study and productivity.

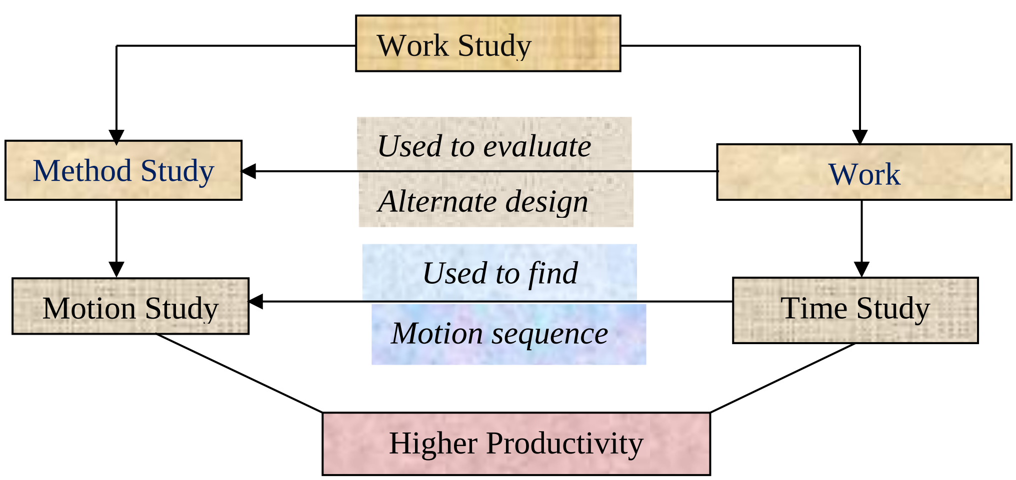


Figure 2. 12 The conceptual model of work-study and productivity
Source: (Chisosa, 2018).

2.7. Integration of Lean and Work-Study

2.7.1. The overview of lean and work-study incorporation

LM and work-study are both popular and have been widely applied to achieve quality and productivity improvement in numerous industrial sectors (i.e. Garment) with high success (Choomlucksana, 2018). Work-study has changed along with the changes in the mfg environment imposed by the development of LM, and to describe how these new integrated techniques can be used to improve the efficiency and productivity in the mfg industry (Abdul Moktadir, 2017). The previous studies found that some researchers apply LM techniques only, whereas others apply only work studies. But not all, a few studies have been applied both techniques and have shown the relationship between them for productivity improvement. For example, Nonglucksana, (2015), applied LM and work-study techniques have to reduce waste caused by excess inventory and over-production in the warehouse (using ECRS: work-study techniques), and lean was implemented with a flow process chart together to maximize production efficiency (Nonglucksana, 2015). According to Kulkarni et al. (2014), a study using these techniques that, to improve performance and conclude that the two when well combined and used, will be the universal solution for any type of industry having any sort of problem regarding productivity. If implemented in proper order, 100% positive results are assured (Sahni, 2016). Hence, to implementing work-study methods and deploying associated LM tools in the garment industry, covering the technical, engineering, and manufacturing aspects as well as the business custom affairs. LM together with work-study methods, being the most sophisticated & vast area of studies has a huge scope for implementation & deployment of their very own concepts. Lean changed the environment itself, requiring work-study to change and develop to answer the requirements of the new manufacturing setting of working smarter, not harder (Dragoslav Slović, 2017). Moreover, both techniques can be effective for productivity improvement; because these techniques are types of improvement concepts (Choomlucksana, 2018). Therefore, several questions remain concerning the gap between the applications of these two techniques. One aim of this research is to find the gap between LM and work-study techniques by reviewing the relationships, differences, and similarities between them; and to present the results of applying both techniques in the Ethiopian garment industry, that enhancing the possible productivity improvement in a real case company using BDTSC garment industry. Thus, both techniques are the most effective for productivity improvement. Because, LM technique mainly focuses on identifying and eliminating seven waste, whereas the work-study technique focuses on reducing the production time and eliminating non-productive processes.

2.7.2. Why lean, and work-study?

This research seeks to better understand the impact on productivity from lean improvements implemented with work-study for a particular garment production process improvement framework. Thus, the integration of lean and work-study techniques allows for the company to see benefits in multiple areas and assist the company culture for continuous improvement by reducing or eliminating those productivity wastes (Eshetu, 2017).

2.7.3. What are the variables that, help to integrate lean and work-study techniques?

Lean techniques provide a good overview of processes, whereas the work-study technique focused on critical areas. These two techniques have slightly different aims. Lean techniques are commonly used to identify and eliminate eight wastes and creating a continuous improvement in the production flow, whereas the work-study technique improves workers' process and eliminate unnecessary time spent by the work (Choomlucksana, 2018). Figure (2.15) shows that the comparison of LM and work-study techniques regarding previous studies indicated that intersect on worker and process which focused on non-value-added activities (Choomlucksana, 2018).

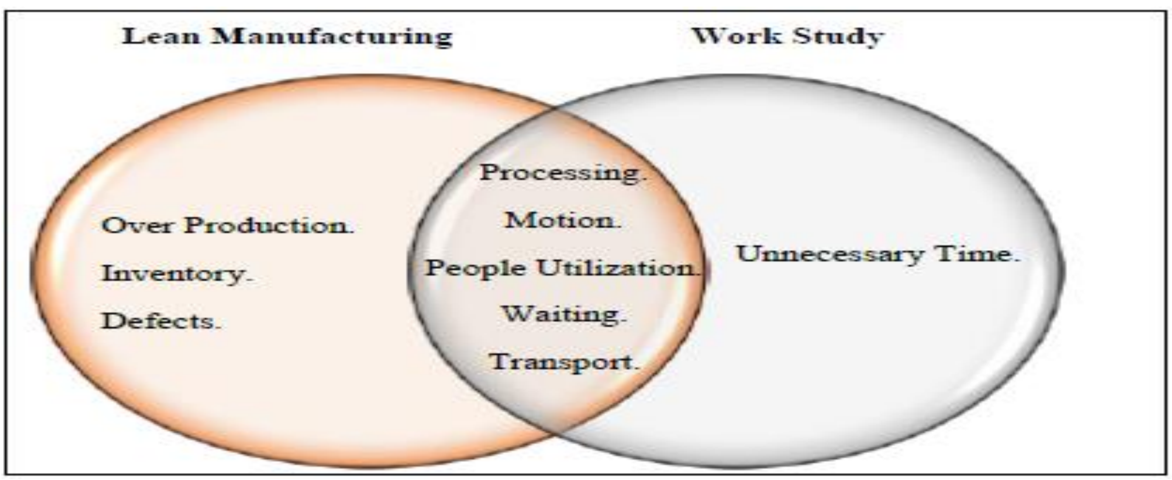


Figure 2. 13 The similarity & differences of integrated techniques

Moreover, both techniques bring special attention and unique tools help the company to clarify solutions according to its areas of focus (a particular problem area) and interest. Additionally, not only LM but also the work-study technique has its tools regarding non-value added activities (discussed in Table 2.4) that depend on its focus and interest.

Table 2. 4 The summary of lean & work-study tools used for waste elimination

Lean Manufacturing	Work-study
Tools for analyzing the processes	
Value Stream Mapping (VSM), Yamazumi Chart, Takt time, Line balancing, Gemba	Process, operation process, flow process, assembly process, multi-product process, travel, multiple activities, man-machine, and operation charts.
Tools for reducing waste of ineffective process	
5W1H, Standardized Work, Scheduling, Cellular Manufacturing, 5S	Why-why analysis, ECRS, plant layout
Tools for reducing waste of motions	
5W1H, Standardized Work, Visual Control, Cellular Manufacturing, 5S	Why-why analysis, ECRS, plant layout, predetermined motion-time system, and charts (flow process, two-handed, multiple activities, SIMO, string).
Tools to reducing waste of unutilized people	
5W1H, Multi-Tasking Skill	Why-why analysis, and different charts
Tools to reducing waste of waiting	
5W1H, Multi-tasking skill, SMED, leveling, one-piece flow, total productive maintenance, Poka-yoke, cellular manufacturing, 5S	Why-why analysis, ECRS, plant layout, flow diagram & charts (process, operation process, flow process, two-handed, multiple activities, man-machine, etc.).
Tools to reducing waste of transportation	
5W1H, One-Piece Flow, Cellular Manufacturing, 5S	Why-why analysis, flow diagram, plant layout charts (process, flow process, man-machine, travel, etc.).
Tools for reducing waste of unnecessary inventory.	
5W1H, pull, kanban, buffer/safety stock, visual control, 5S	-
Tools for reducing waste of defects	
5W1H, standardized work, multi-tasking skill, one-piece flow, Poka-yoke, Jidoka	-
Tools for reducing waste of overproduction	
5W1H, multi-tasking skill, one-piece flow, pull	-
Tools for reducing waste of ineffective time	
5W1H, Single minute of die (SMED), TPM	flow process chart, why-why analysis, ECRS

Based on the reviews the relation of lean and work-study are summarized as:

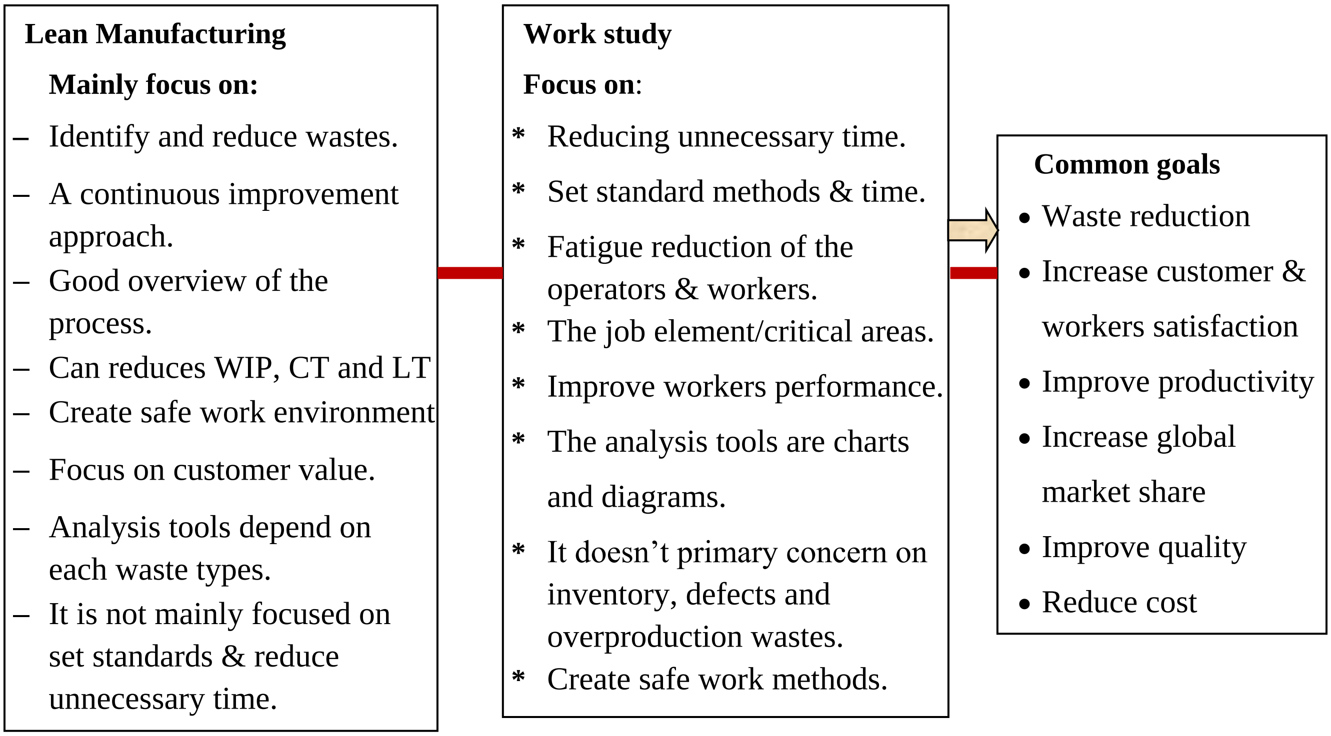


Figure 2. 14 Synergy between lean manufacturing and work-study techniques

Thus, these integration techniques can continuously improve work conditions and productivity and can be applied at the firm-level production process. The application of work-study with lean tools, in any apparel industry, can achieve greater output at less cost with better quality.

2.8. Summary of the literature

This literature review mainly assessed to topic-related information has been reviewed including- productivity improvement (concepts, methods, factors, measurement, etc.); and productivity improvement techniques & tools with its detailed procedures, purpose, roles, concepts, benefits, and also the integration of these improvement techniques (lean and work-study) try to see its gaps, by conducting different recent international journals, articles, conference paper and un-published documents (including - MSc thesis, Doctoral dissertation, and other reports), using different sources: in addition to the previous literature reviews of this research; the next table summarizes the main & recent journals, & articles with related to the topic and concerning lean and work-study techniques. This summarized literature review clearly shows that the previous research works and their gaps about this work and which helps this research to create an opportunity to fill the gaps or uncovered parts of the previous research work.

Table 2. 5 Summary of the literature review

Author /Year	Topic /Focus	Product (Specific case area)analyzed	Method/ Techniques	Setting/ Sample	Findings	Limitation
Y. Buranasing & J. Choomlucksana (2018)	LM and Work Study: Analysis and integration in an outbound logistics	Outbound logistics (in warehouse department)	Quantitative and Qualitative using lean and work stud	Census Sampling (Direct recording time)	Reducing waiting time and cost of outbound logistics (warehouse)	The difference between the two techniques is not clearly defined and it does not detail investigation for improvement using its tools.
Sohel Ahmed & Md.Shafiqul Islam Chowdhury (2018)	Increase Efficiency and productivity of Sewing through low performing operators improvement by using eight waste of lean	a woven shirt (Men's Flannel shirt with two pockets and flaps)	Eight Wastes of lean Methods	census sampling (10 cycle times for each operation was recorded)	To increase sewing line efficiency, productivity and improving operator performance	only consider productivity time of the operators, but not non - productivity time & other input factors
Hiwot Habtemariam (2018)	Productivity improvement through the integration of lean and work-study	T-Shirt	Integration of lean and work-study	Census Sampling questioner, direct recording	Reducing waiting time, defect and model develop	-Does not clearly define the integration of lean and work study (similarity & difference) - Not considered work- methods - The questioner data may not be reliable & improvement not clear
Prathamesh P. Kulkarni1, et. al. (2014)	Productivity improvement through Lean deployment & Work-study methods	For all manufacturing and service industry	lean tools and work-study methods	qualitative approaches	Workplace design, bottleneck & setup time reduction	It only focused on the general approach of these tools but not a detailed investigation

Parthiban. P, Raju. R (2015)	Productivity improvement in shoemaking industry By using method study	Shoemaking industry	Method study tools like diagrams and charts	quantitative approach (direct recording & measuring)	Reduced worker's fatigue, cycle time, avoidable activities, and increasing operator efficiency	The study does not identify each productivity factor and does not develop an appropriate model & standards
S.S.Jadhav, A.M. Daberao, S.S.Gulhane, (2017)	Improving productivity of Garment industry with Time Study	T-Shirt	Time study (stopwatch)	direct recording and observation	Identify non-productivity time, activity & reducing cycle time.	only focused non- productivity time, but not production time of the operators & M/cs.
Md. Abdul Moktadir, et.al., (2017)	Improving Productivity by Work-Study Technique	Leather product industry	Method and time study	quantitative approach (a direct record)	To increase production capacity, efficiency	Not identified the productivity factors and defects
R. M. Nunesca and A.T. Amorado (2015)	Application of Lean Mfg, Tools in the garment industry as a Strategy for productivity change.	Baby Dress	Lean	qualitative and quantitative method (sample:10 cycle)	To reduce manpower, WIP inventory, lead time, defects and improve efficiency	Not focused on the improvement of working method and non-productivity time
Tesfu Berhane, Gebrehiwot and Adhiambo M. Odhuno (Prof.) 2017)	Productivity improvement through line balancing in an assembly line of the apparel industry	T-shirt	line balancing using lean & simulation arena	both qualitative and quantitative methods	To reduced bottlenecks, non-value-adding activity, operators, & workstations.	The study did not consider the input productivity factors (like material, machine, etc).
Daniel Arefayne Legesse (2014)	Productivity improvement through lean mfg. tools	Military T-Shirt	Lean	Quantitative census sampling	Increasing productivity, reducing lead time & labor.	It does not have a detailed investigation about non-value-adding activities and set standards.

2.9. Gaps of the Literature

- The reviewed literature gaps are discussed in Table (2.5) and most of the researchers are focused on improving productivity by develop a simple model or propose solutions by considering a specific production process, using a single tool/ technique, but, a single tool or technique doesn't enhance a significant productivity improvement for the mfg industry i.e. garment industries, due to, the productivity factors are multi-dimensional. And these researchers were trying to improve the productivity of the manufacturing industry by solving the internal and external productivity factors separately, using a single tool, because, this improvement approach did not enhance the overall improvement of this industry.
- These studies do not have a clearly defined framework for model development, target setting, measuring, and analyzing productivity and also did not achieve an optimum improvement.
- Integrated lean manufacturing and work-study approach in industries are not explored and a rare research study has been found in the Ethiopian context and very little literature is available on the integration of lean manufacturing and work-study focusing on the garment industry.
- So, this study emphasizes productivity improvement of the Ethiopian garment industry, taking a special reference of Bahir-Dar Textile Share Company (Garment's) by investigating both the internal and external productivity factors of the garment industry using the integration of lean and work-study tools/techniques for enhancing an overall productivity improvement of the sector and case garment.

CHAPTER THREE

3. RESEARCH METHODOLOGY

This chapter describes the methodology of the study that followed to accomplish its objectives. The initial steps of this study were systematically reviewing related literature are surveyed from various sources such as books, journals, and articles, thesis; conference papers; both primary and secondary methods are collected; then, the collected data are organized, analyzed, and presented by using different software and tools.

3.1. Literature Survey and Data Source

A survey has been conducted on the existing literature to get empirical knowledge and to identifying the previous research gaps for the investigation of this research work. This literature survey covers the concept of productivity, productivity measurement, productivity factors, productivity improvement, and the concept of lean and work-study with their tools and techniques as well as their integrations has been assessed and different interpretation/ analysis approaches to understand. In general other detail regarding the study are inputs and necessary for the well-being of the investigation to include as a sources document as a literature survey. Such sources of data are literature review, primary and secondary data collection methods.

- **Literature review methodology**

In this literature review to accomplished different recently published journals, articles, international conference papers, thesis, and books have been surveyed, to be aware of the concepts, principles, benefits, and improvement approaches & methods gained by integrating lean and work-study techniques and the review helps to identify improvement tools, all wastes, work method/ environment factors, work procedures that affect the Ethiopian garment industry production process, operators productivity efficiency and performances. This is shown in Figure (3.1).

The overall procedures for the literature review were summarized as:

420 Journals, articles, and 15 recent thesis, 6 books downloaded

↓

Selected by their titles in to 280, 10 thesis and 3 books

↓

Selected by approach and contents to the study into 160, 7 thesis and 2 books

↓

Selected 62 journals & articles; 6 thesis and 2 books by abstract, concept of productivity, lean and work study, objectives, findings, and approaches to the title.

Figure 3. 1 The selection procedures of journals, articles, books, and others

The publisher of the journals and articles that used in the literature review were shown as:

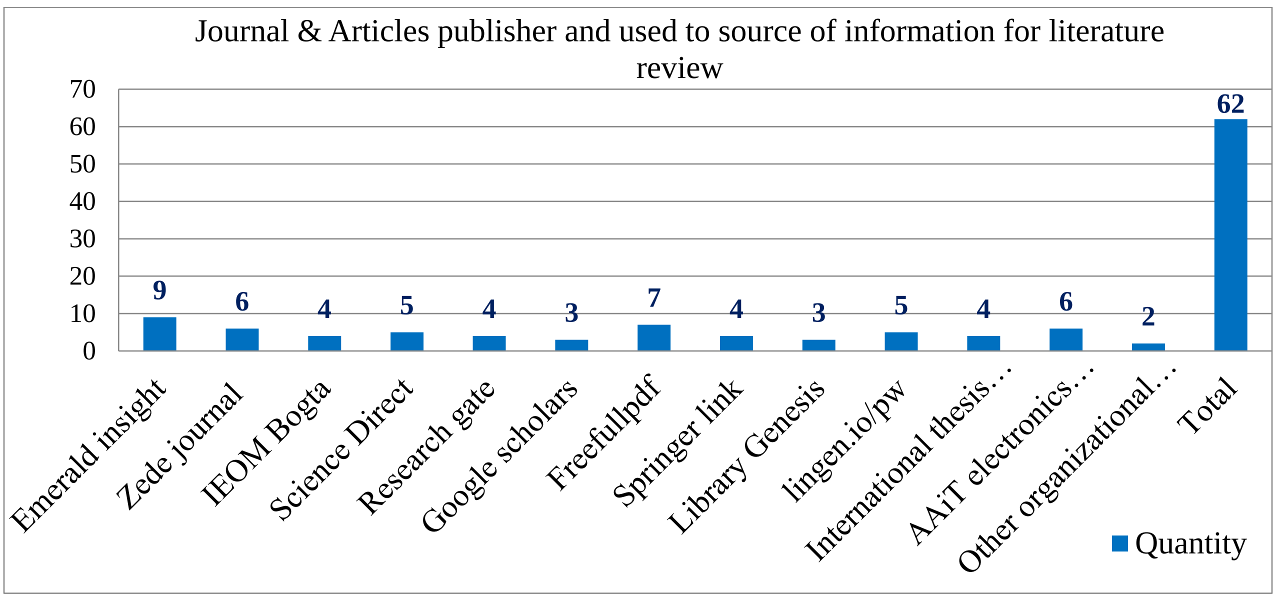


Figure 3. 2 The source of the literature are the international publisher and a well known

The following chart shows that the final selected journals and articles Vs. Year's graph

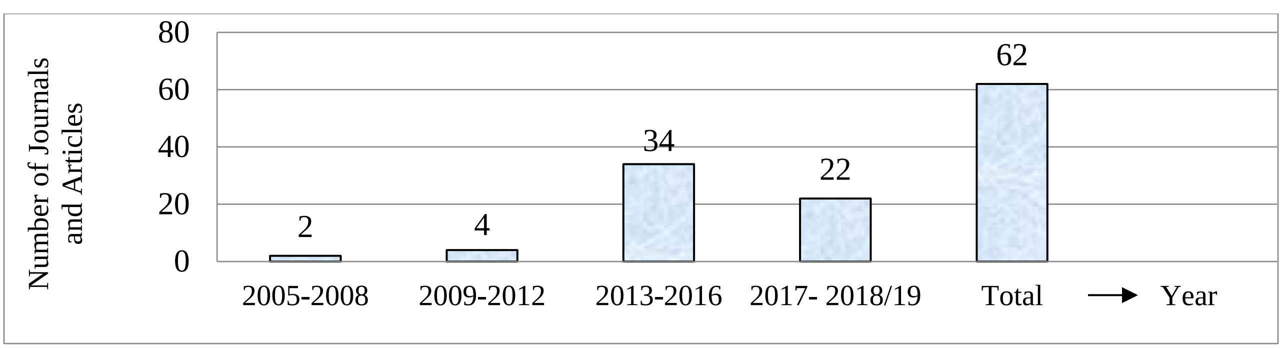


Figure 3. 3 This indicates the literature review mainly focused on the recently published literature

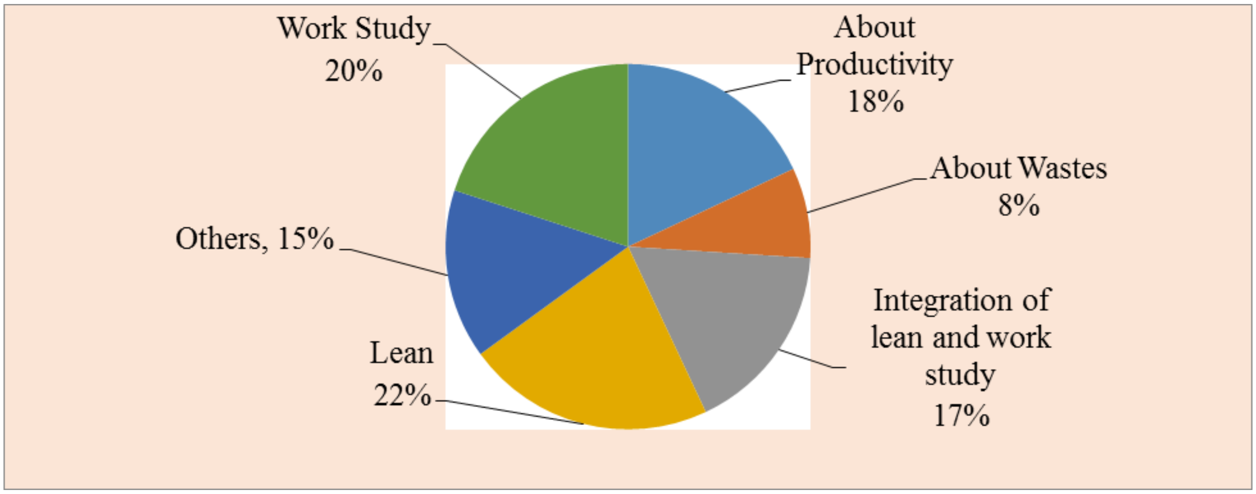


Figure 3. 4 Shows the overall addressed area of the literature review main points in percent

3.2. Data Collection Methods

The primary aim of data collection is to get relevant data from the case company and which is used to supports identifying garment production bottlenecks. This gathering of empirical data is dividing into qualitative and quantitative parts. The qualitative data is collecting mainly through interviews and questioner; quantitative data are collecting through direct observation. Hence, data is collecting through primary and secondary methods. In this research manly used a primary data collection method, which is to collect the data through continuous assessment of the field study.

1. Primary data collection methods

i. **Observation** (Descriptive observation)**:** It is the main method to collect information that is necessary for the study to record each garment operation: operator movement, machines size and work method, working environment, process flow, time study, operation process, and production management & control system of the case company.

ii. **Interview:** using in-depth open interview technique to collect the necessary data including individual & group interviews with the production managers, workers, supervisors, shift leaders, and company management & staffs, in the case garment's and ETIDI, about working time/shift, existing productivity improvement: approaches, tools, raw inputs, operation control system, operator skills, export performance, production targets, production order/shift, operation process, working method, number of m/cs and workers, quality control approaches, both internal & external productivity factors, operators wage, the unit price of the products.

iii. **Questionnaire:** Prepared by reviewing different works of literature related to the study including productivity factors and daily production targets, the existing lean & work-study tools practice, and lean wastes. A structured questioner is prepared for the target sample size and used to get the necessary information with regards to the case company and to address those respondents (for both the internal & external production process) with clear and easy understanding words. In general most of the questioner is close-ended and the scale is vary based on the situation. The questionnaire was prepared into different scale's (rank), the first part has described the impacts (high, medium, and low) of these productivity factors (both internal and external factors), the second part assessed the occurrence of lean wastes (rank: always, usually, often, sometimes and never) and finally assessed to the improvement tools of lean & work-study (rank: to applied & not applied). This scale design was referred from Tadesse (2011), and Tadele (2020).

Table 3. 1 Questionnaire scale design and definition

Description		Low impact	Medium impact	High impact		
Choice	0	1	2	3	4	5
Description		Always	Usually	Often	Sometimes	Never
Description	Not Applied	Applied				

Table 3. 2 Questionnaire scale definition and its requirements

Scale	**Impact rating**	**Description**	**Scale**	**Rating**	**Description**
1	High impact	It is occurred frequently and highly affected productivity.	1	Always	Continuously/ frequently occur.
2	Medium impact	This factor hasn't occurred frequently, but it has been a high effect relative to low impact.	2	Usually	Mostly it happened as a factor.
			3	Often	Commonly to occur.
3	Low impact	The occurrence was rare & which has fewer influences.	4	Sometimes	Possible or known to occur.
			5	Never	Not predictable to occur.
The questionnaire scale for productivity improvement tools and techniques					
0	Not applied	The tools were to be implemented or not well known by workers.	1	Applied	The tools were practiced or implemented as well.

- **Questionnaire pre-test and selection parameter**

After developed the questionnaire based on the previous related studies and the specifics of the case study, then it needs a pre-test for some interested groups, before being distributed to all workers. Because it directly affects the research results. Hence, questionnaire pre-testing is mandatory and a vital procedure. Thus, 10% of the total sample size has been taken. This is used to improve or avoid the ambiguous words, statements that to understand the respondents in this study and helps to detect the problems when preparing the questionnaire. This practice was surveyed to the selected case company workers (who have higher qualification levels/positions) including research development experts, and higher-level management, before final data collection. Then, after conducted the survey, some comments have been taken, including avoiding unnecessary words, statements, and adjusting page layouts, and also suggested adding some ideas. As a result, based on the literature review and this pre-test data the questionnaire was rearranged and distributed for the selected workers. One of the primary activities during this time was to facilitate the respondents, to easily understand the questionnaire (when a worker didn't easily understand the ideas), and directly interview this questionnaire for lower qualified workers (5.9% of the total sample or 6 workers). As a result, the total responses have been returned.

iv. **Data record and Measuring:** Garment production defects, non-value-adding activities, and different time data (both productive & non-productive time) and measuring the working space, machine size & equipment of the case garments. This collected data is present using an excel table & check sheet. During recording the data the following work-study and lean tools use:

- ✓ A stopwatch, time study format, and pen or pencil.
- ✓ Meter: It is used to measure the space of the working area, machine, and equipment.
- ✓ Defect recording sheets (check sheet).

2. **Secondary data collection method**

Different written documents used from the government (ETIDI) and non-government institutions including company documents to be reviewed.

☞ **Document review:**

- Company document: production capacity/shift; the number of workers & machines; defects etc.
- Published paper i.e. journal, article, conference paper, and others like thesis & reports by site review, and statistical data: collected from ETIDI including import-export production capacity, garment production problem, existing market trends.

3.3. Sampling Techniques

Is used to collect appropriate data by determining the size of the population that to get relevant data to this research. Based on the scope indicated the number of population to be taken to the study by using appropriate and standard procedures of the sample size determination. So, the sample size includes the number of population or products that an operator can produce/ day/shift and the number of workers who are working in the garments of the case company.

The first record of a preliminary sample was taken (Quilt cover production) to determine the number of cycles to be timed the whole selected export production is shown in Table (3.3):

$$\bar{x} = \frac{1}{n}\sum_{x-1}^{n} xi \quad (3)$$

Table 3. 3 Preliminary samples for Quilt cover production process

S/No	Operation	Observation	Mean of preliminary Sample ($\bar{x}$ in Sec.)	$(x_i - \bar{x})$ (Sec)	$(x_i - \bar{x})^2$ (Sec)
1	label attach	30	23.2	6.8	46.2
2	Preparation	18	23.2	- 5.2	27.0
3	Side Seam	45	23.2	21.8	475.2
4	Box-Making	32	23.2	8.8	77.4
5	Prepan & Measurement	12	23.2	- 11.2	125.4
6	Marking	18	23.2	- 5.2	27.0
7	Button Hole	21	23.2	- 2.2	4.8
8	Button Attach	16	23.2	-7.2	51.8
9	Manual Work	17	23.2	- 6.2	38.4
	Total	209		0.2	873.2

The preliminary sample mean for Quilt cover production is $\bar{x}$ = 23.2 Sec

Standard deviation and number of observations are calculated as per (4) (5).

$$S = \sqrt{(x_i - \bar{x})2 / n - 1} = \sqrt{873.2 / 9 - 1} = S = 3.7 \quad (4)$$

$$n = \left(\frac{zs}{h\bar{x}}\right)^2 \quad (5)$$

n = $(2 * 3.7/ 0.1* 23.2)^2$ = (7.4/2.32)2 = 10.176 ≈ = 10; cycle time is required for each operation. Where: n – the number of observation; the preliminary sample (x) recorded using stop watch tools); $\bar{x}$ = mean of initial preliminary sample; S = standard deviation for the initial sample; h = half of the precision interval in percent (i.e. if + 5%, then h = 0.1); z = is normal standard deviations that needed for a desired confidence level. The value of z and h were fixed due to most industries used the confidence level for 95% and corresponding values are z = 2 and h = 0.1 (Legese, 2014). The number of observations is directly proportional to the confidence level, hence, in this study 23 * 10 cycles (observations) for Quilt cover and 20 * 10 for Flat sheet production operations, were taken to get accurate data for setting time standards of the case garment workers. After the performance (PR) is rated at 100%, means the work performed at normal condition (Kumar, 2008). The normal time (NT) and Standard time (ST) is computed for each operation by adding allowances:

$$NT = \bar{x} * PR \qquad (6)$$

ST = NT * (1+ Allowance factor); + sign indicates that the time recorded for each work task.

3.3.1. Sampling Strategy

This sampling strategy consists of the target population; sampling size and procedures used to evaluate the current observed time, defects and other data to be collected by interview or questionnaire for each operation process. The target population of this study is addressed for both direct and indirect garment production of the case company workers. As of June 2019 reports was indicated that the case garments production has a total number of 242 employees. Of these 196 are female & 46 are male and 200 employees are direct laborers engaged in production; the remaining production management staff and secretary. In addition to the internal garment production workers and also the study can be addressed the case company other main sub-department workers, managers and staffs (totally about 74 employees can be addressed), to get accurate data for external productivity factors & related information's during the period of questionnaire and interview. In general to considering both the internal and external garment production factors of the case company by addressing a total sampling number of 316 workers.

3.3.2. Sampling Size

Proper sampling is a significant feature of any empirical study and is used to avoid data errors or biases within the population. The most common sampling method is random sampling and which is divided into lottery methods; simple random; stratified random; cluster; systematic random; multistage random sampling (Masuku, 2014), the larger the sample size is the smaller the chance of a random sampling error. The factors which influence the sample size are the purpose of the study, population size, bad sample, and allowable sampling error (Islam, 2018).

Thus, this research applied a simple random sampling and censuses sampling to use. Due to, each member of the population have an equal and independent chance of inclusion in the sample and which provides an unbiased & better estimate of the parameters, if the population is homogeneous (Taherdoost, 2017). Census sampling is attractive for small populations (e.g. 100 or less). It is used to eliminate sampling error and provides data on all the individuals in the population. The four criteria used to determine the appropriate sample size are the population size, level of precision, level of confidence, and degree of variability in the attributes being measured (Islam, 2018). So, to get a representative and reasonable sample size that supports the study findings the following equations were used. Equation (1) is used to calculate the initial sample size (the population size N is finite and less than 50,000); equation (2) is used to compute the final sample size 'n' which is more precise: If the population size N is known or not negligible (Masuku, 2014). These equations were developed by Johnson et.al, (2009) and Freedman et.al (2007), according to (Israel, 2003; Masuku, 2014; Habtemariam, 2018).

$n_o = \frac{Z^2 * p\ (1-p)}{C^2}$.................... (7) $\qquad n_f = \frac{n_o}{1+\frac{(n_o-1)}{N}}$.................... (8)

Where: n_o = the initial sample size; n_f = the final/ target sample size

Z = the values of confidence levels. The common confidence levels including: 90% (0.1: Z value equal to 1.645); 95% (0.05: Z value equal to 1.96); 99% (0.01: Z value equal to 2.57). The percent level of confidence implies that 95 out of 100 samples will have the true population value within the margin of error (E) precise (Taherdoost, 2017). To minimize the risk one should have high confidence. This risk is reduced for 99% confidence levels and increased for 90% confidence levels. In most cases, the 95% confidence level is specified (Masuku, 2014).

P = is the predicted prevalence of the indicator being estimated. When the indicator is unknown, then take P = 0.5. Because it is the most conservative and the largest possible estimate of n. C = confidence interval, expressed as decimal; 0.05 = ±5.

N = Population = 316 workers.

$n_o = \frac{1.96^2 * 0.5\ (1-0.5)}{0.05^2}$ = 150.1; and $n_f = \frac{150.1}{1+\frac{150.1-1}{316}} = \frac{150.1 * 316}{465.1} \approx = 102$

3.3.3. Sampling Procedure

First to use a stratified random sampling method, forgot the desired representative sample of garment employees subgroups in each production operation and other case company sub department's employees those who have a detail information about their final production. Due to this, the existing subgroups in the population are more or less involved in the sample. After sampling each subgroup, the preceding procedures will be used to a simple random method for estimating each employee proportional to the total sample size was covered. According to Kothari, (2004), a sample should be optimum; fulfills the requirements of representativeness, efficiency, reliability, and flexibility (Habtemariam, 2018). The sampling proportionality or each sampling friction from the total population can be allocated as:

Table 3. 4 Target respondents for both internal & external production processes of the garment

Activities	Total staff	Sample size
Transportation of inputs	6	6 * (102/316) = 2
Inspection	8	8 * (102/316) = 3
Cutting	16	5
Sewing, e.g. operators, helpers	87	27
Quality control	6	2
Labeling & packing	47	14
Preparation & transportation	20	6
Finishing	23	7
Store	4	2
Production management & staffs	25	8
Other supported subgroups of the case garments production process are 74.		
Quality control department	2	1
Maintenance department	4	2
Infrastructure & utility center, i.e. power, transport	10	3
Human resource & training center	8	3
Raw material, machine & equipment management	5	2
Marketing and finance department	12	4
Supply chain department	5	2

Company management & staffs	15	5
Employees complain center	4	2
Product design & development center	6	2
Research planning and development center	3	1
Total	316	102

3.4. Data analysis and presentation

First used Microsoft office excel 2013, have been using to analyze and present the data. The necessary data was collected by direct recording & measuring using a stopwatch, meter, and checklist (including production time, defects, non-value activities & distance of each operation motion); responses of interview & questioners, and collecting other related data from the company. The second tool used to analyze the data was SPSS software, which, helps to present the data that requires a regression, for questioner & interview response has been analyzed. Third; SPC tools were used to analyze different quality control charts including cause and effect diagram to show the factors of low production (wastes), a Pareto chart (80/20 rule), a pie chart to illustrate percentage share of sections, bar graph to show the status of each parameter, and also used to lean and work-study tools: including charts & diagrams: flow process (procedure process chart, worker and equipment), flow chart (time scale chart) and flow diagram (string diagram and flow diagram) these tools usually used to identifying and analyzing non-values adding activities and motions. After analyzing the data, problems have to identify, discuss the result and then, find out the improved method. Finally, the conclusion has been drawn and important recommendation for current and future productivity improvement has been forward.

3.5. Ethical Consideration

This study has taken care in protecting respondents' confidentiality and respecting the codes of ethics developed. So, to avoid uncertainty the questions are prepared to include clarification about the study purpose, briefing on respondents' rights & protection, and consent to obtain information. Consequently, the participants were resting assured in the participation of the questionnaire & interview sitting without any bias and feeling with promises of privacy & secrecy through the study. Thus, this research maintains a high level of anonymity during the data collection process to protect the job and privacy of the participants' information for the third party.

Research Design

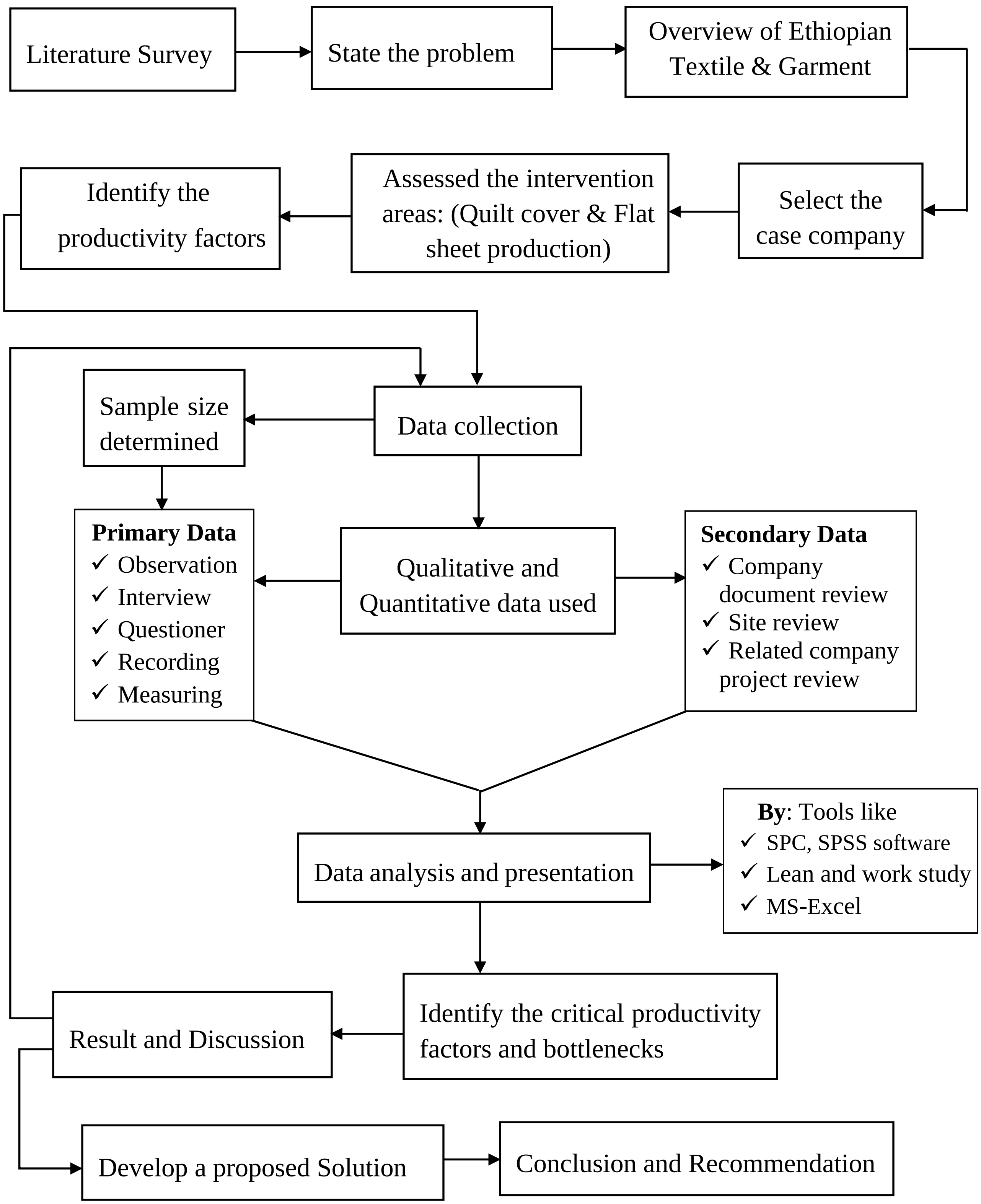


Figure 3. 5 Research design procedures

CHAPTER FOUR

4. OVERVIEW OF TEXTILE AND GARMENT INDUSTRY

The Textiles and Garment industry is one of the oldest, largest, and most global industries in the world. It is the backbone of the socio-economic structure of the nation (Montassar, 2017; Tran Nhung, 2018). And also, used as the incubator of innovation, a fertile environment for developing the knowledge and the technology transfer of industrialization development. This sector is a widely dispersed industry in both developed and developing countries. The primary aims of this sector are to provide, high job opportunity (it create about 60 to 75 million peoples), increase trade share of the GDP, export diversification, foreign currency earnings, and transfer knowledge, in the worldwide (Velde, 2008; Warfield, 2010). The global textile and apparel trade value in 2012, US $708 bn, in 2014, US$ 820 bn. grown and to reached over US$ 1,700 bn, in 2025, and Apparel trade share covered about 56%, while textiles had the remaining share of 44% in the overall trade (UN: Comtrade, 2011). In 2015, the world's largest textile and apparel exports countries are China, EU-27, India, Turkey, Bangladesh, United States, South Korea, Pakistan, and Indonesia (ITC - Trade map, 2018). China is one of the largest exporters of textile and apparel products in the world; which accounts for about 40% of the global trade value (Bui Van Tot, 2014; McKinsey, 2015). Currently, the global competition in the textile and garment sector is very intensive and it can be classified into three categories; textile and garment industry: in developed, developing, and under developing countries (Habtemariam, 2018).

4.1. Historical Background of World Textile and Garment Sector

Since the English industrial revolution in the early nineteenth century, the rise in the production of textiles and apparel has been the first stage of industrial development. After a few decades, later other European counters (e.g. German) were followed and shifts to the USA (Montassar, 2017). According to MacKinnon & Cumbers, (2007), the relocation of textile & garment production has changed dramatically globally. Until the 1960s and 1970s, textile & garment production was mainly domestically manufactured in Europe. Then, after the 1970s, this sector production was started to shift to South East Asia. During the 1980s -1990s, China dominated the textile & garment industry, which employ around 3.6 million people (Alderin, 2014). In general, the evolution of the global textile and apparel industry was started from Europe (originally in England), shift to the

US, Asian countries, Caribbean regions and now to focus on the African countries (Sub-Saharan Africa); the main reason of, this expansion was searching low production/ cheap labors.

Table 4. 1 The world free trade agreements opportunities for textile & garment industries

Trade Regulations	Period	Region or Countries Affected
GATT	1947	Western Europe
VER	The 1950s-60s	Japan
STA	The 1960s-70s	The NICs: Hong Kong, Singapore, South Korea, Taiwan
LTA		
MFA: I-IV	The 1970s-80s	China and the second generation NICs: Indonesia, Malaysia, Philippines, Thailand, etc.
NAFTA	The 1990s	Mexico, CB Region
WTO		South Asia: Bangladesh, India, Pakistan, Sri-Lanka
AGOA	2000	Sub-Saharan African countries
CBTA	2000	CB Region
WOT	2005	'Yet to be determined'

Source: Moon and Change, 1989; Dickerson, 1999; Warfield, 2010.

During the General Agreement on Tariffs and Trade (GATT) was established in 1947, the trade liberalization movement was at its peak in the western countries that were its prime supporters, especially the U.S, and it's creating new markets for the surpluses that accumulated in the U.S. After the WWII, Japan textile and garment was quickly sanctioned for its success by the imposition of Voluntary Export Restraint (VER) in 1955, followed shortly by the Short Term Arrangement (STA) in 1961, which lasted for only one year, and the 11-year Long Term Arrangement (LTA), covering the period between 1962 and 1973 (Warfield, 2010). The Agreement (MFA) signed in 1974 established quotas for exports of products in their markets. This quota system has allowed industrialized countries to save time in the restructuring of this sector. After the elimination of these quotas agreement, from January 2005, will result in a significant reallocation of production to the benefit of the best performing countries (China, joined to WTO in the first place) and at the expense of other less competitive developing countries (before, AGOA) and, to a lesser extent, an increase in world trade (Montassar, 2017).

4.2. Textile and garment industry in developing countries

For the developing countries, this sector has become a suitable choice on the road to industrialization due to its high labor intensity, foreign currency earnings, and low capital requirement. It provides direct employment to over 35 million people (Annual Report 2014-15, Ministry of Textiles). Developing countries produce half the world's textile exports and nearly three-quarters of the world's garment exports (UNCTAD, 2005). As a result, the textile and apparel industry is often thought to represent the first base in a country's economic growth and development (Madan, 2019). So, the current geographical trend of this sector is a continual decline from developed countries, and a geographical shift of production to developing countries. Although, the share of African countries in the world trade of this sector is not comparable to other developing countries. However, currently, as the labor cost in South East Asia is showing a tendency of increasing, the market is starting to shift to Africa (ETIDI, 2012).

4.2.1. The opportunity of AGOA for the Africa textile and garment industry

The African Growth and Opportunity Act (AGOA) is the new trade & investment, job creation, and development policy that initiative towards Sub-Saharan Africa, which was enacted by the U.S. Congress in May 2000. As of 2003, there were 36 Sub-Saharan Africa countries eligible for AGOA. However, only about half had been declared eligible for the apparel provision (Warfield, 2010). To date, out of those countries, 16 Southern Sub-Saharan African (SSA) countries are now qualified to benefit from AGOA as they have already implemented the visa system (AGOA, 2016). So, AGOA is focused on establishing a fair and equitable 'win-win' trade relationship between the U.S. and the countries of SSA by providing duty-free access to the U.S. market for various textile and apparel products from SSA (Warfield, 2010). Which used to African countries become more attractive partners with the developed countries including U.S companies. As a result, the African textile and garment industry is optimistic that, its shipments to developed countries using this duty and quota-free import-export agreements (AGOA, 2016). This free trade market driving many Turkish, Indian, and Chinese textile companies to African countries, particularly, Ethiopia and Kenya, have the greatest interest to global buyers to 2020 (McKinsey, 2015). And it does not only fill the rising production and labor costs at home but also avail of the duty-free exports under the AGOA to the United States (Abdell, 2017).

4.3. Overview of Ethiopian Textile and Garment Sub-Sectors

4.3.1. Why Ethiopia is attracted to textile & garment investment?

According to the world investment report, (2016) states that Ethiopia is one of the future hubs of African textile and garment manufacturing industry leaders and the sector foreign direct investment flow is registering counts 46% to increase in 2016. As a whole, Ethiopia has been a very attractive destination for investors because of the following reasons: 1. Strong export performance (it has grown an average of 51% for last 6 years); Political and Social stability. 2. Huge home markets (total population of over105 a million). 3. Regional hub with access to a wide market, DFQF trade agreements from 23 African countries, EU, US markets, china '0' tariff. 4. Abundant and affordable labor force with low monthly wage $35 to $60, in Ethiopia, compared to $140 to $160 in Kenya, $70 to $90 in Bangladesh, $150 to $170 in Vietnam, etc. 5. The strategic locations to proximity the lucrative markets of the Middle East, Europe, and Asia. 6. Excellent climate and fertile soils, for cotton cultivation and, have cheap hydro-energy. 7. Strong guarantee & protection by constitution & investment law. 8. Huge industrial park development strategy by the government and firms (Ethiopian investment research and promotion team report, 2017).

4.3.2. Historical backgrounds of Ethiopian textile and garment sectors

Ethiopia has long years' experience in the textile industry. It's traditional apparel (cottage industry) produced by handloom to satisfy the needs of local demand of the country and which is made of woven cotton threads made by hand from twisted yarn (Kelbesa, 2014). The first industrial textile factory for domestic consumption was established by the fund of Italians, in 1939 by the name of Dire-Dawa Textile Factory which is the first modern, integrated textile mill industry in Ethiopia (Khurana, 2018). The sector continued to expand in line with the growing cotton production, and the 1960s saw the establishment of five large, private, integrated textile enterprises including Addis Garment p.l.c (known as Augusta) was established in 1958; Akaki Textile Factory was established by the Indian agreement in 1960, and Bahir Dar Textile Share Company established in 1961 by the fund of Italy. While the socialist government (1974 to 1991) nationalized the textile & apparel industry, was established to fulfill the domestic demand, poverty reduction, economic development, and labor intensity (Kumera, 2018). This sector has the priority among other sub-sectors to transfer the country's traditional agricultural-based economy to industrialization. However, the growth has been slow (Tsegay, 2017). From, 2000 onward, the Government began to privatize state cotton farms and ginneries to sell textile mills, then the sector has truly started to grow. The Ethiopian government has designed industrial development strategy in 2002; According to the strategy, this sector has been ranked first of the core industries and given prior attention. Due to the following reasons: 1. The worldwide market next to food commodity, 2. Abundant labor forces at low cost, 3. Fertile soil for cotton development, 4. It can easily create high forward and backward linkages, b/n agriculture sector and the investors (ETIDI, 2012). Due to these multi comparative advantages, the Government of FDRE established

ETIDI in June 2010. This institute provides various supports to the sector; to bring the policies, programs and has to design & implemented long medium, and short term strategic plans. The Growth and Transformation Plan (GTP) is expected to transform the economy from agriculture to an industry-led economy. In the first five years (2010-2015) GTP-I, the cotton and textile industry plan had been implemented and gave feedback to sprint in GTP-II, even though the planned results are not achieved and economic transformation had not been reached. The sector's target output is 1 billion USD and it employed cover over 450,000 people directly in 2015-2020 (ETIDI, 2017). However, this sector was generated below half of the targets in terms of foreign exchange in 2017/18. So, to achieve the envisaged export target in addition to improving the productivity and product quality must be to attract both foreign & local investors.

4.3.3. Market access opportunity of Ethiopia textile and garment industry

According to the latest United Nations, estimates, Ethiopia is one of the fastest-growing consumer or large domestic market economies in Africa with a current population of 105,989,947. The transformation of Ethiopia from an agricultural economy to a fast-upcoming industrial economy in sub-Saharan Africa is incredible (Khurana, 2018). Still, Ethiopia is a well-positioned country for global exports & situated at the crossroads of Africa; the Middle East-easy access to Asia through the port of Djibouti and proximity to Europe used to facilitate the values of exports markets. It is qualified to enjoy Duty and Quota Free trade agreements to manufacture and export products from different regional and international markets from the 2000s to 2025 (Ethiopia trade and investment, 2016). Including, AGOA duty and quota-free access to the US market (AGOA, 2016); Common Market for Eastern & Southern Africa (COMESA) - a region inhabited by more than 420 million people; and bilateral trade agreements established with western countries; USA, and global markets through Everything but Arms (EBA); European Union (EU), China –'0 Tariff' privilege and India – DFQF (Pols, 2015; Walle, 2018). According to ETIDI, (2016), Ethiopia also has duty-free access to 16 other foreign nations, namely, Australia, Belarus, Canada, China, India, Japan, Norway, New Zealand, Russia, Switzerland, Turkey, etc. Ethiopia is also the second from bottom to use the opportunity of AGOA from those countries which are eligible to use this opportunity, as South Africa 21%, Ghana 17%, Malawi 13%, Liberia 12%, Kenya 9.9%, and Ethiopia 8%, and Nigeria 5%. Among member countries, Ethiopia has a share of as low as 8% from COMESA when compared to other member countries (Kelbesa, 2014). To feat these chances the government of Ethiopia has expressed and executed several policies and strategies (like private sector-led industrialization, development of export-oriented industries, strengthening the capacity of existing industries, and investment promotion and facilitation with increased emphasis on foreign investment utilizing to the extent possible labor-intensive technologies to create employment, generating incomes and alleviating poverty. But, still, now the contribution of textile and garments in the Ethiopian economy is as low as 5.04% of foreign currency which lower than other African countries because of low preparation to exploit these privileges (World Bank report, 2013). According to ETIDI, (2019) data report shows that the Ethiopian textile and garment industry import-export market value trends are shown in the following Figure.

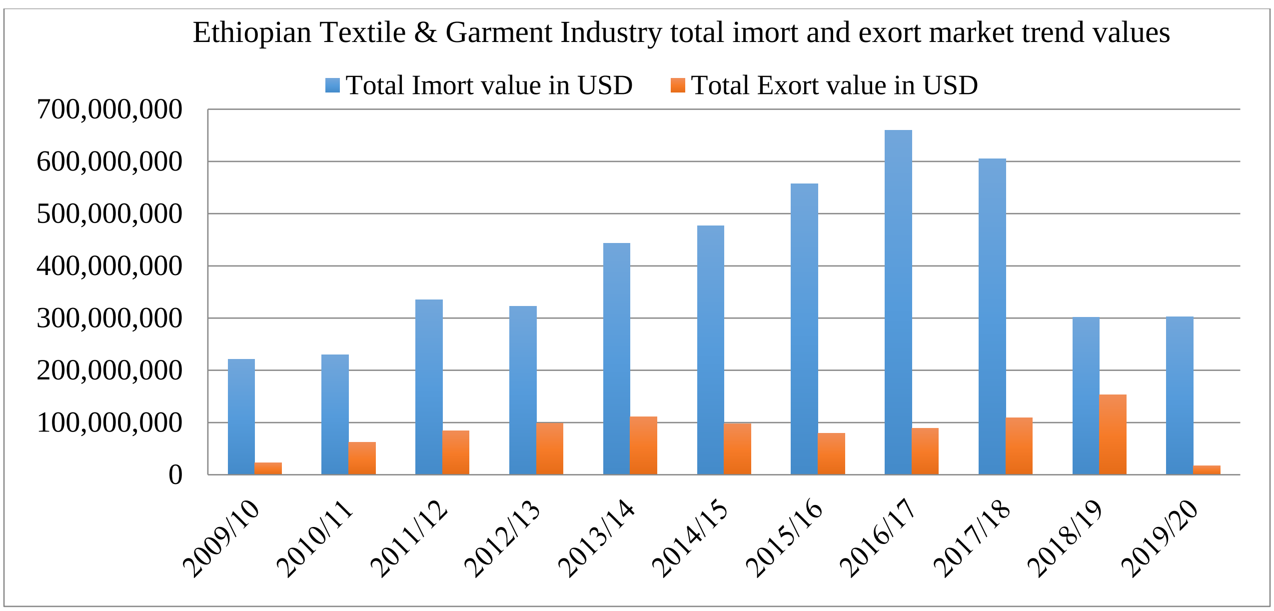


Figure 4. 1 The capacity of Ethiopia textile & garment import-export values in $ US

This Figure indicates that the Ethiopian textile and garment industry import-export values (in $) are not balanced. So, it indicated that the inputs of the sector are dependent on imports.

4.3.4. Employment opportunity trend of Ethiopian textile and garment industry

The textile and garment industry is known for involving a large number of skilled as well as semi-skilled and trainable workforces. According to Ethiopian GTPs (GTPI-II) documents indicated that at the end of GTPII (2015-2020) this sector creates around 450,000 workers' job opportunities. However, only 23,133 males, 72,987 females' total of 96,120 jobs were cratered with an average annual growth rate of 4.9% and 47% of the target was achieved. In the same manner, the garment industry took about 63% of the total workers of the sector. So, the following Figure shows that the total number of employees in medium and large Ethiopian textile & garment industries by Sex and Year (ECSA, 1991-2018/19).

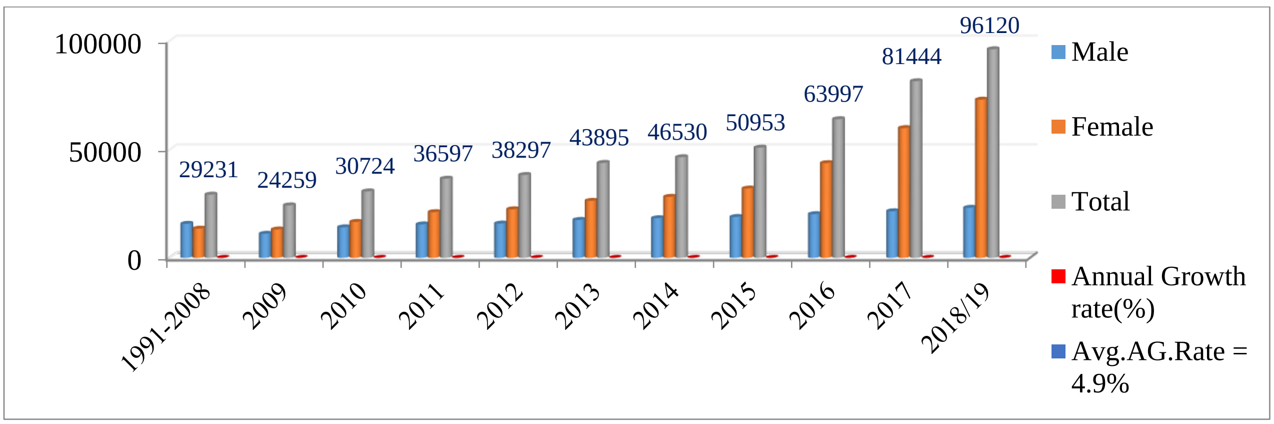


Figure 4. 2 Total number of employees' job opportunities in Ethiopia textile & garment industry

To observe from the Figure is that along with employment generation, female comprises around 76% of employment share in textile and apparel sector. The men were contributed to the majority of technical and management positions. For the time being a large & cheap workforce with low labor costs helps Ethiopia becomes the most attractive feature for investors. According to Francis, (2015) provides that Ethiopia's textile and garment industry, the monthly wages range was "between" $26 to $60. According to an Ethiopian government survey in 2016 found that 52% of monthly wages of employees earned less than $35. Thus, now Ethiopian textile & garment sector employee monthly wages (b/n $35 and $60) is lowest than with compared to other similar manufacturing countries. This used to increase exports from the current 20% of total garment and textile production to increase 80% by 2020 (Abdell, 2017). It is shown in Figure (4.3).

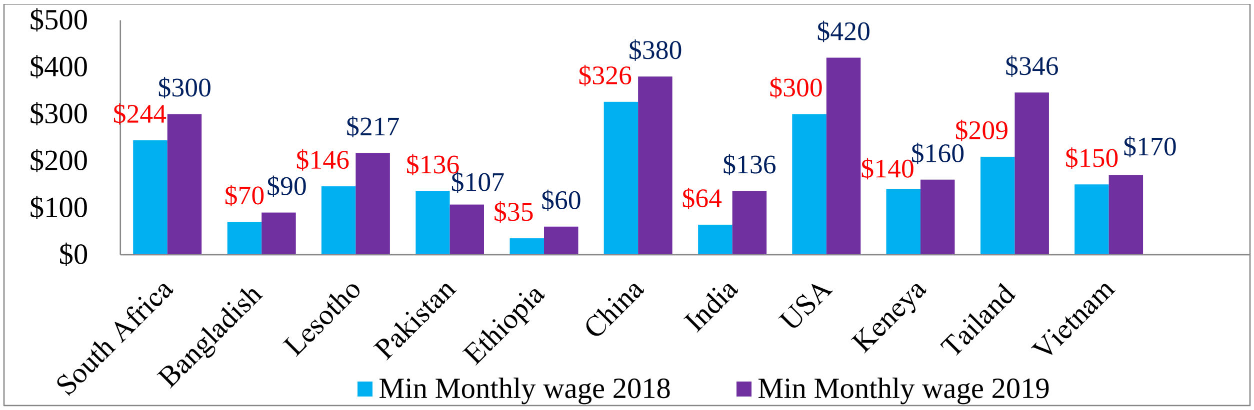


Figure 4. 3 Average monthly wages of employees in the global textile and garment industry

Source: World Bank and ETIDI

4.3.5. Production capacity of Ethiopian textile and garment sectors

Ethiopia's textile & apparel industry is relatively diverse and can be divided broadly into four main product types are spinning, knitting, weaving, and finishing/ garment. This industry produces a wide range of products, such as yarn (cotton yarn, polyester blended yarn), grey knitted and woven fabric, finished fabrics (workwear, knits and uniform, printed sheeting), and made-ups (curtains, terry towels, blankets, mosquito nets, bed sheet, shirts, carpets, gunny bags, wearing apparels) (Kelbesa, 2014; Abdell, 2017). These production factories are located in Tigray, Afar, Amhara, Oromia, SNNP, Addis Ababa, and Dire Dawa. There are also 79 mills in Addis Ababa, 22 mills in Oromia, 7 mills in Amhara, 4 mills in Afar, 3 mills in SNNP, 3 mills in Tigray, 2 mills Dire Dawa and 1 mill in Gambela are that produce cotton fiber, yarn, fabrics and garments (ACTIF: Benchmarking reports, 2016). The installed capacity of each section of the sector is 72 million kg of yarn, 49 million meters of finished woven fabric, 62 million pieces of knitted garments, and 18 million pieces of woven garments, etc. The capacity utilization range from 35% to 70% and the average utilization of the industry is below 58% (Kumera, 2018).

Table 4. 2 Ethiopia's current installed and attained annual capacity of textiles and garments

No	Section	Installed Annual Capacity	Attained Annual Capacity	Utilization of capacity
1.	Ginning	106,164 tons of lint cotton	37300 tons of lint cotton	35%
2.	Spinning	72 million kg of Yarn	54.4 million kg of yarn	70%
3.	Weaving	122 million meters of woven fabric	61 million meters of woven fabric	50%

4.	Knitting	30 million kg of knitted fabric	13.5 million kg of knitted fabric	45%
5.	Knitting Processing	18 million kg of processed knitted fabric	8.64 million kg of processed knitted fabric	48%

Source: ACTIF Benchmarking report, 2016

4.3.6. Ethiopian Cotton Production

Cotton plantation has a long historical development in Ethiopia and traditionally farmers grew cotton of the backward species by household to satisfy their clothing needs. Since the 1960s, the government proposed to promote cotton cultivation and made favorable land policies to meet the raw material necessities (Matebu, 2009). Nowadays, the Ethiopian government showed its diligence to cotton production in first (2010-2015) and second (2015-2020) growth & transformation plans striving to be one of the leading textile & garment sourcing destinations and to achieve middle-income status by 2025 (Desalegn, 2016). Because Ethiopia has a land area of 1.14 million square kilometers, it is twice the size of the United Kingdom (Ministry of Trade and Industry, 2004). From this total land of the country 3.2 million ha, are suitable for cotton cultivation. However, only around 3.7% is utilized, implying untapped potential (Abdell, 2017). So, Ethiopia has a huge potential for Cotton cultivation all over the country (Khurana, 2018). The total land cultivated in 2012 was 111,886 ha, by small and large scale companies. However, current production is very small compared to the area designated by the government for potential cotton farming. Only 30,000 to 40,000 ha, are currently being utilized, which is not enough to keep up with current garment production demand. This means the cotton is still being imported (annual cotton report of Ethiopia, 2015). According to a US Global Agricultural Information Network (GAIN) report, Ethiopia’s total cotton production for 2014-15 was approximately 40,000 metric tons. The estimation for 2015-16 is 38,000 metric tons and increase slightly to a total of 45,000 metric tons in 2016-17. Meanwhile, to predict the imports continue to increase to 8,000 metric tons in 2014-15, and 14,000 metric tons, in 2016-17. So, the cotton production of the country is still very insignificant compared with the five top cotton-producing countries, like India, was produced 5.74 m; U.S 2.81 m and China 4.79 m metric tons in 2015-16. See in the following Figure (4.4).

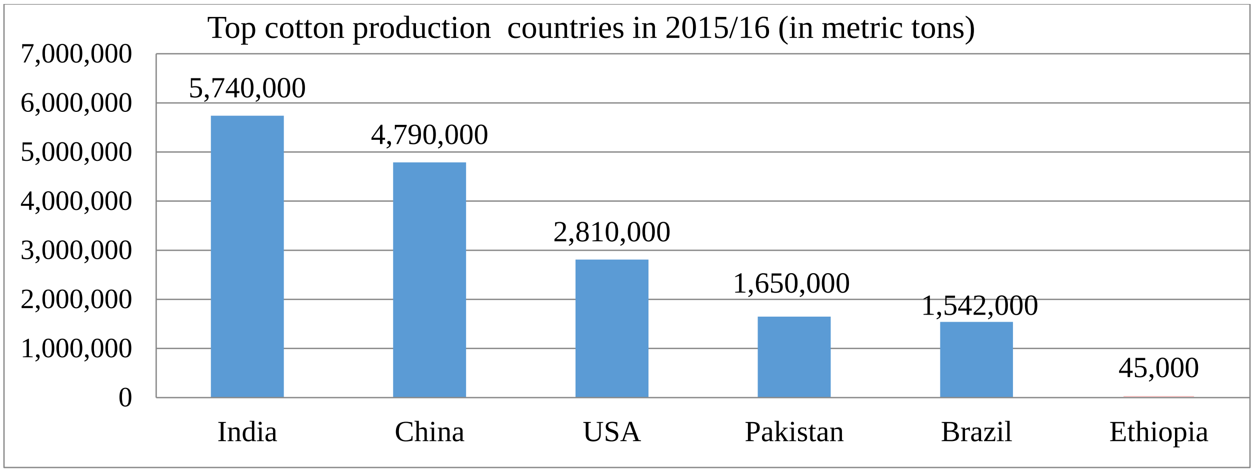


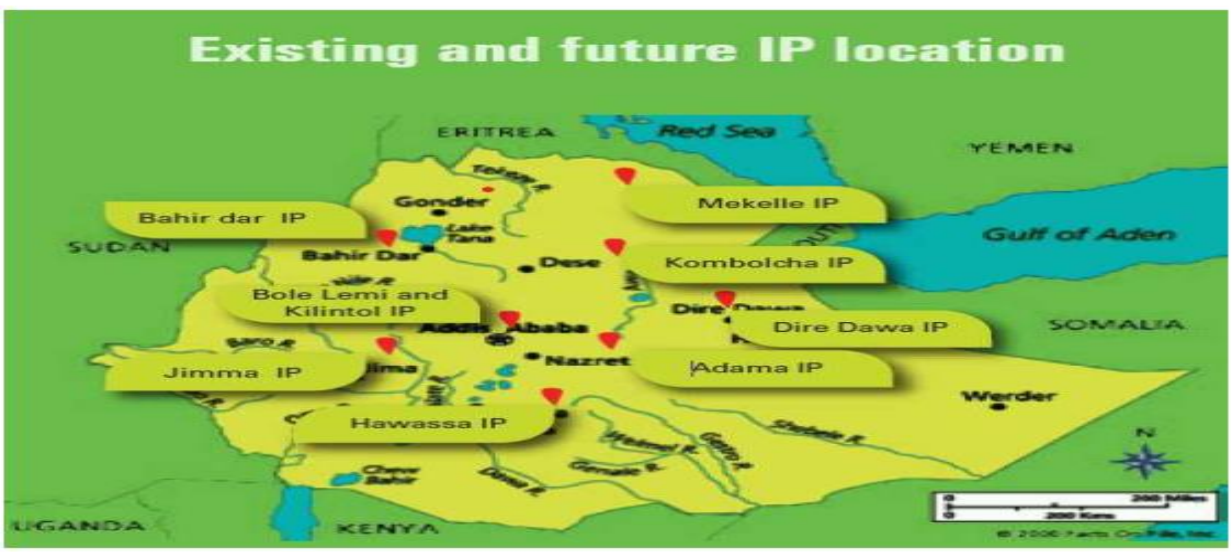
Figure 4. 4 Ethiopian cotton production capacity compared with the world cotton producers

Source: USDA, 'Cotton: World Markets and Trade,' 2016

This Figure indicated that Ethiopia utilizes only (US Department of Agriculture, 2016) a small percentage of its cotton-producing potential, as a result, Ethiopia was forced to imports raw cotton from the world's leading cotton producers to fully meet the demands of its garment and textile industry. The shares of these countries are India 55%, China 7%, USA 3%, Turkey 8%, Nes Areas 12%, Pakistan 10%, Sudan 2%, and others 3%. Because, Ethiopia used only less than 40% of local cotton production input (UN: Comtrade database, 2015). In 2015, Ethiopia imported cotton products for a value of $32,928,021 and cotton exports were valued at $19,787,667. But, in 2016-2019 the export value of cotton decreased to $11,486,499. Thus, the import and export values of cotton are not balanced still the end of GTPII (ETIDI, 2017). The main cause for decreasing cotton export is low land-utilization rates, planning errors, low crop yields, and quality problems, low production efficiency (currently runs b/n 40 and 50%), and long lead time (world trade center, 2018). Meanwhile, Ethiopia's cotton imports consisted mainly of 'cotton, not carded or combed' (41%), carded or combed' (22%), and 'woven fabrics cotton (22%), and others (15%). Thus, the Ethiopian government and firms must be focused on cotton cultivation to fulfill the local and export raw material demands of the garment & textile industry.

4.4. Industrial parks of Ethiopian

The first and second Growth and Transformation Plans (GTPs) predict the transformation of the country's economy from agrarian to industrial (Abdell, 2017). To achieved this plan, the government recognized industry park development program for effective land usage, eliminate the problems in logistics and customer service, expand investments, create linkage among middle and large scale industries for the transfer of technology, leadership methodologies, growing job opportunities, use national resource appropriately and strengthen green industry development trend (Ethiopian investment research and promotion team, 2017). Then, the Ethiopian Industrial Parks Development Corporation was established in 2014, became an engine of rapid industrialization that nurtures manufacturing industries, to accelerate economic transformation, promote and attract both domestic and foreign investors (Khurana, 2018). According to Brautigam, (2015), Ethiopia has adopted an active, state-driven industrial policy aimed at incentivizing exports, attracting lead firms and foreign direct investment, supporting local farms, and creating local linkage to promote priority sectors, like apparel and textiles industry (Shields, 2017). Based on this, the Ethiopian government plan (GTP-I) intends to construct 15 export-geared, state-of-the-art, and eco-friendly industrial parks in different regional states' main cities and now most of these parks are operational manly used for textile and apparel production. And also, the government to recognize about 10 industrial parks and to identify 700 potential locations for the development of clusters within the GTP II period, and these grouped in 3 sizes of 50, 100, and 250 ha, of land depending on the potentials and the stages of dev.t of the locations. Among these are Bole lemi, Hawassa, Mekelle, Adama, Bahir Dar, Gondar, etc., industrial parks. The Figure shows Ethiopian industrial parks and their locations.



Source: Ethiopian Ministry of Industry: investment research and promotion team report, 2017.

All parks have an international standard building with high infrastructure, safety facilities, and a low carbon footprint (ETIDI, 2016). According to ETIDI, About 60% of the country's budget is being invested in infrastructure, which facilitates meeting the GTPs and improving industry sector productivity. Example - to build a new electric railway network that links Addis Ababa, the dry port of Modjo, and Djibouti reduced cargo transit time from 3 days by road to 10-12 hrs by train and rail corridors that cover 6000 km network are underway to create a series of trade routes to neighboring Kenya, South Sudan, and Sudan. In addition, Ethiopian Airlines plays a key role in the logistics process (Sileshi, 2016). Thus, at the end of GTP-II (2015-20) the Ethiopian government expected that the agricultural economy transforms into an industry-dominated economy to increase worker productivity and to achieve middle-income status for the country by 2025 and hopes to bring in textile and garment exports worth $30 billion by 2025 & creates above 450,000 job opportunity and also to increase foreign currency by using these industrial parks throughout the country (Tsegay, 2017). So, to achieve these targets the government set up various sub-organizations to handle the flow of work. Some of them are ETIDI, ETGMA, Addis Ababa chamber of commerce, Labor inspectorate of Addis Ababa, Industrial federation of Ethiopia textile, leather and garment workers trade union, Ethiopian development research institute, Leather industry development institute, and fashion design association (Theuws, 2017; Kumera, 2018). But, still, now the target of GTPs couldn't meet its objectives. For example, Hawasa Industrial Park is established in July 2016by the China CEC Corporation at the cost of $250 million and is comprised of 37 factory buildings on 300,000 m^2 dedicated to the textile and apparel sector and this industrial park consists of 21 Foreign, Domestic textile and apparel investors (Industry reports, 2016). Currently, this industrial park was fully operational, in mid-2017 and under the GTP-II plan, the government expected to this park creates about 60,000 workers' job opportunities and to get about 1 billion dollars in export revenues for Ethiopia (Khurana, 2018). But, currently can operating not more than 20% capacity, (ETIDI, 2018).

4.4.1. The garment industry in Ethiopia

The industrialization of Ethiopian garment manufacturing started in the 1950s. In 1958, 1961 Italian took the lead to establish Addis Garment and Bahir Dar textile mills factory respectively. In the 1990s, private investment had increased in Ethiopia garment sectors, due to, the development of a free-market economy (Matebu, 2009). Currently, there are more than 90 garment factories have been established in Ethiopia (ETIDI, 2018). The main products of these garment factories are men & women's underwear (trousers, skirts, dresses& nightwear); home garments (sleepwear, pillowcase, & bed sheets); clothing (casual jackets, pants, t-shirts, polo shirts); sportswear (baseball pants, sports jackets) and special products (military uniforms, work clothes, suits & fashion garments) (Nyagari, 2017). So, Ethiopian garments are broadly segmented into three: first are the exporters making low-priced garments; second is the garment importers importing Chinese products occupying a large segment of the market, and third, being the local manufacturers of garments (Ambassador and WOW garments). While the local market of the garment product is dominated by either fake Chinese apparel or export surplus countries of Dubai and Thailand. However, Ethiopia has a huge opportunity for local ready-to-wear brands of fashion garments (Khurana, 2018). Thus, the Ethiopian government has spearheaded the sector as one of the key priority sectors for the generation of future employment & foreign currency earnings. But, the sector is needed capacity building and improving productivity (Pols, 2015). According to Shields, (2017) states that export earnings have grown from $60 million to $160 million at the end of GTP I, and the Ethiopian government has a target to reach $1 bn by 2020, (GTP II). But, the GTP-II plan is far distant from the earlier projections of 1bn USD (Sileshi, 2016). Thus, currently, the sector represents only 6% of the country's total export value and 0.01% of world total apparel export values with the ambition to grow to 22% & 0.15% respectively, in 2020 (McKinsey, 2015; world trade organization, 2016). According to ETIDI, (2017) states that the efficiency of the Ethiopian garment industry during the GTPs period is a slow as 40-45% in production. This is mainly due to bad processes, lack of education, and other reasons (Ethiopian Apparel Business opportunity report, 2015). So, still, now the productivity of the Ethiopian garment industry cannot meet the expected targets of the GTPs, and the export market trends are decreased continuously under the GTP II plans (2015-20). Therefore, the main reasons for decreasing the Ethiopian garment export values were related to the poor production process, product quality problem, lack of skills of the employee & management, low productivity, low employee wage, limited input material, long lead time, poor infrastructure, and lack of integrated system between institutes.

4.4.2. Import-export market share trends of Ethiopian garment industry with compared to other textile sub-products

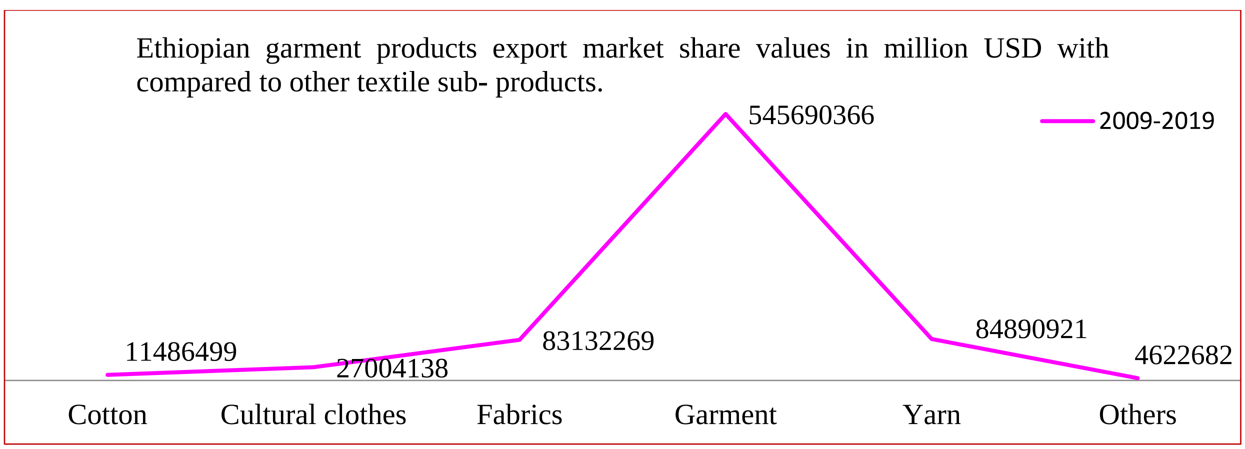
Apparel market share accounts from textile products about 43% of exports, followed by yarn at 32%. Similarly, the import value of apparel accounts for 46%, followed by fabric and yarn, with 20% and 11% respectively (UN: Comtrade database, 2013). According to the Ethiopian textile industry development institute (ETIDI, 2019), the data report indicated that the export values of Ethiopian garments have higher shares as compared to other textile sub-products. It is clearly shown in the following Figure with their values in million USD:

	Cotton	Yarn	Fabrics	Garment	Cultural Clothes	Others	Total
Garment share in %	58.15	60.86	68.99	71.39	71.96	74.20	78.14
2019	195,645	518,060	1,396,190	13,718,730	744,690	982,358	17555673
2018	253,787	1,668,017	11,674,487	137,416,801	2,390,012	106,702	153509806
2017	7,104,785	3,118,018	15,276,250	80,894,184	2,272,031	363,068	109028336
2016	2,880,157	4,991,938	12,928,970	64,285,475	3,747,503	507,116	89341159
2015	1,052,125	11,211,724	6,866,127	56,412,994	3,345,226	134,979	79023175
2014		12,135,510	13,500,374	67,625,574	4,601,890	158,002	98021350
2013		28,851,370	9,426,341	67,766,527	4,716,895	591,068	111352201
2012		22,396,284	12,063,530	57,570,081	5,185,891	1,779,389	98995175

Figure 4. 5 Ethiopian textile sub-products export market share trend values

This indicates that Ethiopian garments export market share is higher than other textile product types (the share of garment export covered: 58%, 61%, 69%, 72%, and 74% of Cotton, Yarn, Fabrics, Cultural clothes, and other textile product types respectively). Consequently, studying in this area is mandatory to improve the productivity of the sector.

In general, the values of each textile sub-product are clearly shown in the following charts.



Thus, the garment production market share is covered about 78% of other textile sub- products. But, when comparing other manufacturing sectors, the country's total GDP and the global garment market shares, only contributed 22%, 6% & 0.01% respectively (Business opportunity report Ethiopia Textile and Garment industry, 2015). So, Ethiopian garment production needs more attention in both the government and private sectors to achieve, that of the sector multidimensional benefits (including- foreign currency earnings, high job opportunity, technology transfer, etc.). Similarly, the import of garment production inputs market share values has been higher contribution with compared to other textile sub-product types. Among these sub-products that covered high import market share values (in dollars) are garments, fabrics, and yarn. It is clearly shown in the following Figure.

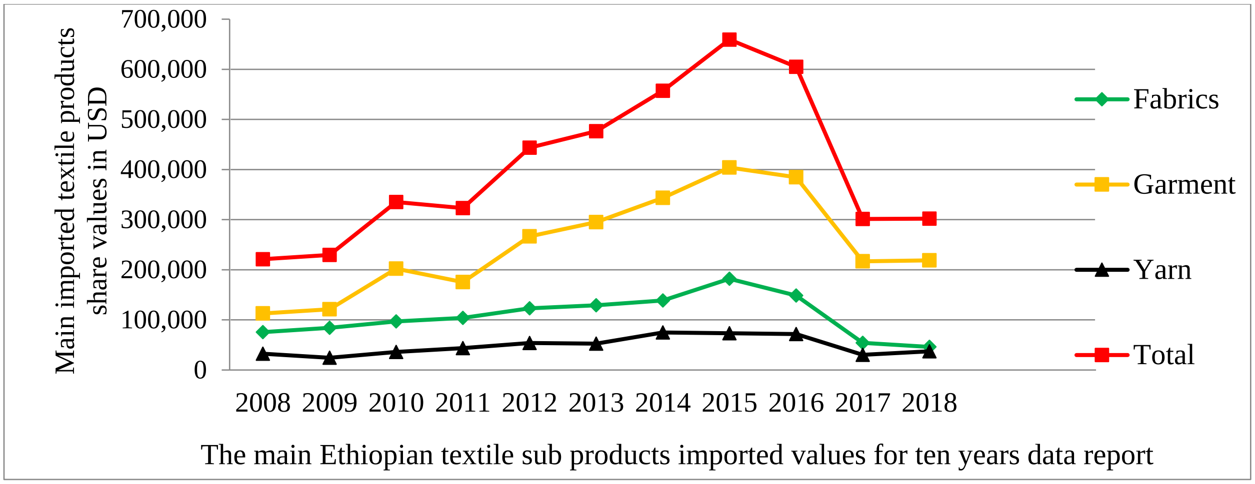


Figure 4. 6 The main Ethiopian textile sub-products imported market share trend values

Thus, to observe from Figure (4.6) is that, the raw input of garments is the main challenge for improving the productivity of this sector.

4.4.3. Export performance of Ethiopian textile & garment industry under GTPI & II plans

According to ETIDI (2017), the report states that the export performance of the Ethiopian textile and garment sector, with regarding the plan of GTP I and mid-GTP II, is indicated that the capacity utilization rate increased from 57 percent in 2012/13 to shift only 68 percent in 2016/17. And also, at the end of the GTP-II plan, the government proposed that the performance of this sector increase to 97 percent (Kumera, 2018). While, the garment sector capacity utilization has been decreased, from 68 percent to 47 percent even though the planned target was 70 percent in 2012/13 and to 95 percent, in 2016/17. As a result, this sector's capacity utilization growth rate progressively declines. According to ETIDI, (July to March 2018/19) (nine-month report; indicate that the export performance of the textile and garment industry progressively decreased. For example, the cotton production only 8.5 % performed from other products share in percent.

The following Table (4.3) shows that the export performance of the Ethiopian textile and garment industries were declined at the end of 2019.

Table 4. 3 Nine-month export performance of textile and garment industry in Ethiopia

Product Type	Annual planned	Nine-month planned	Performed	Performed in (%)	% of share	% from the annual plan
Yarn	6718	4596	2442	53.1	3.1	36.3
Fabrics	49602	33990	11615	34.2	14.7	23.4
Garment	179337	119077	56053	47.1	70.9	31.3
Cultural clothes	1292	1021	2242	219.5	2.8	173.5
Total	158684	236949	72352	45.6	91.5	30.5

Source: ETIDI, (2019) report

Therefore, it is indicated that under the GTP- II period the Ethiopian textile and garment industry plan the growth rate of production capacity utilization is progressively decreased, due to, many problems were faced in this sector, that was discussed in the review & the statement of the problem.

4.5. SWOT Analysis of Ethiopian Textile & Garment Sectors

SWOT is an acronym that contains four logical analytical words for any kind of analysis. These are Strength, (the significant advantage); Weakness (the negative impacts/disadvantages); Opportunity (the elements that should be further implemented and exploited to achieve the desired objectives); and Threat (Elements of the environment that could cause trouble for the business or projects (Ayub Nabi Khan, 2018). So, this analysis is used in any textile and garment industry of Ethiopia, for identifying the impacts and opportunities of the sector.

A. Garment sub-sectors

According to, Matebu; Temesgen; and ETIDI, (2009; 2014; 2016) respectively, stated that the main point of SWOT analysis for the existing situations of the Ethiopian garment sector is shown in Table (4.4).

Table 4. 4 Strength, weakness, opportunities and threats of Ethiopian garment sub-sectors

Strengths	Weakness
* Abundant labor resources at low cost * Cheap electricity: B/n $0.002 and $0.78 per KW. * Water is free. Have excess water resources * Duty-free market access to import and export of garment products. * The sector is strongly supported by the gov.t. E.g. transportation cost decreased by 25%; income tax holiday 2-8 years; 5-8% interest-loan facilities. * Relatively increased number of investment * Growing domestic & global demand * Low production cost * Duty-free access to EU and USA markets * Facilitation of market access for competitive suppliers through ETIDI.	• Limited variety & low quality of products • Low market concept and networking • Lack of skilled human resources • Inefficient production (45% maxi) & export incentives and poor infrastructure. • Limited availability of raw materials, only cotton is available. • Lack of integration between the sectors. • Slow production leads time up to 120 days. • High competition in the local market; non-availability of spare parts & machines. • Limited innovation and design input in production and lack of information about the needs of buyers in export market success.
Opportunities • Huge international market share • Global garment firm relocation • Raising local and regional demand • Potential of the trainable labor force • Investment in infrastructure and materials	**Threats** • High continual global competition • Limited capital for infrastructure • Dependence on third-country port • Commitment to continuous change

B. Textile Sub- Sectors

Ethiopian traditional cloth produced by handloom has a long historical development and it is continuing still now and also it has high contribution to adequate people's needs (Matebu, 2009). As a summary, the SWOT analysis of the general overview of current states of textile sub-sector.

Table 4. 5 Strength, weaknesses, opportunities and threats of textile sub-sector

Strengths	Weakness
* Abundant cotton resources * Increased domestic and global market share * The abundant trainable labor force at low cost * Duty-free access to EU and USA markets * Cheaper utility resources: electricity, water, etc.	* Low productivity& old machines * Insufficient availability of infrastructure * Limited variety & low quality of products * Low market concept unclear market role * Lack of skilled human resources etc.
Opportunities	**Threats**
* Vast international market * Global textile relocation * Potential of the trainable labor force	• unbending global competition • Limited capital for infrastructure • Commitment to continuous change

Source: (Matebu, 2009; ETIDI, 2016)

Overall, textile and garment sub-sectors are facing up the high battle and currently almost all of the sectors export progressively decline and they are not able to cover the cost of production. The main problem is not only its low contribution in terms of output and employment but also its lower capacity and productivity to compete in the rigid international market.

4.6. Company Background (Bahir Dar Textile share company, Garments)

Bahir Dar Textile mills S.C., vertically integrated textile company, manufacturing 100% cotton products, including yarns, fabrics, and garments. It was established in 1961 from the fund of Italian war reparation in the town of Bahir Dar, 570 km North West of Addis Ababa, Ethiopia. When the company was established, there were 563 Ethiopian employees. The initial capacity of the mills was 20,000 spindles, 360 looms together with a processing plant with a total output of 10 million meters square fabric per year. At this time the legal shape of the company was registered as a public corporation, in the name of the Bahir Dar Textile Mills, S.C., with a capital of 9,649,600 Birr. The government established a national textiles corporation and this business title changed from textile mills to textile factories, became under the corporate management. After 27 years of establishment of the factory, of the number weaving machinery reached 423, the total employees raised to 3,000, the capital grew to 16 million Birr, and the total production reached 20 million meter square per year. In 1989, this factory was rehabilitated by investing about 44.2 million Birr. As of September 1999, the factory changed from a public enterprise to a share company and it was financially restructured. The name of the Company is again Bahir Dar Textile Share Company. Its capital amounts at present to 56,808,379 Birr. Its total land holding is 187,908 m^2, out of this 39,200 m^2 is covered by buildings. In 2004, with, 22 million Birr, some finishing processing machinery have been changed with modern machinery. After two years in 2006, the company leased to the Chinese company. But the lessee was not able to stay more than 18 months. After the leased period, the company's management made viable two things: structural adjustment and expansion and renovation project, worth more than 500 million Birr, which expected to be inaugurated in June 2012. The project is environmentally friendly. At present, the company became increased profitability but doesn't meet the targets still now.

- ***Business Mission***

The missions of the company are listed as:

- Make the company beneficiary by using efficient labor force local inputs and resources, lower manufacturing cost, and product quality textile products.
- Delight our customers by producing tailor-made textile products supported by better service.
- Create employment opportunities and bring knowledge transfer in areas of the textile sector
- Contribute its part for the betterment of the national economy.

- ***Business Vision***

– *It* is to make our factory competent in the international market by producing fabric & yarn from 100% cotton fiber with customer needs and requirements by the end of 2025.

- ***Values***

* Employees are our backbones, and Customers are always right.
* Quality has never been compromised, and Much care for the community.
* Commitment for the benefit of factory and gender balance.

The raw material suppliers*:* The main raw material of the factory is 100% cotton. The main local areas of suppliers of raw cotton to the mill are Metema, Dansha, in Gondar. The other foreign suppliers are India, Sudan, China, etc. The main products of the company are Quilt cover; Bed &Flats sheet; Printed & Griege fabrics; Yarn; Kutta; Abujedie; Pillow Case and Abay Shema.
From those product types: The Quilt cover, Pillowcase, and Flat sheet are the main export products.

4.6.1. Workflow Process of Bahir Dar Textile Share Company

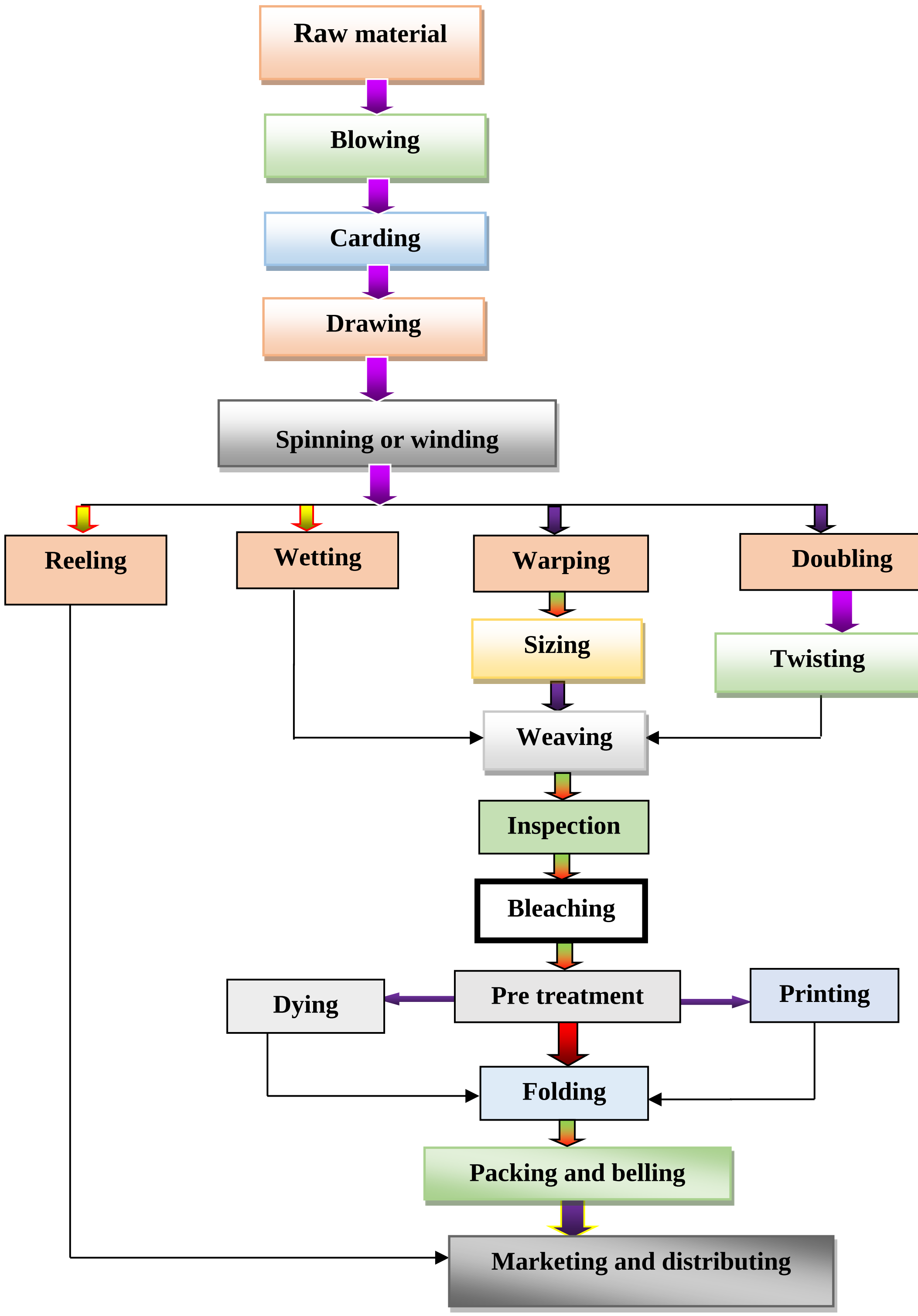


Figure 4. 7 The overall production flow process of BDTSC, Garment's

4.6.2. Overview of Bahir Dar Share Company Garment production

This garment department is one of the main production areas of the case company, and there are several activities were performed. The main activities classified as inspection, cutting, and sewing, labeling, and packaging operations were done every day. Currently, there are a total of 66 sewing machines and mainly there are four types of machines and equipment:

- Single Needle machine (SNM) and 5-Trade machine (5-TM)
- Button Hole Machine and Button Attach machine (BHM & BAM)
- Bell press machine and Spreading Table (machine)
- Manual cutting table and other transporting equipment.

4.6.3. Main Products of the case garment's

The main garment products of the case company that are used for the local and export markets are Bedsheet, Kutta, Abay Shema & Pillowcase (for the local market), and Flat sheet, Quilt cover, & Pillowcase (for export markets). In the meantime, in the case of garment production, there are 242 employees. Most of the employees are young women and they are directly participating in the production process. And the existing workflow of the garment's shown as:

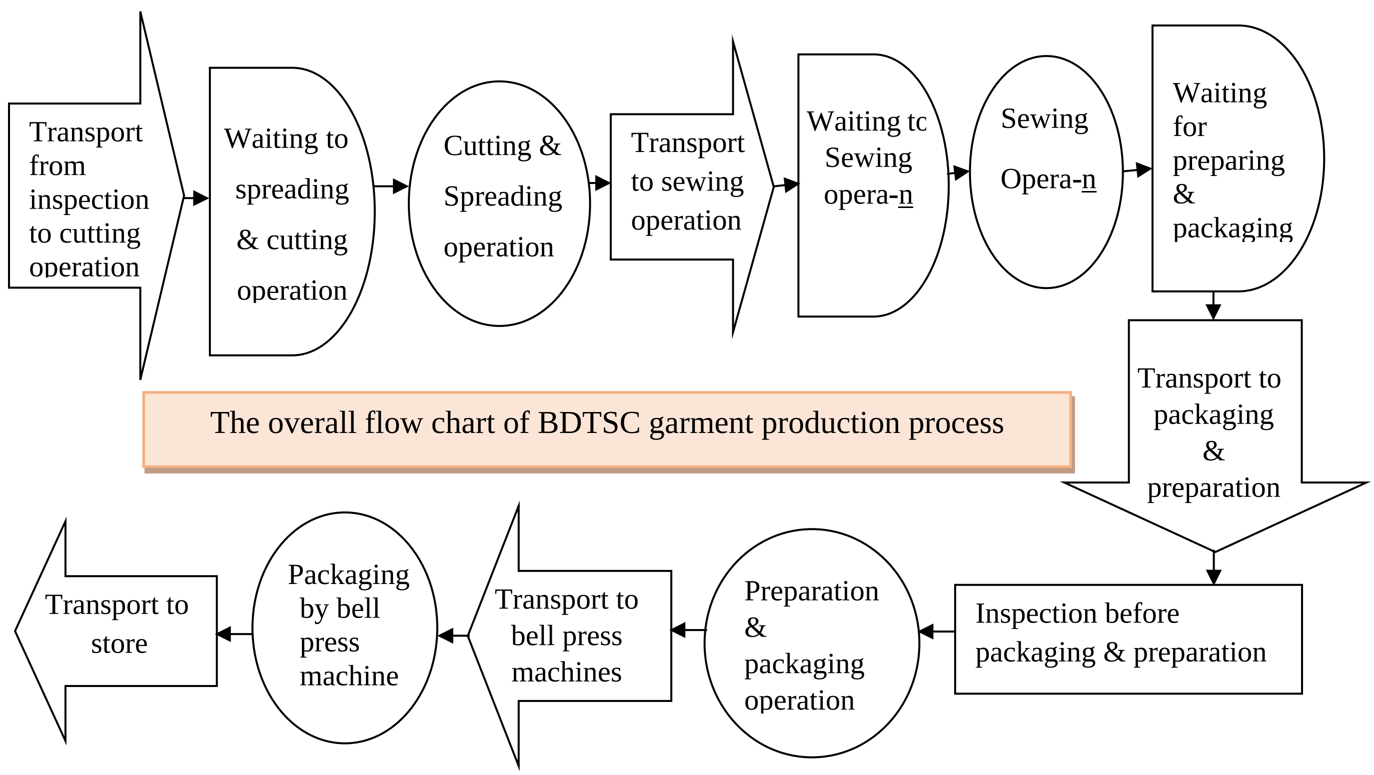


Figure 4. 8 The overall production flow process chart of BDTSC, garment's

The case company production process has the following main working areas such as:

Spreading & Cutting operation: There are two cutting areas; these are cutting for export market products, which are the most manually cutting fabrics using manual cutting table and the other is for local market products which spread the fabric by using the spreading machine.

Spreading is the process of superimposing layers of fabrics in perfect alignment on a spreading table or cutting table. During cutting, the alignment must be 90 degrees on both ends and at least one side of layers.

Figure 4. 9 Spreading cutting operation for the local product (Bed-sheet & pillowcase)

Figure 4. 10 A manual cutting operation for the export product (Quilt cover & Flat sheet)

- Sewing production process

After the cutting operation, the next operation is sewing operations. It is the assembling process of the fabrics with the customer specification. This, the basic process of sewing involves the fastening of fabrics, with the help of a needle and threads. The detailed sewing room production flow of Bahir Dar Textile Share Company, the garment is shown in the following Figure:

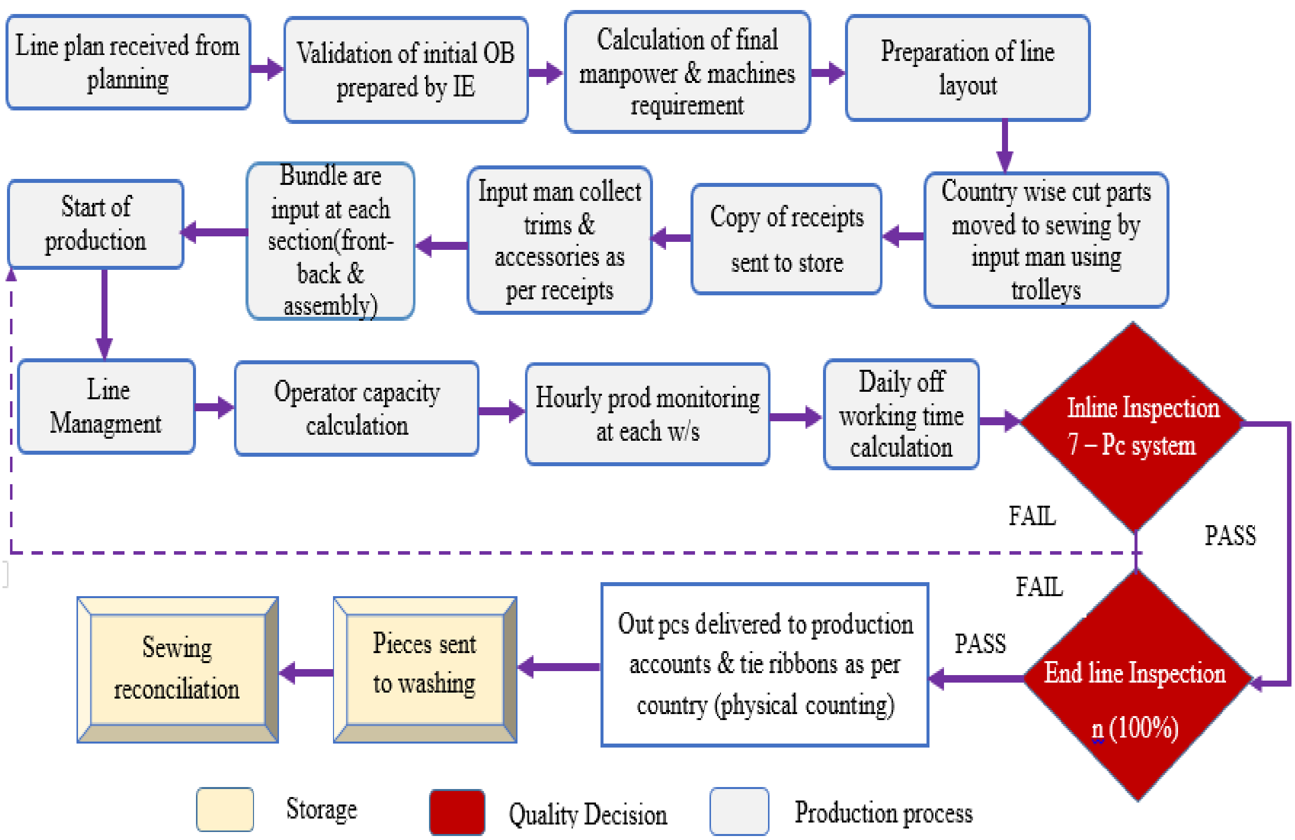


Figure 4. 11 Shows that the sewing room production process flow

The main products of the case company

Figure 4. 12 Shows both local and export products of the case company

☞ **Folding/ packing and packaging**

Packing: used to protect goods and used as a promotional tool as well as to makes a good image builder contributing to product success in the garment production, but, the packaging is concerned with product promotion of garment products. Activities of packing and packaging are preparation, turning, barcoding, insert carton, belling, bonding, and transporting to site light/ temporary store. Production capacity of BDTSC, garments, have a total working hour per shift is 7:30 hours with, 2 shifts per day. The production capacity of export products per shift is: 1000 pcs pillowcase 750 pcs Flat sheet and 800 pcs Quilt cover products can be assembled, with one of these products in a shift/day. However, the export performance of the company is decreased from year to year. Based on the ETIDI, (2019) data shows that the market share of the case garment is shown in Table (4.6).

Table 4. 6 The case garment's industry export market share trends for ten consecutive years

The Sum of full export production capacity values (in percent) of the case company garments for consecutive years in USD										
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Export production capacity share from100%.	2%	4%	2%	26%	14%	19%	12%	14%	6%	1%

It indicates that the market share of the case garments is decline continuously. These problems are stated in the problems of this study. So, the company needs a detailed investigation

CHAPTER FIVE

5. Method of Data Collection, Analysis, and Interpretations

5.1. Introduction

This chapter will be discussed and processed the empirical data collected from direct observation, recording interviews, and questionnaire survey by using MS-Excel-2013, SPC software (Qi macros software-Version 2020), SPSS (Statistical Package for Social Science, Version -21) software for data analysis. The primary purpose of this questionnaire survey is to identify the most critical productivity factors (internal, external, and wastes) of the case garment and analyzed them by SPSS software. This software is used to analyze the qualitative data of the respondent and it can easily show the results of regression, correlation, proportion, & frequency distribution of the dependent variables (Quilt cover and Flat sheet products) and independent variables (all productivity factors which are listed in the questionnaire).

5.1.1. Introduction to Questionnaire Survey Data Analysis

In order, to know the existing productivity factors and improvement approach & practice of Ethiopian garment industries has been conducted by literature survey and interview with ETIDI and directly observing the case company. However, to understand the most critical factors from these productivity factors are assessed by interview and questionnaire survey. This questionnaire has four major parts. The first part is about respondents' information, like gender, qualification, specialization, and experience status. The second part focused on the internal (direct production) and external (indirect production) productivity factors. The third part mainly concentrated on the lean wastes. Fourth focused on the existing practice of lean and work-study improvement tools in the case company. But, before preparing the questionnaire and distribute the paper for workers, first assess the company written documents related to the qualification level of those workers. The results indicate that only 17% of the total population has been qualified under Diploma. So, this indicates most of the workers have been qualified with and above diploma level. Then, the questionnaire was prepared and distributed for the estimated samples size (N = 102). And from these samples only 5.9% were qualified under diploma level, and also the data was collected for these workers using direct interviews. As a result, the total responses have been returned. Consequently, the data collection was done without missing variables and can meet the estimated sample size. So, this qualitative data were analyzed using SPSS-V 21 software. And clearly shows these variables (dependent and independent variables) correlation, regression, frequency distribution, and proportion was tested and estimated the analysis part of this study. The data accuracy or validation was checked by the SPSS case process summary table and to read the values of the Chi-Square, Hosmer, and Lemeshow test in the appendix. So, the data was valid and the analysis shows that most of the estimated variables drown in the regression was fit, which values (p values) less than 5%.

5.1.2. Descriptive Statistics (SPSS) for the research variables

1. *Respondents information and their characteristics*

In this study from a total of 102 respondents' majority of 60.8% were male and the remaining 39.2% were female, and also the values of productivity distribution were covered by males 63.7% and 36.3% were females. So, when it considers the values of productivity females were less than non-productivity. But, the productivity of females was greater than males' productivity by 12.4%. When to see the qualification percentage of the respondents' on the productivity distribution, the workers have been BSc/MA degree (42.1%) were more productive relative to Diploma (34.2%), MSc/MA (35.0%), and others (16.7%), especially for the involvement of direct productions. In general, in this selected garment industry there weren't Ph.D. qualified persons, and have been only 5.9% of workers were low qualified levels (below diploma). In fact, MSc/Ma is more productive than BSc/MA when assigning these workers to an appropriate workplace. On the other hand field, specialization is the most vital for improving productivity. Different scholars suggested that textile and garment industry workers should be qualified in textile and industrial engineering. But, currently, most of the garment industry workers haven't specialization in this field. So, this is one of the factors for the low productivity of the garment industries. Finally, increasing the experience of the workers was a help to improving productivity. Which is shown in Table (5.1).

Table 5. 1 Socio- demographic productivity factors result

Variables	N = 102	Overall Productivity Distribution			Total
		Count	Productive	Non-Productive	
Gender	Female	40	35.0%	65.0%	36.3%
	Male	62	37.1%	62.9%	63.7%
Qualification	Diploma	38	34.2%	65.8%	37.3%
	BSc/BA	38	42.1%	57.9%	37.3%
	MSc/MA	20	35.0%	65.0%	19.6%
	PhD	0	0	0	0
	Others	6	16.7%	83.3%	5.9%
Field Specialization	Industrial Eng.	2	0.0%	100.0%	2.0%
	Textile Eng.	25	36.0%	64.0%	24.5%
	Others	75	37.3%	62.7%	73.5%
Work experience (in Years)	0-5	62	40.3%	59.7%	60.8%
	6-11	26	34.6%	65.4%	25.5%
	12-17	10	20.0%	80.0%	9.8%
	18 & above	4	25.0%	75.0%	3.9%

2. ***Frequency distribution for internal productivity factors of the respondents***

Based on the respondents' information the most common internal garments productivity factors are limited and low-quality inputs (42.2%), inappropriate working method (67,6%), unbalanced work distribution (61.8%), long lead time (46.1%), high defects (44.1%) and others are listed in the following Figure (5.1).

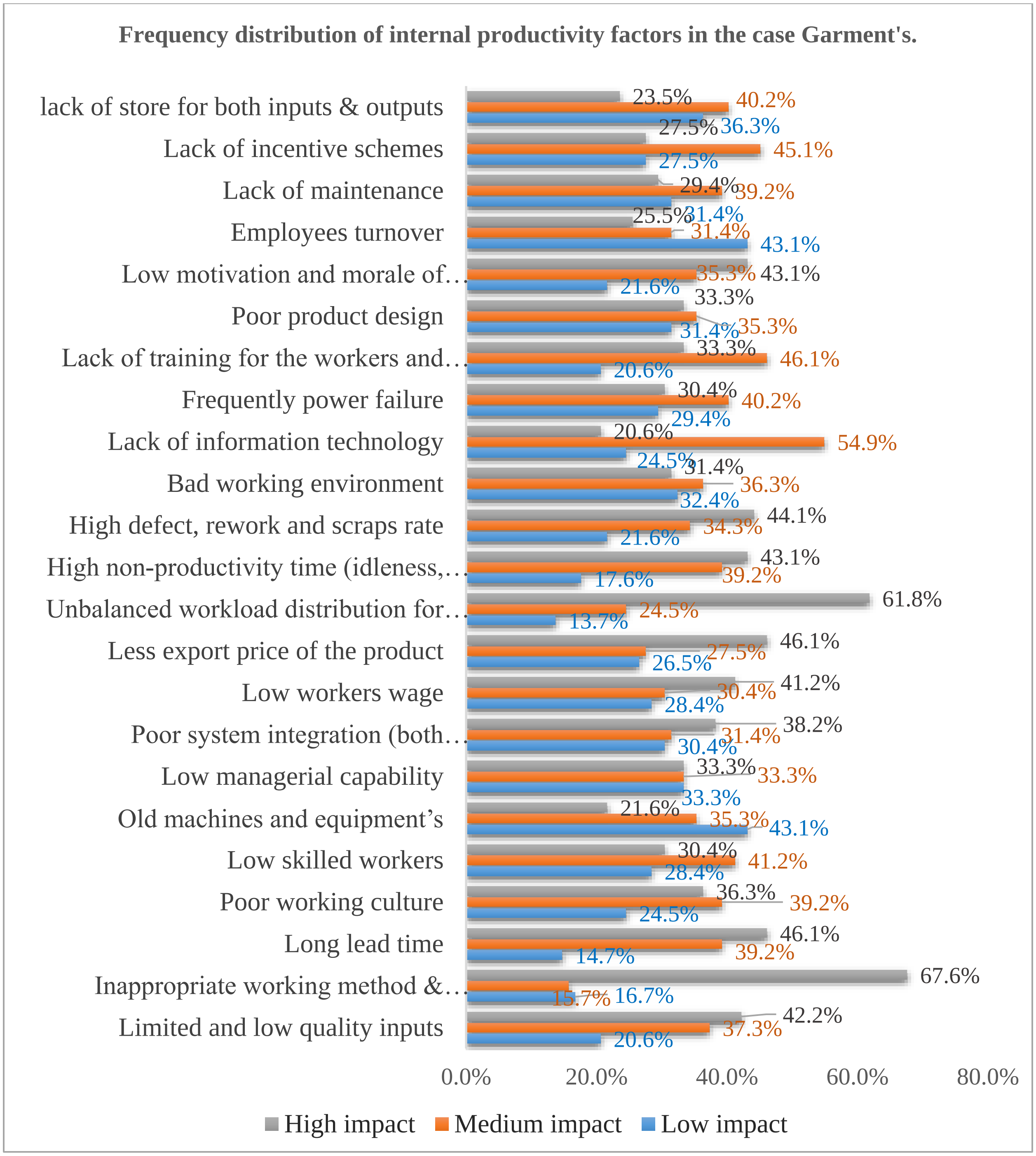


Figure 5. 1 Frequency distribution of internal productivity factors of the case Garment's

3. ***Frequency distribution for external productivity factors of the respondents***

Based on the respondents' responses the most common case garment's external productivity factors are maintenance department (52.9%), quality control department (48.0%), research planning and development center (43.1%), human resource & development center (48.0%), procurement & property administration (42.2%) and others are listed in the following Figure.

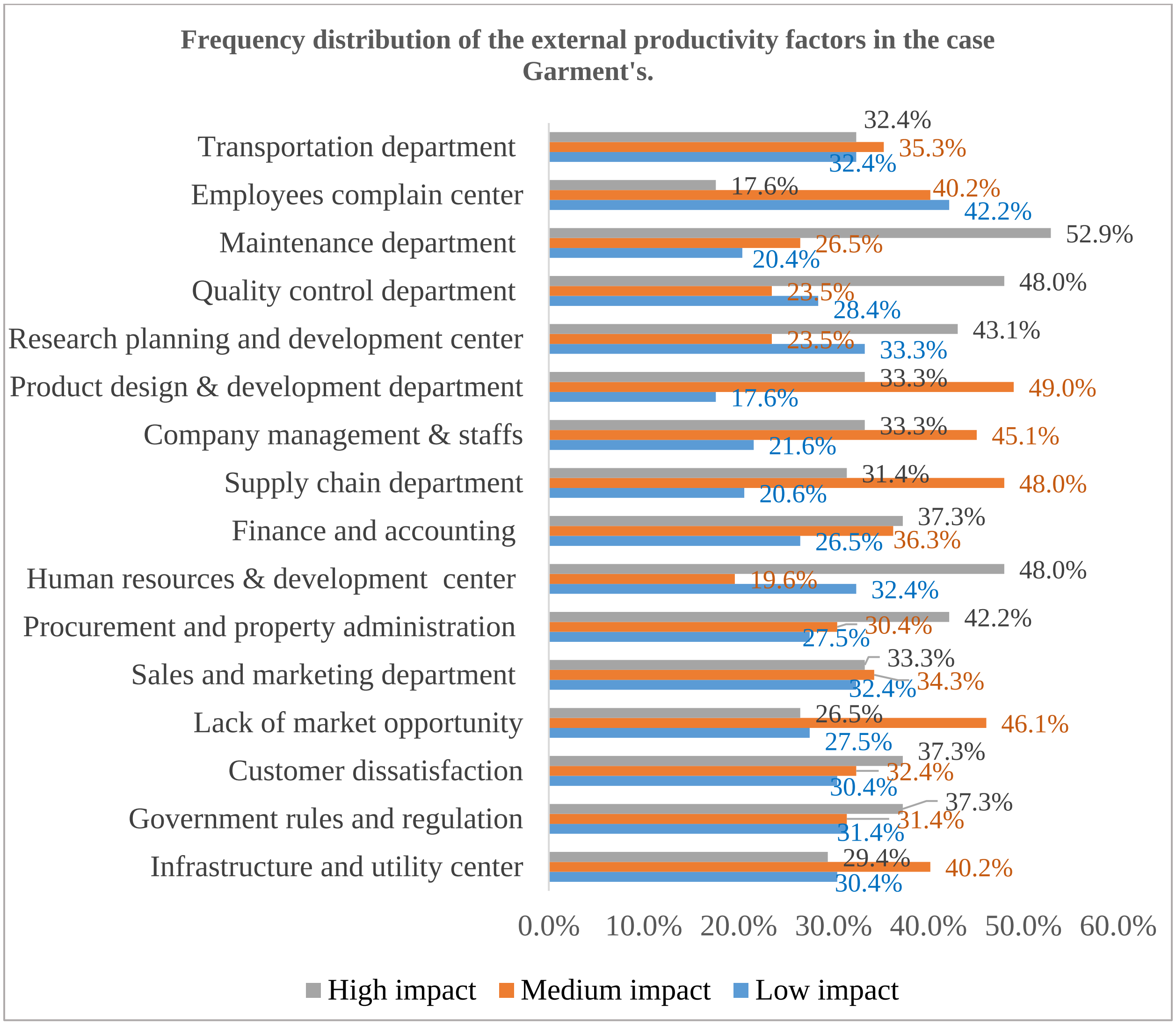


Figure 5. 2 Frequency distribution of external productivity factors of the case garment

4. ***Frequency distribution for eight wastes (lean wastes factors) of the respondents***

The respondents' responses indicate that the most frequently occurred lean wastes in the case of garment production were defects (63.7%), inappropriate-motion (61.7), and waiting (64.7%) unnecessary transportation (65.7). These wastes are one of the major factors for the low productivity of the case garments. Figure (5.3), shows the frequency distribution of lean wastes, and the coding "No" means, wastes didn't occur frequently, as a result, the company was productive. While the coding was "Yes" these wastes were occurred frequently, as a result, the company was not productive. So, over-production & inventory weren't productivity factors for this company.

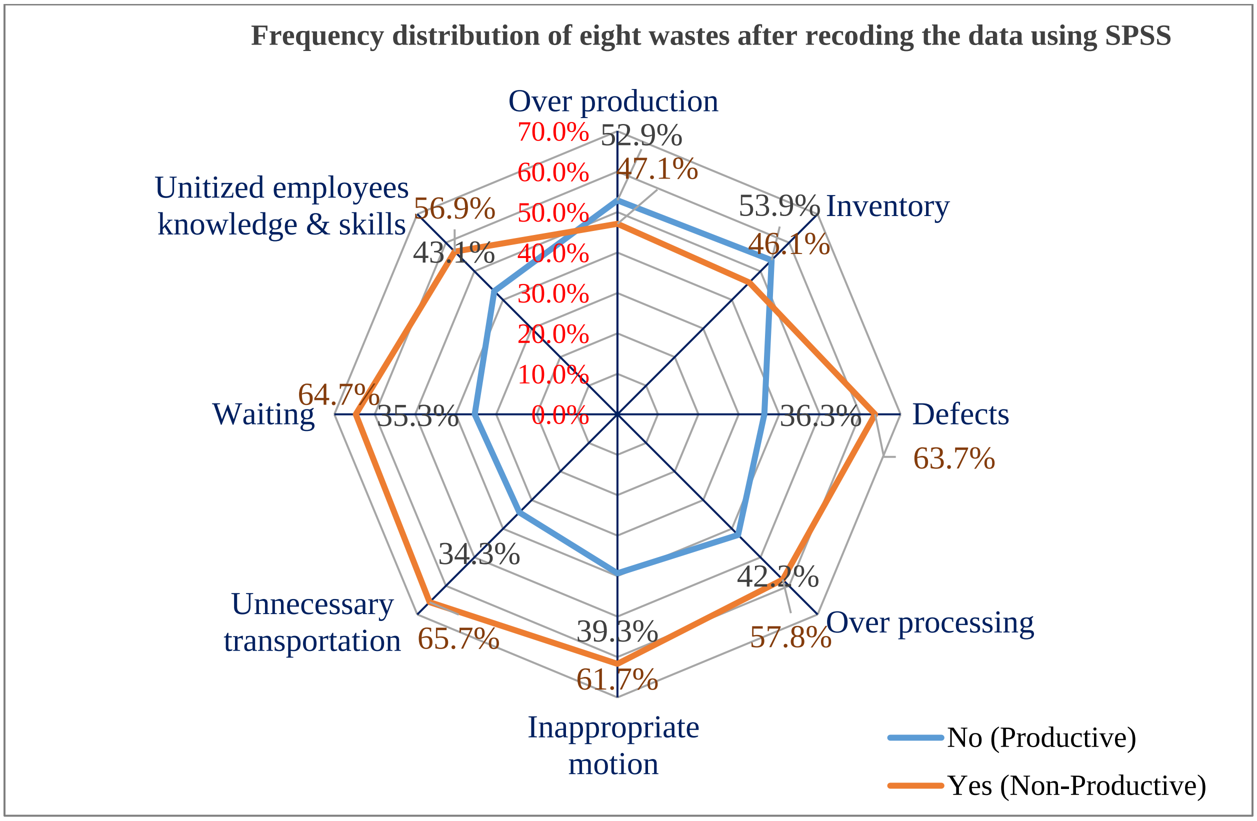


Figure 5. 3 Frequency distribution of lean wastes in the case of garment

5. ***Frequency distribution for lean and work-study techniques & tools of the respondents***

The questionnaire survey analysis shows that most lean and work-study tools were not well known and applied in the Ethiopian garment industry, specifically in the case company, due to a lack of knowledge of the management and workers related to these tools. But, some lean and work-study tools were started to implement in the case garment including VSM, 5S, TQM, Kaizen, and work measurement. However, the company hasn't an expert to apply these tools effectively, that to enhance the productivity of this garment industry. So, to improving Ethiopian garment industry productivity, those companies should apply integrated lean and work-study techniques and tools effectively and also these industries should have a training center about these improvement tools & techniques. Therefore, applying appropriate improvement tools and techniques leads the company to increase productivity. The following Figure shows that the frequency distribution of lean and work-study techniques and tools.

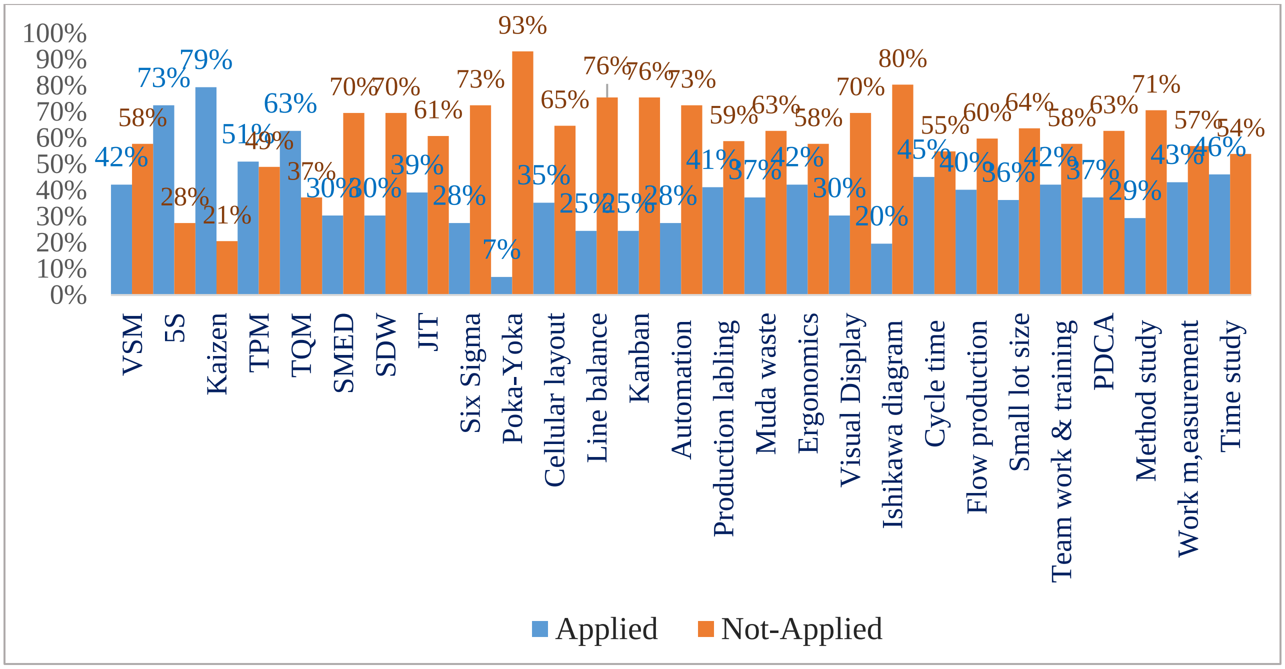


Figure 5. 4 Frequency distribution of lean & work-study tools in the case garment

5.2. Result and Discussion

5.2.1. Qualitative data analysis

5.2.2. Logistic regression analysis

This tool was used for statistical analysis to see the relationship between dependent & independent variables in linear regression with the main difference by dichotomous outcome variables to the logistic regression and the outcome dichotomous variables are coded by 0 and 1, which earnings, 0 for the absence of outcome of interest and 1 for the presence of outcome of interest (Tadele, 2020). Therefore, this tool has been used for the analysis of this study into two main functions, primarily used bivariate logistic regression for checking the significance of each independent variable with compared to the overall dependent productivity variables, and the second was used multivariate logistic regression to select the most significant productivity factors (can be analysis multiple independent variables with two dependent variables at a time).

5.2.3. Bivariate logistic regression analysis

The analysis of binary logistics regression shows that the values of productive factors which affected productivity with related to limited and low-quality inputs show the Exp (B) or COR (crud odd ratio) values of .338 (which, means these productivity factors was affected the final production outputs with the values of 0.338 times than the worker who wasn't responded of not affected productivity). Similarly, for poor working method (COR = .206), Long lead time (COR =.161), Low skilled workers (COR = .310), and the remaining COR or Exp (B) values were seen in Table (5.2). And the total of internal productivity factors (23), were regressed & the significance values (P- values), was below 5%. Hence, this value indicated that the most significant internal productivity factors were 13. And also the variables in the bivariate analysis which have p-values less than 0.05 have been used for further analysis in multivariate regression (Goshu, 2018).

Table 5. 2 Bivariate logistic regression for internal productivity factors

S/No	Variables in the equation	Level (coding)	B	S.E.	Sig.	Exp(B)
1.	Limited and low quality inputs (1)	0. Not-affected 1. Affected	-1.086	.446	.015	.338
2.	Inappropriate working method & process flow (1)	0. Not-affected 1. Affected	-1.578	.542	.004	.206
3.	Long lead time (1)	0. Not-affected 1. Affected	-1.826	.656	.005	.161
4.	Low skilled workers (1)	0. Not-affected 1. Affected	-1.172	.514	.023	.310
5.	Low production managerial capability (1)	0. Not-affected 1. Affected	-1.640	.542	.002	.194
6.	Poor system integration (1)	0. Not-affected 1. Affected	-.981	.457	.032	.375
7.	Less export price of the product (1)	0. Not-affected 1. Affected	-1.477	.458	.001	.228
8.	Unbalanced workload distribution between workers (1)	0. Not-affected 1. Affected	-1.321	.545	.015	.267
9.	High product defect, rework and scraps rate (1)	0. Not-affected 1. Affected	-1.147	.446	.010	.317
10.	Lack of information technology (1)	0. Not-affected 1. Affected	-1.958	.654	.003	.141
11.	Lack of training for the workers and managers (1)	0. Not-affected 1. Affected	-1.956	.585	.001	.141
12.	High employees turnover (1)	0. Not-affected 1. Affected	-1.014	.437	.020	.363
13.	Lack of stores for both inputs & outputs (1)	0. Not-affected 1. Affected	-1.688	.658	.010	.185

In a similar way from the total external productivity factors (16) were regressed & the significance values (P- values) were below 5%. Thus, these values indicated that the most significant external productivity factors were 10. And also the variables in the bivariate analysis which have p-values less than 0.05 have been used for further analysis in multivariate regression.

Table 5. 3 Bivariate logistic regression for external productivity factors

S/No	Variables in the equation	Level	B	S.E.	Sig.	Exp (B)
1.	Infrastructure and utility center (1)	0. No 1. Yes	1.705	.587	.004	.182
2.	Government rules & regulation (1)	0. No 1. Yes	-1.134	.471	.016	.322
3.	Sales and marketing department (1)	0. No 1. Yes	1.364	.512	.008	.256
4.	Procurement and property administration (1)	0. No 1. Yes	-1.227	.457	.007	.293
5.	Human resources & development center (1)	0. No 1. Yes	-1.202	.439	.006	.301
6.	Company management & staffs (1)	0. No 1. Yes	-1.114	.489	.023	.328
7.	Product design & development department (1)	0. No 1. Yes	1.640	.542	.002	.194
8.	Quality control department (1)	0. No 1. Yes	-1.823	.475	.000	.161
9.	Maintenance department (1)	0. No 1. Yes	-1.336	.437	.002	.263
10.	Transportation department (1)	0. No 1. Yes	-1.300	.512	.011	.272

Based on the bivariate regression analysis of lean wastes only four wastes have been most significant with the values of p is less than 5%.

Table 5. 4 Bivariate logistic regression for lean wastes of the responses

S/No	Variables in the equation	Level	B	S.E.	Sig.	Exp(B)
1.	Defects (1)	0. No 1. Yes	-1.584	.732	.030	.205
2.	Unnecessary transportation (1)	0. No 1. Yes	1.853	.526	.036	.189
3.	Waiting (1)	0. No 1. Yes	-1.014	.430	.018	.363
4.	Unitized employees knowledge & skills (1)	0. No 1. Yes	-1.321	.364	.042	.265

5.2.4. Multivariate logistic regression analysis

Multivariate regression is used to regress several dependent variables jointly with the same independent variables. So, this regression is being a joint estimator, also estimates the between – equation covariance's and can be test coefficients across equations (Goshu, 2018). Hence, to get the most critical productivity factors (which were regressed previously using bivariate logistic regression) associated with low productivity outputs in the case company, specifically, the selected product types are analyzed using this multivariate logistic regression with enter, forward conditional, backward conditional methods were checked. The results of the analysis were the same values of productivity factors were gotten.

Table 5.6 - shows the results of multivariate logistic regression analysis with the significance values of each critical productivity factor. The iteration of this regression in the data validation test has been taken 9 steps and these values are shown in the appendix. But, the final result of this multivariate regression analysis was taken four iteration steps. The ten most critical productivity factor variables are found form these internal, external and waste in the (iteration four) iteration of the regression process, these are: limited and low quality inputs (COR = .338 and AOR = .116), Inappropriate working method & flow (COR = .206 and AOR = .059), long lead time (COR = .161 and AOR = .258), less export price (COR = .228 and AOR = .131), unbalanced workload distribution b/n workers (COR = .267 and AOR = .092), poor infrastructure and utility center (COR = .182 and AOR = .314), human resources & development center (COR = .301 and AOR = .162), quality control department (COR = .161 and AOR = .061), waiting time (COR = .363 and AOR = .363) and Defects (COR = .205 and AOR = .052). As to Fagerland, (2013) and Hosmer, (1988), the multivariate regression analysis was fit (Tadele, 2020). According to Hosmer and Lemeshow estimation, stated that the collected data was valid in the model when the significance level (P-value) should be greater than 5% and the value of the Chi-square test become below 5%. So, the validation test details are shown in the appendix, and its summary is shown in the following table.

Table 5. 5 The summary of data validation test in SPSS

No	**Fit Test**	**Cut point**	**Current Study**	**No of iteration**	**Source**
1.	Chi-square	≤ .05	.000	9	Fagerland, (2013)
2.	Hosmer and Lemeshow	≥ .05	1.000	9	Hosmer & Lemeshow, (1988) and Tadele, (2020)

In general, the data was valid and the most critical productivity factors of the selected garment were identified from those productivity factors that were assessed in the literature review & overview of this sector and directly observed some garment industries. As a result, this qualitative data analysis was used to the study for identified the most critical productivity factors that were stated in the statement of the problem and which, helps the study for further detailed investigation of these critical factors in the case garment's using quantitative data. So, the most critical productivity factors were summarized in the following table:

Table 5. 6 Multivariate logistic regression of the most critical productivity factors in BDTSC

The most critical productivity factors	**Level**	**P-Value**	**Adjusted Odd Ratio (AOR)**	**95% C.I. for Exp (B)**	
				Lower	**Upper**
Limited and low-quality inputs	0. No 1.Yes	.016	.116	.020	.667
Inappropriate working method & process flow	0. No 1.Yes	.009	.059	.007	.496
Long lead time	0. No 1.Yes	.012	.258	.051	1.310
Less export price of the product	0. No 1.Yes	.023	.131	.023	.751
Unbalanced workload distribution between workers	0. No 1.Yes	.018	.092	.013	.666
Poor infrastructure and utility center	0. No 1.Yes	.002	.044	.006	.314
Human resources & development center	0. No 1.Yes	.010	.162	.040	.651
Quality control department	0. No 1.Yes	.000	.061	.013	.286
Waiting time (in the production)	0. No 1.Yes	.018	.363	.156	.843
Defects	0. No 1.Yes	.003	.052	.008	.753

As a summary, this analysis was used to identify the most critical productivity factors, which are significantly affected the case garment productivity. Hence, based on the respondents' response the most major productivity factors are grouped as quality problems, poor work method, waiting time, fewer products price, unbalanced work distribution, poor infrastructure, and lack of training for workers and managers. Therefore, based on this data, to require further detailed investigation about these critical problems of the case company using quantitative data. However, some of the problems may not have an appropriate solution, but, it can be forward suggestions for the management, like product price, infrastructure and give training for workers.

5.2.5. Quantitative Data Analysis

5.2.6. The existing working method flows and wastes analysis

Under this analysis mainly identified the internal productivity factors including unnecessary movement or motion, inappropriate production flows, inappropriate working methods, reducing production cycle time, ineffective resource utilization by detail investigation of value-adding & non-value-adding activities. Because most operations consist of many discrete activities and complicated distance traveled in the case of garment production. Each operation involves repetitive work using a great deal of labor and ones that are likely to run for a long time. The movements of material and operators are run over a long distance b/n each operation, and which requires repeated handling of materials. As a result, which creates a bottleneck between each operation. This bottleneck is holding up other production operations, lengthy operations that consume a great deal of time. Overall production views of the case garment are shows as:

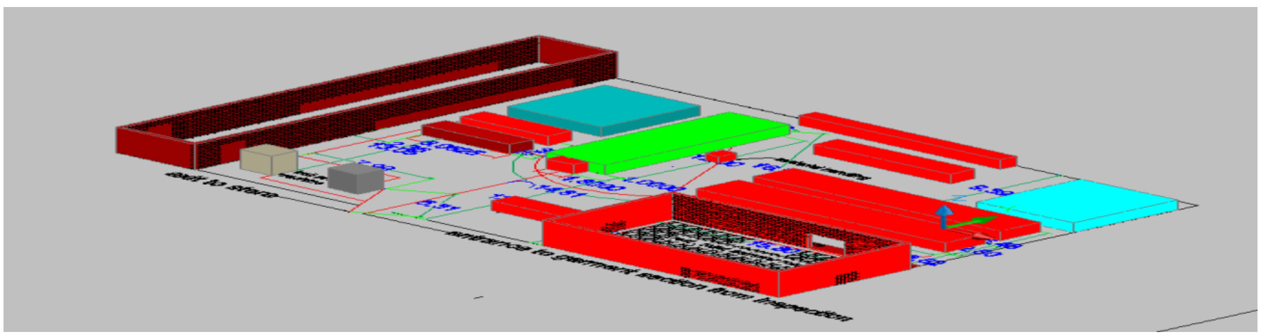


Figure 5. 5 The general view of BDTSC, garment production layout

This garment production process's detailed work activities are shown in the following Figure.

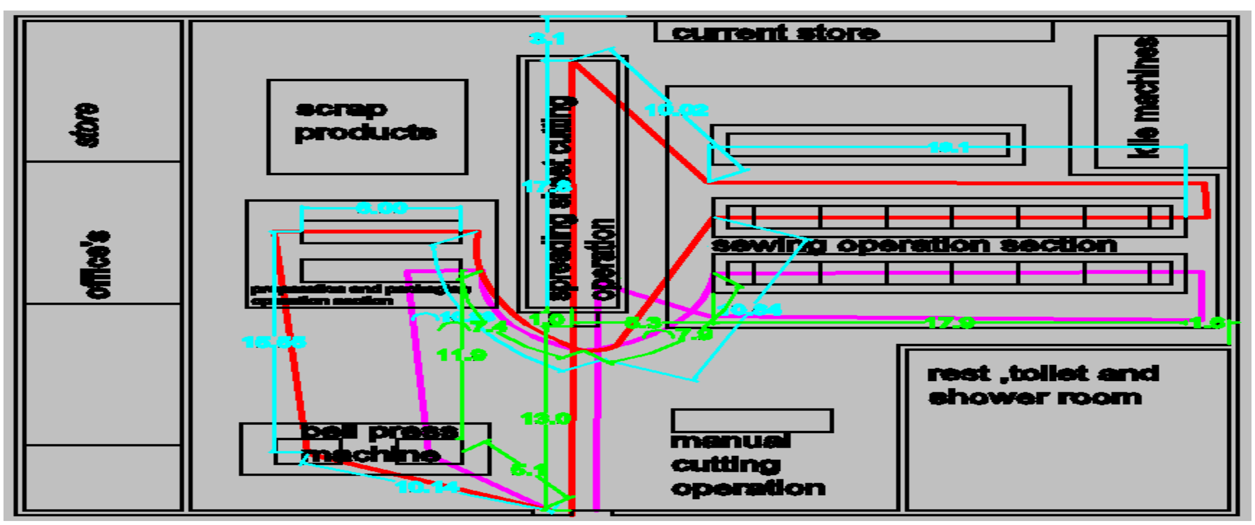


Figure 5. 6 The detailed garment operation activities of the case garment

Figure (5.6) shows that the case garments working methods with its detail activists and which indicates that there is a long path of movements from inspection to finishing operation by measuring distance traveled and time. It is clearly shown in the following Figure.

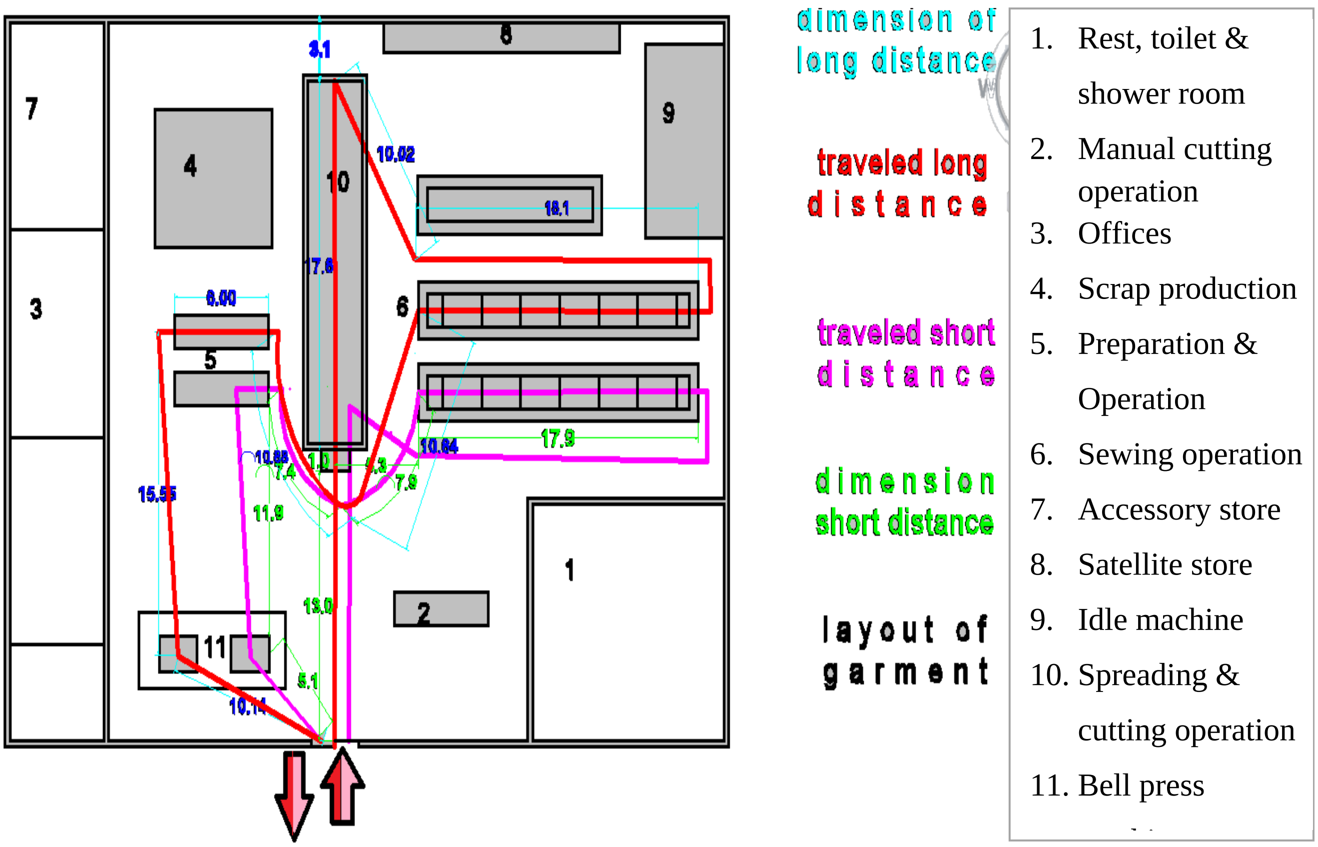


Figure 5. 7 The existing working method of the case company

This Figure shows that the existing recorded workflow & operation sequence of the case garment. This sequence of the garment production activities is not properly arranged, which means the companies haven't a written or organized operation sequence. So, it is a critical step in garment production and a mistake or negligence at this stage can result in huge losses later in terms of operator time, work content, and quality. In general, the current process of the case garment production was improper line balancing or an irregular sequence of activities feeding the material or product to the machine at low possible swiftness, because, its setting is to a different direction within backtracking or overlapping flow of productions, especially at the end of sewing operation, are overlapping operation process for a specified production. Therefore, it requires a detailed investigation about each operation activity by recording and measuring both value-adding and non-value adding activities and the production space along the production process as:

Table 5. 7 The case garment material type flow process chart

Material Type Flow Process Chart					
Chart No Sheet Summary					
Subject charted Used for Quilt cover product (140 * 220)	Activity		Present	Proposed	Saving
	Operation	○	12		
Activities Swing, cutting, level attaching, packaging to store Method: present	Transport	⇨	5		
	Delay	D	3		
	Inspection	□	2		
	Storage	▽	1		
Location garment operation	Distance (m)		132		
Operates	Time (min)		151		
Approve by date Charted by date	Cost Labor Material				
	Total				

Description	Distance (m)			Time (min)	Symbol					Remark
	Mini	Max.	Avg.		○	⇨	D	□	▽	
Inputs inspection								●		
Transport to cutting operation	13	13	13	5		●				
Waiting from spreading operation	1	1	1	10			●			
Spreading operation	18	18	18	44	●					
Cutting operation	2.6	2.6	2.60	20	●					
Waiting to Sew operation	1.10	1.50	1.3	15			●			
Transport to sewing operation	23.3	28.1	25.7	10		●				Long. D
Label Attach	2	2.5	2.25	1.14	●					
Preparation	2.25	2.25	2.25	1.30	●					
Side-Seam	2.25	2.25	2.25	1.20	●					
Box-Making	1	2	1.5	1.30	●					
Preparation and Measurement	2.25	3.25	2.75	1.05	●					
Button Hole	1	1.5	1.25	1.40	●					
Button Attach	2.25	2.25	2.25	2	●					
Manual Work	3	3	3	1.15	●					
Total inspection	2	3	2.5	5				●		
Waiting to leveling and packaging	2.6	2.6	2.6	8			●			Unnecessary
Transport to leveling & packaging	16	20	18	3		●				Long. D
Leveling and preparing	6	6	6	8	●					
Transport to package bell press m/c	11	15	13	2		●				
Bonding and packaging	2.4	2.4	2.4	8	●					
Transportation to store	6.8	9.6	8.2	2		●				
Inspection on store									●	
Total	122	142	132	151	12	5	3	2	1	

Existing production working methods and motions, the management wants to improve this problem by using different traditional problem-solving approaches. But, the problems are still not solved. A good workplace method will eliminate unnecessary movements/ motions and fatigue resulting in a substantial increase in the efficiency of the operator. In BTSC garment production has been a process type production workflows, which means similar operations or machine settings, are grouped in a specific area but the same operations or equipment are not set properly arranged. This method especially the spreading machine is simply setting in the center of garment production and it leads to creating a bottleneck in the production process, as result, it causes material handling costs, backtracking, hazards to personnel, less labor efficiency, minimize employee morale, increase lead time, decrease daily output, etc. One of the most important steps in a method study is critical examination. It is used to critically examine the current method by observing, measuring, and recording the case garment detail activities. Thus, it is important to select the critical examination of the production process at the longest distance, length of spreading machine, and the methods of the operation sequence.

- ✓ The purpose of minimizing the longest distance traveled on the garment operation used for better work method, minimizing stress and increase efficiency and increase productivity
- ✓ The place of to minimize the distance from spreading operation to sewing operation
- ✓ The sequence of the critical operation to be changing position or direction.
- ✓ For calculation of out of control

The data are shown in Table (5.6) can be analyzed by using a descriptive control chart because it shows the mean, standard deviation, and range. Analysis shows using an x- bar chart to monitor the change in the mean of a process or central tendency.

Mean can measure of central tendency, $\bar{x} = \frac{\sum_{i\,=\,1}^{n} x_i}{n}$, which x_i = number of activities

The range is the difference between large and smallest observations in the asset of data,

$r = 1^{st}_{max} - 2^{nd}_{min}$

Standard deviation measures the amount of data dispersion around mean, $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$

So, to calculate upper control limit, control limit, and lower control limit by three sigmas.

Table 5. 8 Existing calculated statistical process control chart data

Variation	Min	Max	Average
$\bar{X}$	5.8	6.75	6.27
σ	6.52	7.61	7.04
r	23.3-18 = 5.3	8.1	7.3

$UCL = \bar{\bar{X}} + Z\sigma_{\bar{X}}$; Where $z\ is\ 3\ sigma, CL = \bar{\bar{X}}$

$LCL = \bar{\bar{X}} - Z\sigma_{\bar{X}},\ \sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$

Where $\bar{\bar{x}} = \frac{\sum_{i=1}^{n} \bar{x}_i}{n}, Z = 3$ and

$UCL = \bar{X} + Z\sigma_{\bar{X}} = 6.27 + 3 * 7.04/\sqrt{21} = 10.87$

$CL = \bar{X} = 6.27$

$LCL = \bar{X} - Z\sigma_{\bar{X}} = 6.27 - 3 * 7.04/\sqrt{21} = 1.68$

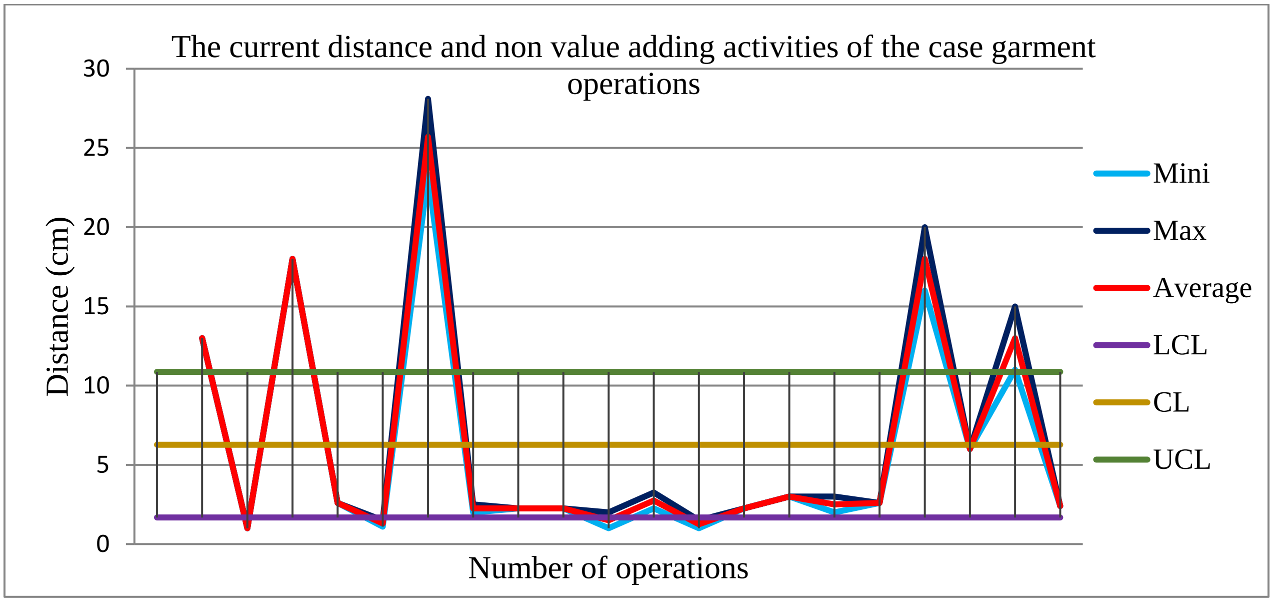


Figure 5. 8 The SPC chart of the current distance for garment operation

There are different data that recording and observing on garment operation related to working method, production movements or motion, and the existing problems in particularly on total production flows throughput of the product. By the cause of poor work methods due to long-distance traveled, crowdedness, backtracking, increase scrap rate, a bottleneck occurs. So, it is forced the company for low productivity and workers fatigues & stress occurred.

Table 5. 9 Analysis of the existing production space measurement (distance) data using SPC

No	**Each operation activities**	>= UCL (10.87)	CL= 6.27	<= LCL (1.68)	Avg. Value
1.	Transport to spreading operation	√			13
2.	Waiting for spreading operation			√	1
3.	Spreading operation	√			18
4.	Cutting operation		√		2.60
5.	Waiting for the sewing operation			√	1.3
6.	Transport to sewing operations	√			25.7
7.	Label attach		√		2.25
8.	Preparation		√		2.25
9.	Side seam		√		2.25
10.	Box making			√	1.5
11.	Preparation and measurement		√		2.75
12.	Buttonhole			√	1.25
13.	Button attach		√		2.25
14.	Manual work		√		3
15.	Total inspection		√		2.5
16.	Waiting to leveling & packaging		√		2.6
17.	Transport to leveling & packaging	√			18
18.	Leveling and preparing		√		6
19.	Transport to package on bell press	√			13
20.	Bonding and packaging		√		2.4
21.	Transport to store		√		8.2
	Total	5	12	4	

This Table shows that 12 activities are in control and 9 activities are out of control which means 5 activities travel a long distance which compares with 12 activities and 4 activities are under low control limits. So, the next step is to calculate the upper control limit, control limit, and lower control limits to know how the process or activities are controlled (solved) or not.

Generally, the out of control activities require another iteration to be in control which means, if the out of control is changed in to control limit then all activities are traveled in the smooth way or effective distance traveled, therefore the working method of garment production become stable.

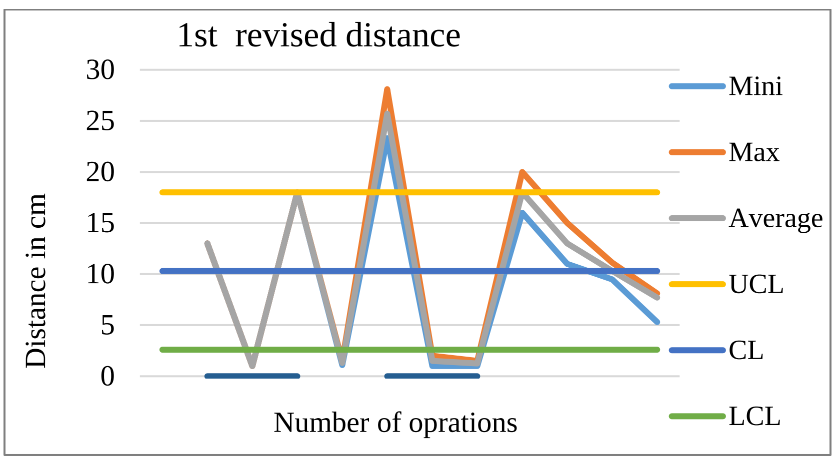
Hence, to calculate the control chart parameter to show the critical problem or the longest distance on the production process can be eliminated or reduced.

Table 5. 10 Revised distance statistical process control chart data

Variation	Min	Max	Average
$\bar{X}$	9.4	11.1	10.3
σ	8.7	10	9.3
r	5.3	8.1	7.7
LCL	2.6		
CL	103		
UCL	18		

A detailed analysis of each operation activities used to know identifying the value-added and non-value-added activities of the case garments. Thus, the value-adding ratio can be calculated as Value-adding ratio = $\frac{\text{Non}-\text{Value adding activities}}{\text{Value}-\text{adding activities}}$ and

Non- Value-adding activities $=$ Lead time $-$ Value adding activities



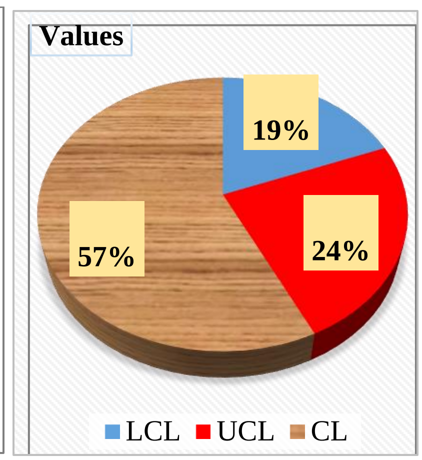


Figure 5. 9 The analysis of existing revised distance for value & non-value-add activities chart

But, still, now some activities (about 43%) are out of control which means there is the unnecessary distance traveled in each production process. So, to eliminate non-value adding activities by considering different requirements like space, machines, the number of operators' availability, etc.

Table 5. 11 The analysis of existing third revised activity distance control chart

No	Activities	UCL	CL	LCL	Value
1.	Transport from inspection to next process		*		13
2.	Waiting for Spreading operation			*	1
3.	Spreading operation		*		18
4.	Waiting for the sewing operation			*	1.3
5.	` Transport from inspection to sewing operations	*			25.7
6.	Box making			*	1.5
7.	Buttonhole			*	1.25
8.	Transport to leveling and packaging		*		18
9.	Transport to package bell press m/c		*		13

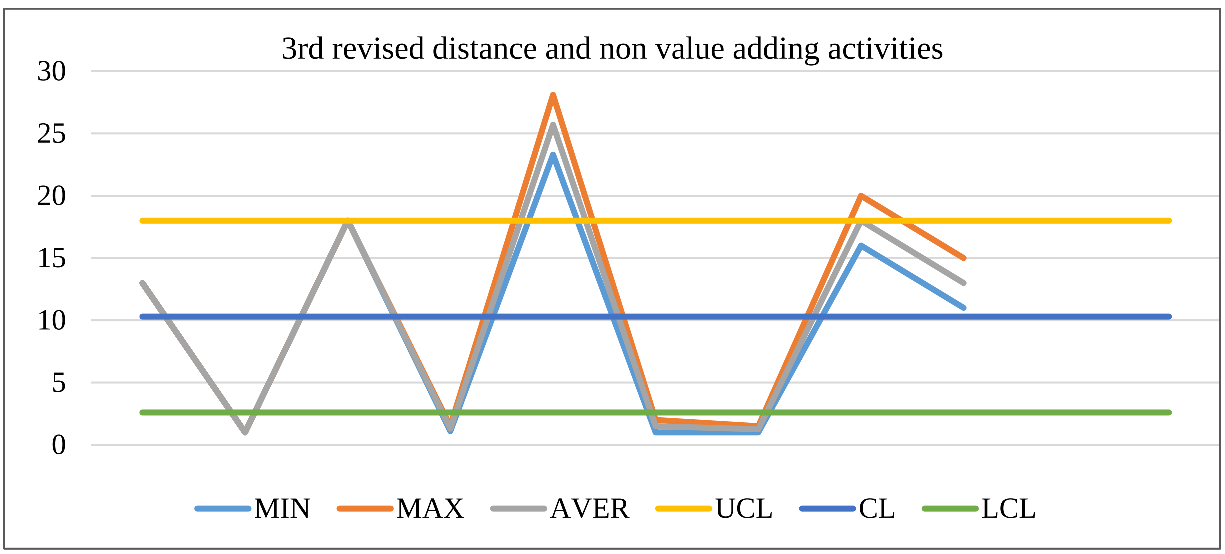


Figure 5. 10 The analysis of the third revised activity distance iteration chart

This Figure shows that still, some activities are out of control (it is not smooth), but most of this each operation activities have been under the control limit (which are value-adding activities). So, after the fifth iteration, each production process becomes under control limit, which means that each production line has smooth flows and each activity is value-adding for the case garment production effectively.

5.2.7. Defects analysis for the case garment's raw material inputs (fabrics)

Improving quality has an energetic role in improving the productivity of the garment industries and the case company. So, it needs a detailed investigating on quality improvement for the case garments by using Pareto analysis and cause and effect diagram. Based on direct observation and eight-month recorded data of the company indicates that there are high defects, rework and scraps rates of the garment input materials (fabrics) than the garment operation defects (that comes by operators error, machine problems, and others), which means the most critical garment quality defects comes from the garment input materials or fabrics. Some of the case company garment raw inputs defective items are clearly shown in the following Figure.

Figure 5. 11 Defective items of the case garment raw input (fabrics) materials

Thus, these input defects are the main cause of the final garment product defects. As a result, assessing the main causes and their effect on the productivity of the garment industry is mandatory. Because the quality defects and reworks are making a negative effect on the actual production. In previous studies, many researchers are focused on exploring the final garment production defects, reworks, and scraps, but not considering the source of quality defects, which is garment input materials (fabrics). So, this discussion is more intensive on the quality defects of the case garment inputs by using Pareto analysis and cause and effect diagram. Depend on data the existing quality status of the case garment raw inputs/ fabrics are shown as in Figure (5.12) and it represents accepted, rejected, and cumulative percentage of defects.

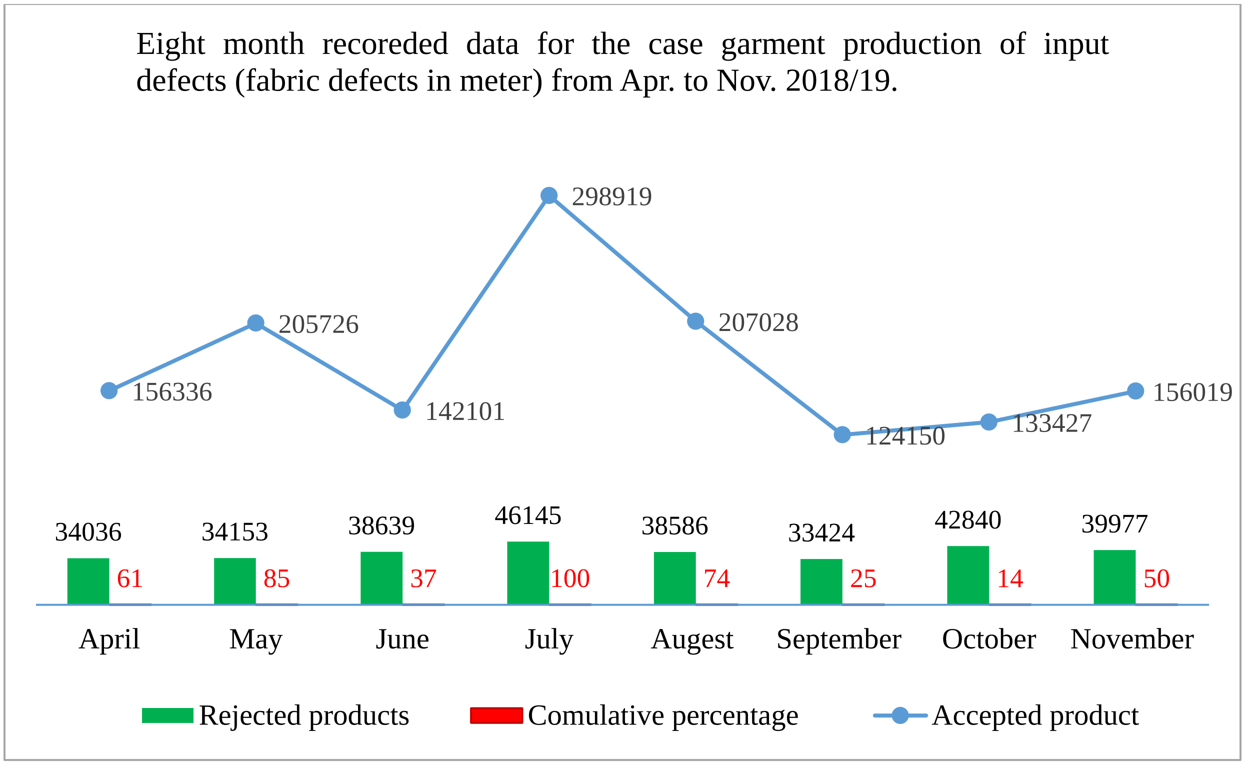


Figure 5. 12 Eight months recorded data for the case garment input defects (fabrics)

This Figure indicates that the case company inquired about high production costs due to high-quality defects at the sources of raw materials or garment inputs (fabrics) and its results are low-quality products and also reducing the productivity of the company. Hence, based on the data of defects specifies that the most common garment raw inputs defect (fabrics) types are: miss print, color contamination, short width, hole, oil, color variation, miss-end, miss pick, rust, selvage tear, spot, shade variation, screen blockage, etc. Hence, to reducing the defects of garment production outputs that must be reducing the cause of defects starting from the source of production inputs. Because, quality defects on the garment production or the final products with related to human error, machine and others problems has been deliberate by many scholars in previous studies, but didn't enhance a significant quality improvement outcomes on the garment industry. The following Figures show different types of garment input fabrics defects.

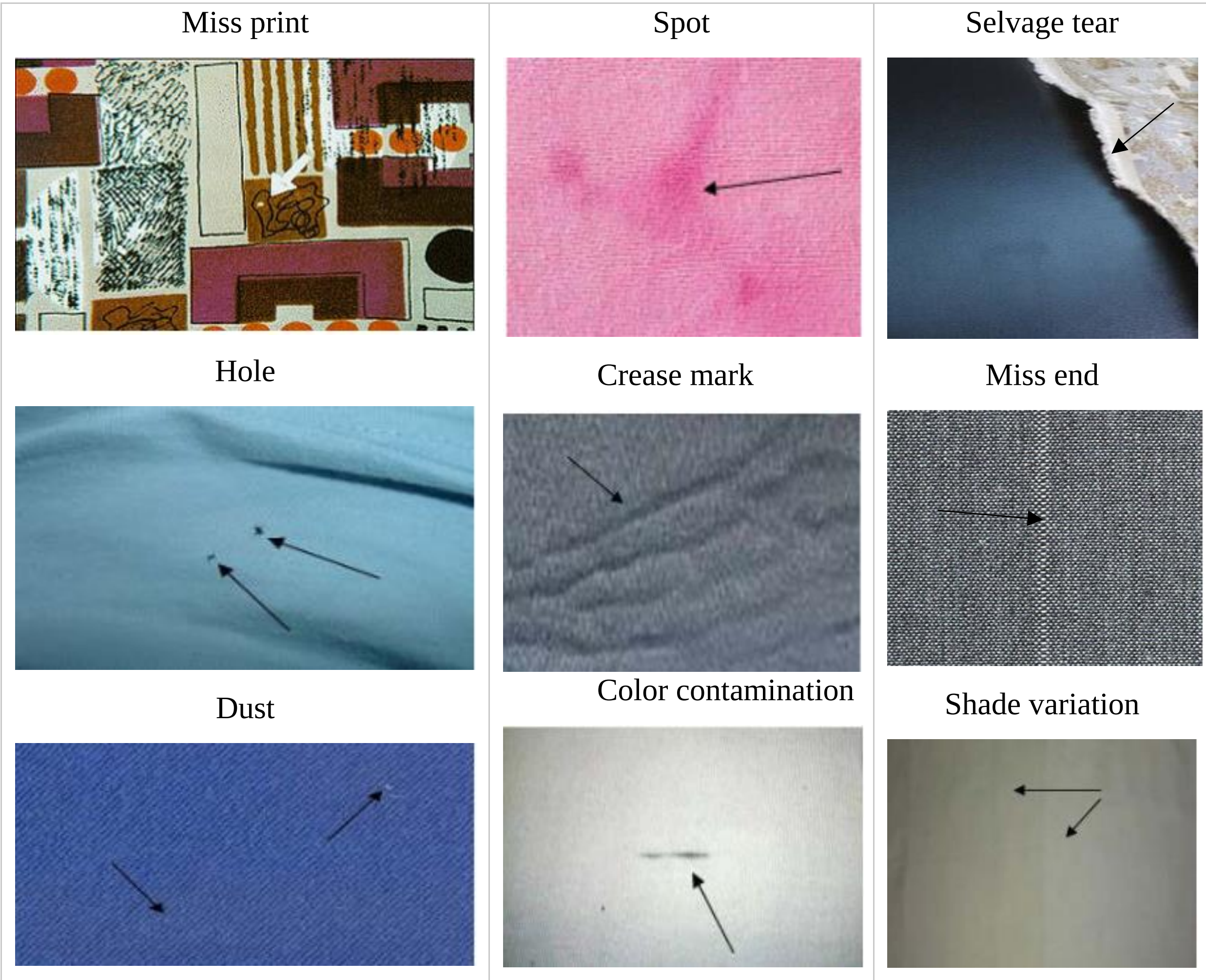


Figure 5. 13 Different types of garments raw inputs (finished fabrics) defects

☞ **Pareto Analysis and observation**

The basic concept of the Pareto tool is "20% causes or reasons are responsible for 80% defects in the company." It is also known as the 80/20 rule, which means 'few'20% causes "vital few" while the rest 'many' 80% causes are known as "trivial many." As a result, a vital few occur frequently and then trivial many occur frequently. And also it helps to easily identify the most frequently occurring defects. During this time the cooperation of management and inspection line operators helped to collect accurate data and to identify the exact defect type & its root cause of the garment fabric defects. So, the following Pareto chart indicates that the most common garment industry and the case company production raw inputs defect type analysis with their significance based on the data.

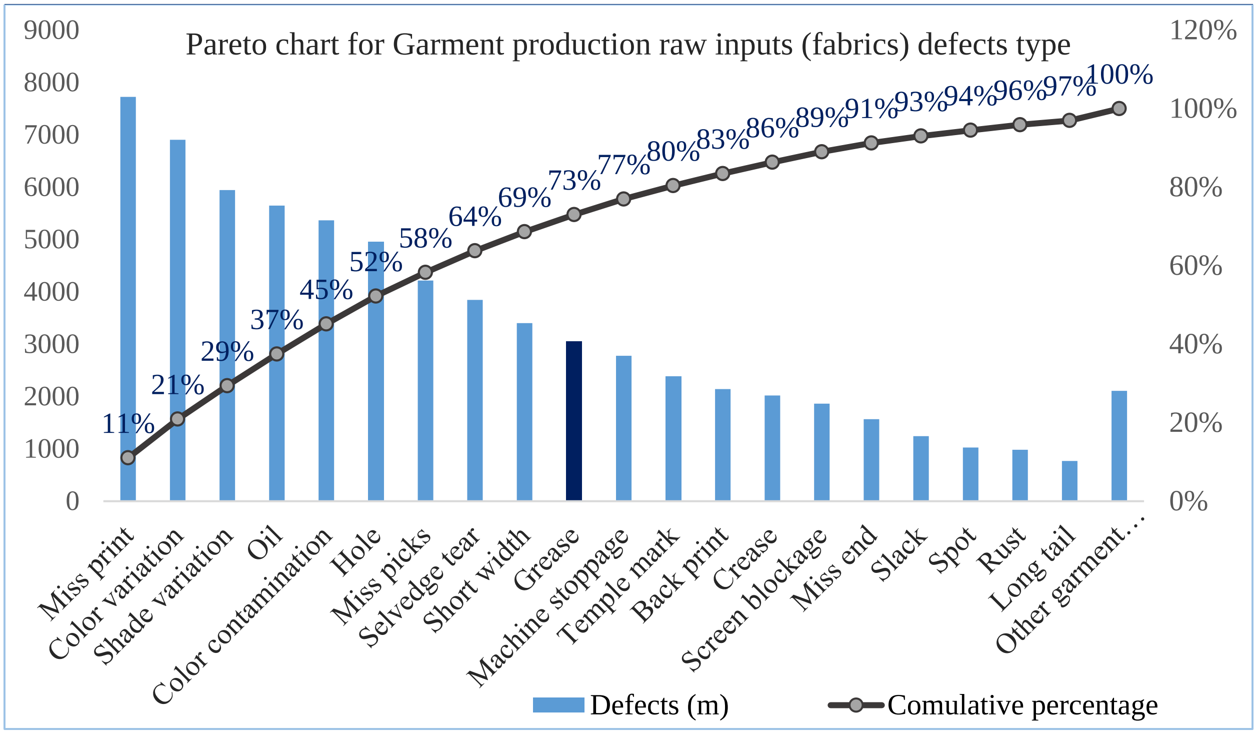


Figure 5. 14 Pareto analysis for the case garment raw inputs & output defects

❖ ***Pareto analysis observation***

a) Miss print is the most frequent garment raw inputs defect, which counted as much as 11.04% of the total inspecting of input fabrics was covered. b) Color contamination is the second most frequent defect with 9.87% of the total. And also, shade variation 8.5%, Oil 8.08%, and Color contamination 7.67%, Hole 7.08%, Miss Picks 6.03%, Selvedge tear 5.5%, Short width 4.86% and Grease 4.37%. c) The other defect positions are machine stoppage (3.97%), temple mark (3.41%), black print, and point up-down. These twelve top defect positions (from miss print up to temple mark) are the "vital few" where 80.31% of total defects happen. However, based on the data the first ten (from miss printing up to grease) defects have been happened frequently. So, investigating the root causes of these defects is important. Because these defects are the most significant quality problems for garment raw inputs (fabrics) as well as the final garment products and which counted about 73% of the total. But the remaining 11 defects count only 27% of the total. The root cause analysis for 73% of the cause of raw input defects and to explore how to reduce these critical defects is discussed in the next part.

❖ ***Cause and effect diagram analysis & suggested solution for garment fabric defects***

Cause and effect diagram is very useful tools and that used to sort, display the specific defect problems or quality characteristic. 'Cause', which eventually leads to creating an adverse 'effect'. The effect is the quality problem. Hence, to searching the root cause of garment inputs or fabrics defect in the case garment by collected appropriate defects data for eight consecutive months. And these causes could be interconnected with the machines, humans, measurement, process, method, materials, and environment. Figure (5.15) represents the cause-effect diagram of the major defects including Miss print, Color variation, Shade variation, Oil, Color contamination, Hole, Miss picks, Selvedge tear, Short width Grease and point up down respectively.

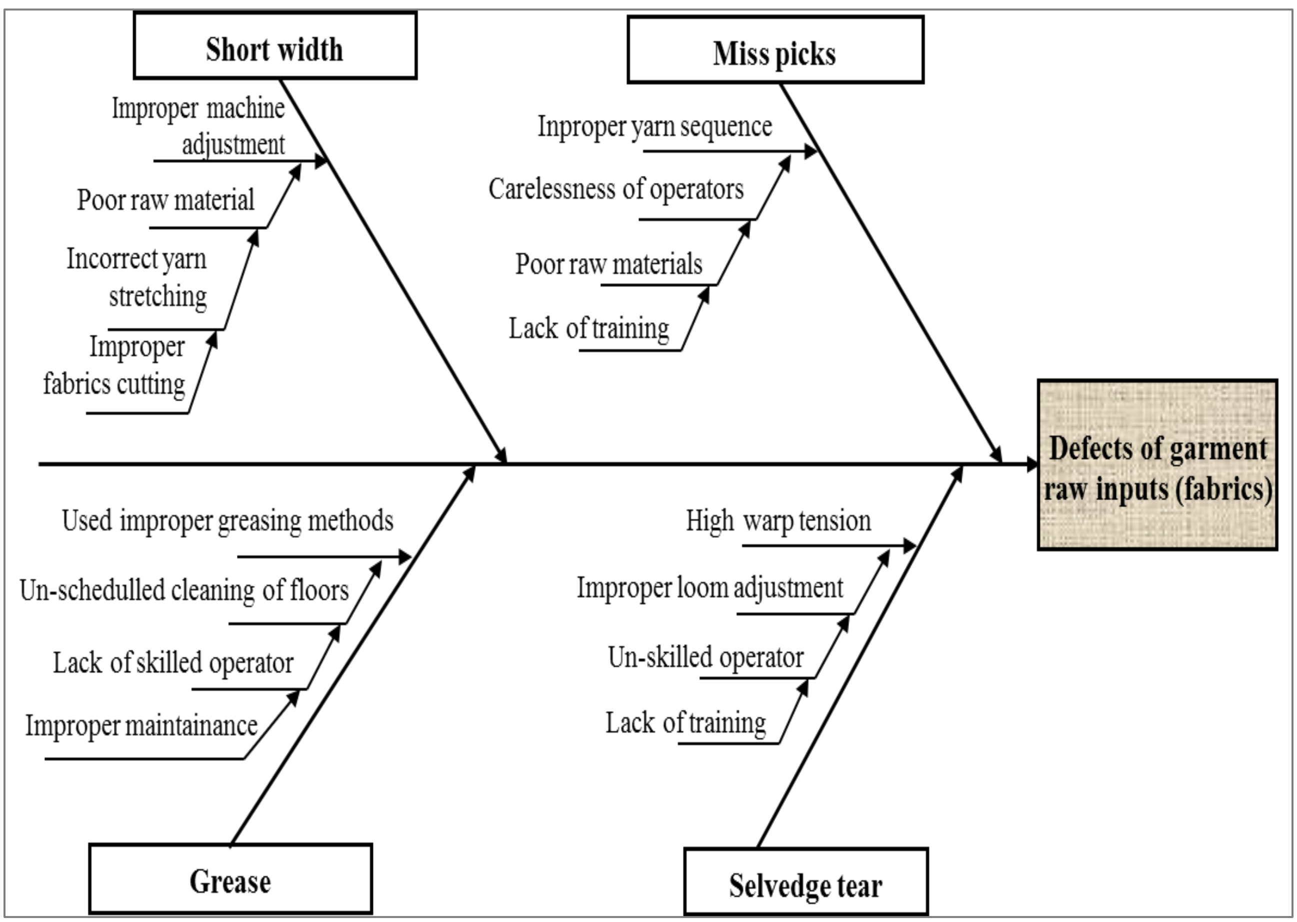


Figure 5. 15 The cause and effect diagram for minor garment raw input defects

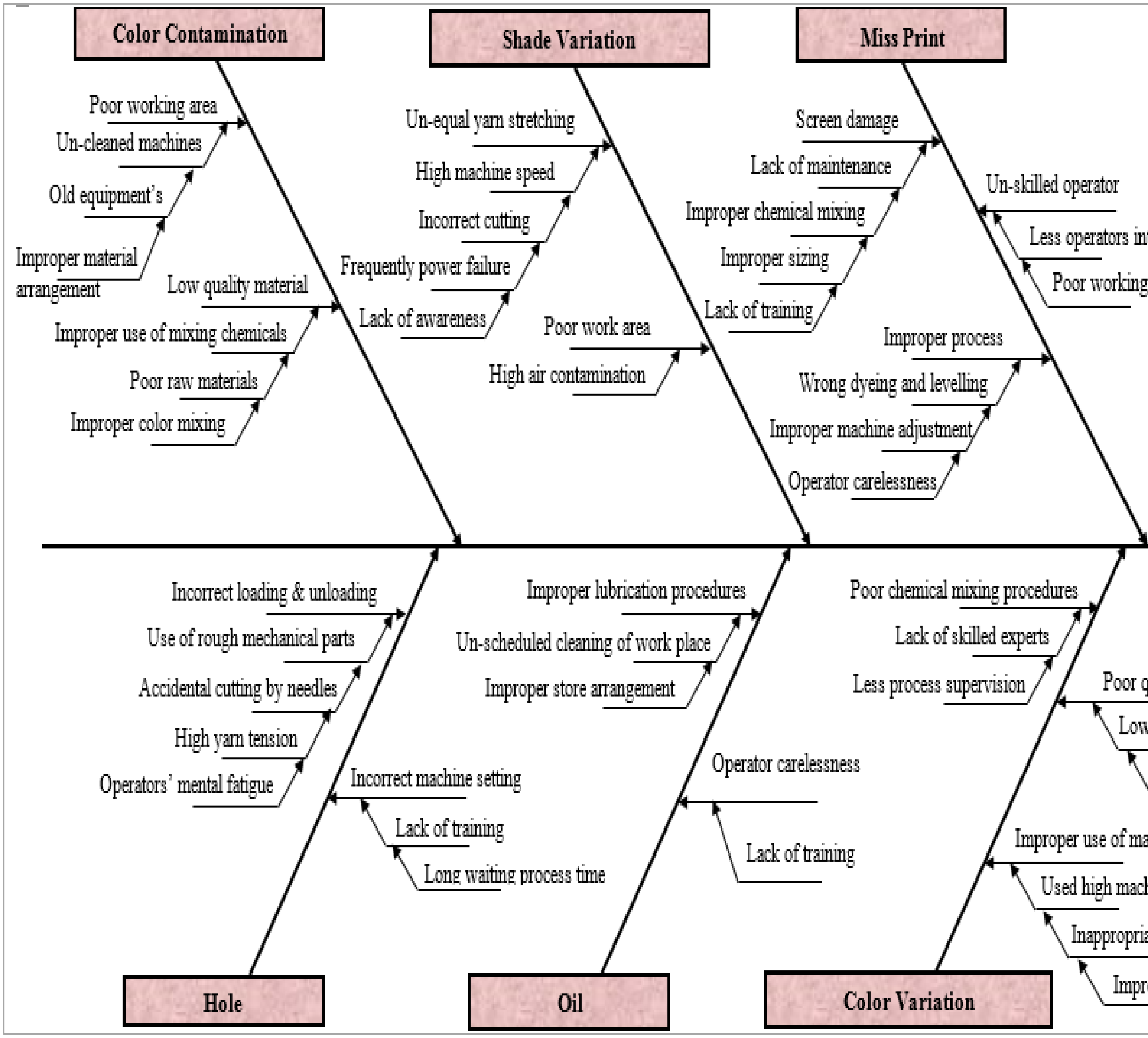


Figure 5. 16 Cause and effect diagram for the major garment raw material (fabrics) defects

Table 5. 12 The main fabric defects type with their suggested solution of the case company

S/ No	Defects	Main Causes	Suggested solutions
1.	Miss print	• Screen damage • Unskilled operator • Improper sizing of fabrics • Improper pre-adjustment of rollers during the printing • Chemical mixing problem • Wrong dyeing, recipe, and incorrect leveling of dye lots & scouring fabrics	– Repair and clean the screen regularly – Create awareness for employees – Properly adjusted the rollers before feeding the fabrics for printing – Mixing chemicals using standard procedure & assigning chemist experts. – Using uniform dyeing, leveling, and scouring process.
2.	Color variation	• Wrong chemical mixing ratio due to lack of experts • Improper use of steam, temperature, pressure, and water during the process • Using low-quality raw materials and chemicals	– Hiring the chemists or training the existing operators once a week. – Before producing the specified sample first it must be adjusted all production processes i.e. Temp, pressure, steam, water, equipment, and check the ratio of chemicals mixing and the quality of raw inputs
3.	Shade variation	• Unequal fabrics stretching during sizing • Improper fabrics cutting, numbering, and bundling • Improper adjustment of machine time & speed • Old M/C & equipment's • Frequently power failure • Chemical mixing problem • Waiting for printed fabrics on a roller for a long time.	– The fabrics must be equally stretching before starting the process. – Using the same base of materials & to set parameters for each production item. – To use the machines with their operating time and speed by maintaining regularly. – To provide a maintenance program for machines or equipment each week. – Properly controlling the process and using an automated generator for finishing process during high garment production

		• Operators carelessness & working environment air contamination	– Using appropriate mixing proportion of chemicals and rolling the fabrics after checking its requirements. – Provide adequate training for operators and clean working methods.
4.	Oil	• Operator carelessness • Cleaning problems of machines, equipment's and floor of fabric stores • Improper process flows • Poor lubrication system	– Improve supervisor. – Before starting the process, the work must be kept neat and clean. And it is better for implemented 5S tools. – Separate the store of oil and fabrics. – Follow the right oil usage procedures.
5.	Color contamination	• Presence of dead fibers & other foreign materials when fiber mixing. • Un-cleaned machines and low quality of yarn. • Improper color mixing and old screen equipment.	– Use rich fiber mixing for the yarns. – Before starting the printing process that should be clean & maintain screen. – Providing adequate training for inspecting operators for raw inputs. – Using an appropriate chemical mixing ratio based on the design samples.
6.	Hole	• Poor loading - unloading fabrics in each process. • Very stiff, low strength, and dry yarn. • The long run of fabrics & use more chemicals in the dying • Taking a long time in the wet stage for fabrics to be dried in finishing • Use of rough mechanical parts of the looms.	– Fabrics should be transported carefully by using smooth & safe equipment. – The yarn must be flexible, sufficient strength to withstand the stretching. – Properly adjusting the dyeing machine and use appropriate chemicals. – Adjusting the working hours of dyeing machines as its standard procedures. – Using smooth mechanical parts of looms and improving or changing fabrics handling equipment.

		• Used old transportation equipment. • High yarn tension during knitting. • Accidental cut or tear to the fabrics by needles. • Inadequate M/C setting in finishing	– The RPM of the knitting machine & fabrics take–up tension should be adjusted properly. – Fabrics feeder and needles should be set correctly in position. – Provide adequate operator training once a week and properly adjusting the machines as well as improving the inspection capacity of fabrics.
7.	Miss picks	• Missing or out of yarn sequence. • Operator carelessness • Poor raw material quality • Used old machines	– Adjusting the machine before feeding the yarns in the weaving process. – Improve the supervision – Use good quality yarns – Maintain the machine once a week
8.	Selvage tear	• Incorrect adjustment of looms during weaving. • Incorrect fabrics edge construction. • Under high tension of warp yarn. • Operators inefficiency • Old machines and their incorrect adjustment.	– Correct adjusting the loom and properly constructing the edges of the fabrics in the weaving process. – The tension of the warp is properly adjusted. – Provide adequate training to the operators. – Maintain the machine regularly and adjusting the machine threads.
9.	Short width	• Shrinkage of wet in yarn processing. • Improper stretching the fabrics • Improper sizing of the fabrics	– Using appropriate raw materials – Properly adjusting machines sizes – Properly dried the fabrics during the sizing process – Using appropriate materials

		• Improper machines size adjustment	
10.	Grease	• Incorrect M/C adjustment • Incorrect greasing system • Un-skilled operator • Old machine &equipment • Poor cleaning methods	– Properly adjusted the knitting machine – Using standard greasing procedures – Provide adequate training to the operators on how to use greasing for the M/Cs. – Maintain machines twice a day and neat & clean the workplace properly.
11.	Machine stoppage	• Frequently power failure • Operators error • Unscheduled maintenance	– Using standby generators in the finishing process. – Train the operators once a week – continuously controlling the process
12.	Temple mark	• Poor quality raw material • Incorrect design • Inappropriate process	– Using sufficient strength fabrics – The design should be fit with the samples & follow standard procedures

In summary, minimization of defects is important for the garment industry specifically in the case company, and which has been guaranteed for the final quality products of garments. Based on the observation and recording data the most quality defects of the final garment products are the sources of garment raw inputs, which is fabrics. So, this discussion mainly focused on different quality defects of raw fabrics of the case company by investigating major and minor defects using the nature of occurrence during inspecting the fabrics. And these defects have been tried to identify and positioned using Pareto analysis and also tried to examine the causes of these defects by constructing a cause and effect diagram (using Qi macro software-2020). Finally to provide some suggestion solutions by indicating the critical sources of defects and how to solve these causes effectively. Therefore, to improve the quality of the final products and improving the productivity of the case garments that must be reducing the defects of fabrics at the sources. So, the management gives more attention for implement these suggested solutions to minimize the occurrence of these defects and for improving the productivity of the garment production process.

5.2.8. *The existing production time analysis*

The main workflow of the case Garment production operation is shown as:

Inspection → **Cutting** → **Sewing** → **Labeling** → **Packaging** → **Belling** → **Store**

The Sewing operation detail activities for the Quilt cover product:

- ✓ Label attach
- ✓ Preparation
- ✓ Side seam
- ✓ Box-Making
- ✓ Preparation & Measurement
- ✓ Buttonhole
- ✓ Button Attach & Manual work

Sewing operation detail activities for Flat sheet product:

- Label attach
- Hemming (2 cm)
- Preparation and measuring
- Manual work

General Consideration for production time analysis is shown in the following Figure:

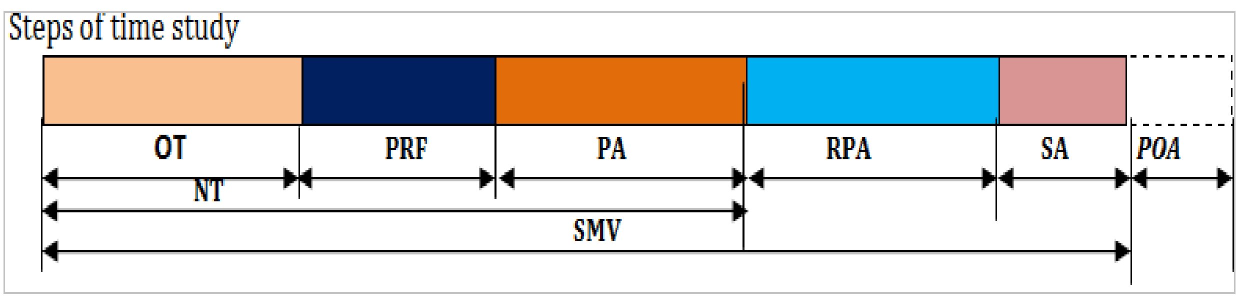


Figure 5. 17 The main steps of time study, its allowances, and rating factor

The above Abbreviations are expressed as:

- OT: Observed time; SA: Special allowance
- PRF: Performance rating factor; PA: Process allowance
- RPA: Rest & Personal allowance
- POA: Policy allowance
- SMV: Standard minute value = Standard Time
- NT: Normal time

Case 1: Observed time for Quilt cover production

Table 5. 13 Observed time analysis for Quilt cover (140 x 220 cm size) product

No	Operator	Operation	M/C Type	Operation Time (Seconds)										Total	AVG (Sec)	SMV (Sec)
				1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th			
1.	A	Label Attach		38	43	35	36	41	39	40	43	42	40	397	39.7	47.6
	B		S/N	31	32	34	36	35	37	30	32	34	32	333	33.3	40.0
2.	A	Preparation		22	18	20	17	22	19	21	18	17	19	193	19.3	23.2
	B			23	17	19	16	20	22	18	17	21	18	191	19.1	22.9
	C			17	15	19	14	16	18	17	16	20	19	171	17.1	20.5
	D			18	16	19	14	15	19	18	16	21	16	172	17.2	20.6
3.	A	Side Seam	M/c	49	46	48	50	48	49	54	52	50	49	495	49.5	59.4
	B			45	49	42	46	47	46	42	50	44	45	456	45.6	54.7
	C			47	49	46	51	50	44	42	49	46	47	471	47.1	56.5
	D			54	51	53	50	54	52	51	50	58	55	528	52.8	63.4
4.	A	Box Making		31	33	34	34	35	32	39	37	36	32	343	34.3	41.2
	B		S/N	37	34	31	35	32	33	36	33	35	34	340	34	40.8
	C			35	30	34	34	41	36	36	36	34	38	357	35.7	42.8
5.	A	Preparation & Measuring		18	15	17	16	14	13	14	12	18	15	152	15.2	18.2
	B		Meter	17	16	17	16	15	13	14	15	17	18	158	15.8	19.0
	C			14	10	11	12	12	15	14	13	12	10	123	12.3	14.8
	D			12	11	12	14	10	13	15	13	11	12	123	12.3	14.8
6.	A	Marking	Meter	21	18	19	20	21	19	18	17	22	20	195	19.5	23.4
	B			21	18	20	19	17	21	19	18	20	18	191	19.1	22.9
7.	A	Button Hole	B.H M/c	25	23	21	22	24	22	23	26	23	26	235	23.5	28.2
8.	A	Button Attach	B/A M/c	23	18	20	17	18	16	22	15	20	18	187	18.7	22.4
9.	A	Manual Work		18	15	14	16	16	17	17	19	17	19	168	16.8	20.2
	B			19	16	14	15	17	18	19	17	20	17	172	17.2	20.6
	C			16	14	15	13	17	16	15	17	14	16	153	15.3	18.4
	D			17	16	14	15	16	14	17	14	15	17	155	15.5	18.6

General formula to calculate time study for Quilt cover operation:

Total observation time = $\sum_{i=1}^{10} t1 + t2 + t3 \ldots \ldots .. + t10$, t1, t2…..each observed time.

For label attach operation for one operator total observed time can be calculated as $= \sum_{i=1}^{10} 39 + 42 + 36 \ldots \ldots .. + 41 = 397$ sec by using this formula to calculate other total observed times.

Average Time (AVG) = $\sum_{i=1}^{n} / n = \sum_{i=1}^{10} t1 + t2 + t3 \ldots . + t10$/n, n = 10; AVG Time = 39.7 sec

Basic Time = Normal Time = $\frac{\text{Observed time} * \text{Performance Rating}}{Standard\ \ Rating}$

SMV = Normal Time * (1+Allowance Factor), for a specific job of the operation but for the general job of the operation calculated as SMV = Normal Time/ (1-Allowance Factor). Accordingly to use the first formula, due to specific operation.

Primary data required for time analysis are Observed time from Table (5.13): total working time per shift = 7:30 hrs. = 450 min = 27000 sec; performance rating (PR) = 100%, which is get from the case garment's written document; total production volume (Quilt cover); order per shift = 800 pieces per shift; total allowance factor (AF) = 20%, which is considering (workers skill level, existing working condition, etc.) the following allowances by reviewing different written documents & detail discussion with the company production management. Such as

- Tea and break time (5%) & Washing (3%)
- Personal allowances (fatigue, relaxation, 5%) & Drinking (2%)
- Delays (5%) and the values is 20 % of normal time.

Detail findings of quilt cover operation time analysis:

For Label Attach Operation calculated as:

Total Observed Time for first & second operator (OT1) = 397 sec and OT2 = 330 sec.

$$\text{AVG.OT} = \frac{\text{Sum of OT1+OT2} = 397+333}{2 \qquad\qquad 2} = 365 \text{ sec.}$$

Normal time for label attach = OT * PR, but PR = 100% divided by standard rate = 100, PR = 1.

NT = OT*1 = OT, So, NT1 = OT1 = 39.7 sec.

Standard time for label attach = normal time (NT) * (1+allowance factor), used for a specific job operation. Then, ST = NT * (1+AF).

ST1 = NT1 * (1+AF) = NT (OT1) * (1+0.2) = 39.7 * (1.2) = 47.64 sec.

ST2 = NT2 * (1+AF) = OT2 * (1+AF) = 33.3 * (1.2) = 40.0 sec.

AVG Standard Time = $\frac{ST1+ST2}{2}$ = 43.82 sec.

Daily output per one shift = 27000/43.82 = 616 Quilt cover / shift.

Using a similar approach for preparation operation

Total Observed Time = OT_1 & OT_2 = 192 sec and OT_3 & OT_4 = 172 sec.

Total AVG Observed Time for Preparation = 19.2+17.2/4 = 18.2 sec.

Normal Time = $\frac{\text{Observed time} * \text{Performance Rating}}{\text{Standard Rating}}$, but $\frac{\text{Performance Rating}}{\text{Standard Rating}}$ = 1

Standard Time (ST) = Normal Time * (1+Allowance Factor).

ST1&ST2 = NT1 * (1+AF) = 19.2 * (1+0.2) = 23 sec and ST3 = ST4 = 17.1 *(1+0.2) = 20.6 sec.

Total standard time = ST1+ST2+ST3+ST4 = 87.2 sec.

AVG ST = 86.8/4 = 21.7 sec.

Daily output (Quilt cover) per Shift = $\frac{\text{Total Working Time}}{\text{Standard Time}}$

Daily output = 7:30 hrs. = 27000/ 22.8 pieces = 1244.2 pieces per one shift.

For Side Seam Operation Calculated as:

OT1 = 495 sec; OT2 = 456 sec; OT3 = 471 sec; OT4 = 528 sec.

AVG Observed Time for Side Seam = 1950/4* 10 = 48.7 sec.

Normal Time = Observed Time, Due to PR =1.

Standard Time = Normal Time * (1+Allowance Factor).

Total standard time = OT1*1.2 + ST2 (OT2*1.2) + ST3 (OT3*1.2) + ST4 (OT4 * (1.2) = 234 sec.

AVG standard time = 234 sec /4 operators = 58.5 sec.

Daily output (Quilt cover) = 27000 sec / 58.5 sec/pieces = 462 pieces per shift.

For Box Making Operation calculated as:

Total AVG Observed Time for Box Making = $\frac{OT1+OT2+OT3}{3}$ = 34.7 sec.

Total AVG Normal Time = Total AVG Observed Time = 34.7 sec.

Standard Time (ST) = Normal Time * (1+Allowance Factor).

Total Standard Time = 41.2 + 40.8 + 42.8 sec = 124.8 sec.

AVG Standard Time = 124.8/ 3 operators = 41.6 sec.

Daily output (Quilt cover) = 27000 pieces/ sec /41.6 sec = 648.8 pieces per one shift.

Thus, to calculate by Similar Ways the remaining operations have the following chart Summary shown as:

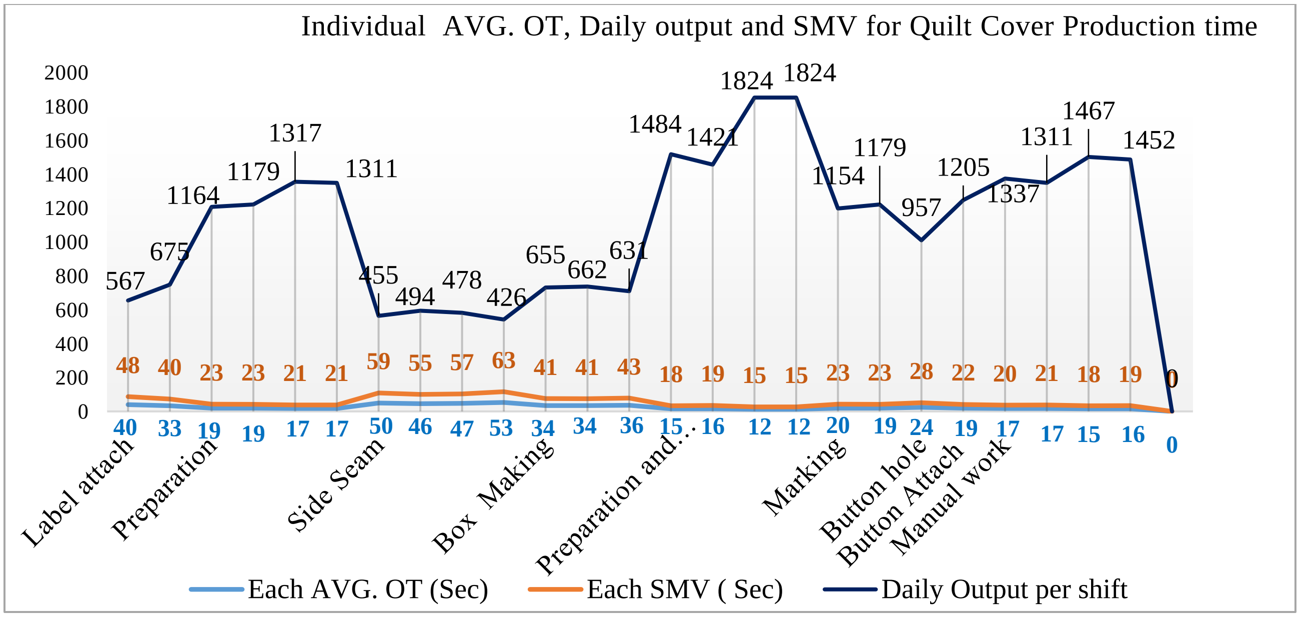


Figure 5. 18 Existing summarized time analysis chart for Quilt cover production

Target production of Quilt cover products = 800 pieces per shift.

Table 5. 14 The summary of existing OT & SMV for Quilt cover product (140 x 220 cm)

S/ No	Operation Type	M/C Type	No of M/C	No of Worker	AVG. Time (sec)	SMV (sec)	Daily Output per shift (in pieces)	Remark
1	Label Attach	S/N M/C	2	2	36.5	43.8	616.4	Approach to target
2	Preparation		-	4	18.2	21.8	1238.5	Above target
3	Side Seam	5-Trade	4	4	48.8	58.5	461.5	Below target
4	Box-Making	S/N	3	3	34.7	41.6	649.0	Below target
5	Preparation& Measurement	Meter	-	4	13.9	16.7	1616.8	Above target
6	Marking	-		2	19.3	23.2	1166.3	Above target
7	Button Hole	B/H M/C	1	1	23.5	28.2	957.4	Above target
8	Button Attach	B/A M/C	1	1	18.7	22.4	1205.4	Above target
9	Manual Work		-	4	16.2	19.5	1388.2	Above target
	Total		11	25				

This Table indicated that the production process of the case garment (Quilt cover production which is the major export) does not smoothly flow; means there is a bottleneck or is not line balanced. It summary clearly shows in the following charts (by rounding up the numbers):

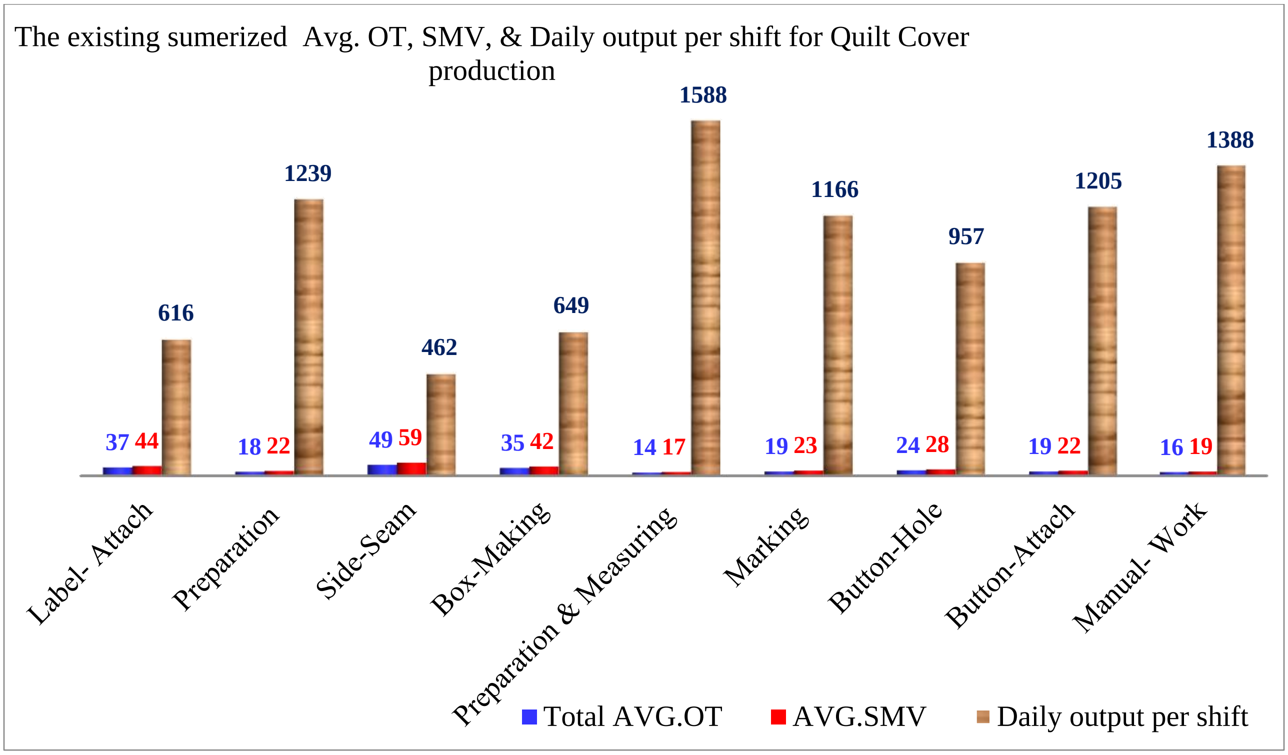


Figure 5. 19 The existing summarized time analysis chart for quilt cover production per shift

Figure (5.19) shows that the existing production process of the case garments wasn't a suitable flow for a specified production. Consequently, the chart indicates that several problems have been faced in this garment's major export products. Some of those are idleness of machines & workers, bottlenecks, low operator efficiency, long lead time, high production cost (paying a monthly wage for idle workers& depreciation cost of idle machines), etc., as a result, those problems leads the company low productivity.

Case -2: Flat sheet production recorded data for time study analysis

Product: Flat sheet (150× 260 cm size):

Table 5. 15 Observed Time of Flat sheet product

S/ No	Name	Operation	M/C Type	Operation time (in the second) one side only										Total	Avg. OT	SMV
				1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th			
1.	A	Label Attach	S/N	65	64	59	56	52	57	61	63	64	60	601	60.1	72.1
	B	"		71	70	75	69	74	78	68	72	76	74	727	72.7	87.2
	C	"		69	68	74	66	79	62	73	72	77	75	715	71.5	85.8
	D	"		67	74	72	76	75	73	76	70	68	72	723	72.3	86.8
2.	A	Hemming	5-Trade	60	67	72	63	56	57	61	55	54	66	611	61.1	73.3
	B	"		64	58	71	75	74	67	70	69	74	70	692	69.2	83.0
	C	"		64	70	73	75	72	61	64	62	60	64	665	66.5	79.8
	D	"		74	71	73	75	62	70	63	64	60	67	679	67.9	81.5
3.	A	Preparation	Meter	15	11	13	15	12	17	21	16	15	17	152	15.2	18.2
	B	"		15	14	13	11	13	16	15	14	13	17	141	14.1	16.9
	C	"		13	16	15	14	16	19	18	17	15	20	163	16.3	19.6
	D	"		19	14	16	15	13	15	16	17	15	19	159	15.9	19.1
4.	A-D	Measurement	Meter	16	13	16	15	14	20	17	14	12	16	153	15.3	18.4
				12	11	13	14	13	15	12	10	11	16	127	12.7	15.2
5.	A	Manual Work		19	15	16	13	17	21	15	12	16	17	161	16.1	19.3
	B			16	15	14	16	17	13	14	16	19	18	158	15.8	19.0
	C			17	16	18	13	19	14	16	15	21	14	163	16.3	19.6
	D			14	17	20	21	19	16	15	19	15	16	172	17.2	20.6
Total															696.2	835.4

General formula to calculate time study for flat sheet operations:

Total time observation = $\sum_{i=1}^{10} t1 + t2 + t3 \ldots\ldots + t10$, t1, t2…..each observed time.

Average Time (AVG) = $\sum_{i=1}^{n} / n$ = $\sum_{i=1}^{10} t1 + t2 + t3 \ldots + t10$/ n, n = 10

Basic Time = Normal Time = $\frac{\text{Observed time} * \text{Performance Rating}}{\text{Standard Rating}}$

SMV = Normal Time * (1+ Allowance factor), for a specific job of the operation but for the general job of the operation calculated as SMV = Normal Time/ (1-Allowance Factor). So, it should be used in the first formula, due to a specific operation.

The data used for flat sheet time analysis

Observed Time (OT) from recorded data; Total working time per shift = 7:30 hrs. = 27,000 Sec.

Performance rating (PR) = 100%, this data have got from the case garment written documents.

Total product (Flat sheet) order per shift/target = 750 pieces per shift and total allowance factor have been taken 20% by considering different scenarios in the first case discussion.

The required of this time analysis of flat sheet operations is to solve the following activities:

- Total observed time and average observed time for each operation.
- Total normal and standard time for each operation.
- Each worker's daily production output per shift and the number of new workers required.

Then, each operation time analysis was used to identify the existing problems of flat sheet (major export products) production of the case garment.

Calculations for label attach operation for the flat sheet production:

Total time observation = $\sum_{i=1}^{10} t1 + t2 + t3 \ldots. + t10$, t1, t2…..each observed time and average observed time (Avg. OT) = $\sum_{i=1}^{n} / n$ = $\sum_{i=1}^{10} t1 + t2 + t3 \ldots. + t10$/ n, n = 10

The total average observed time for label attach operators is 69.15 sec.

Basic time = Normal time = $\frac{\text{Observed time} * \text{Performance Rating}}{\text{Standard Rating}}$, PR = 1

NT1 = OT1* PR = OT1 = 60.1; NT2 = OT2 * PR = 72.7; NT3 = 71.5 sec and NT4 = 72.3 sec.

SMV = Normal time * (1+ allowance factor), for a specific job of the operation but for the general job of the operation calculated as SMV = Normal time * (1+allowance factor)

Total ST = $\sum ST, 1 + 2 + \ldots 4$ = 331.92/ 4 sec = 82.98 sec.

Daily output for each operator = $\frac{\text{Total Working time}}{\text{Each Standard Time}}$ = $\frac{\text{7:30 Hrs. = 27000 Sec.}}{\text{Standard Time}}$ = 27000/ 82.98 = 325.38 pieces per shift.

Follow similar procedures for calculating hemming operation of the flat sheet production.

ST1 = NT1 * (1.2) = 61.1 *1.2 = 73.3; ST2 = 83; ST3 = 79.8 and ST4 = 67.9 * 1.2 = 81.5 sec.

Total ST = ST1+ST2+ST3+ST4 =317.6/4 = 79.4 sec (Avg. OT).

Daily output of hemming operation per shift = 27000 sec per shift/79.4 = 340.1 Pcs.

No of workers = 4

Calculation for manual work of flat sheet operation time

Normal Time = Observed time * PR (=1) and Avg. total observed time = 16.35 sec.

ST = Normal time * (1+ allowance factor)

Total ST = $\sum_{i=1}^{4} ST$ = 78.48 sec. and Avg. ST = 78.48/4 = 19.62 sec.

Daily output per shift = 27000 sec/ 19.62 = 1376.15 pieces per shift.

In general, the following figure shows the detailed time analysis of each flat sheet operation as:

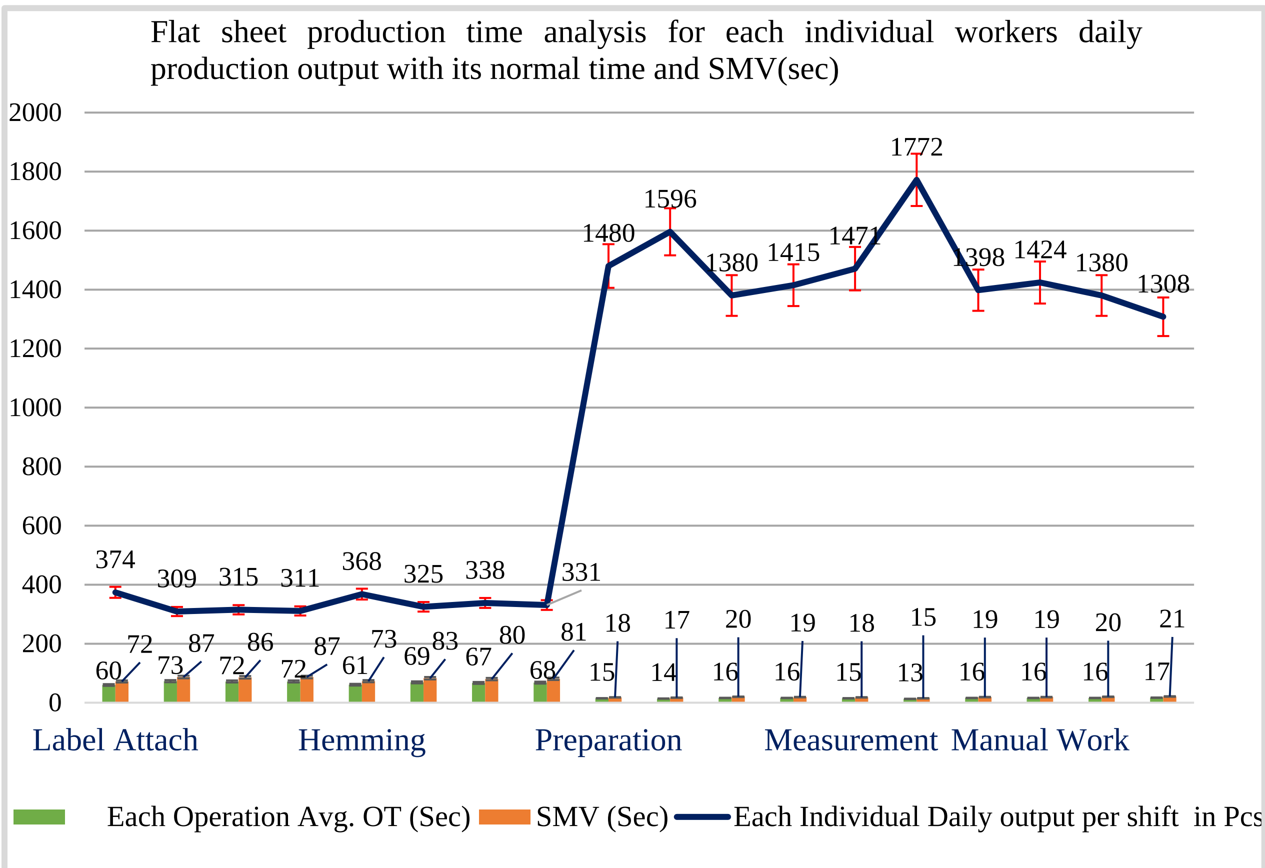


Figure 5. 20 It shows that the existing time analysis of Flat sheet product

This Figure indicates that the existing production process of flat sheet products is not smooth flow between each operation activity, due to the workload distribution of the workers are not balanced. This leads to the idleness of workers & machines, low daily production output, low production efficiency, long lead time, poor production control and management, incur high production cost, and dissatisfaction of customers and workers (because of long operational time). The following table shows the existing summarized Flat sheet production process time analysis.

Table 5. 16 Existing summarized Flat sheet operation time data analysis

S/ No	Operation Type	M/C Type	Number of M/C	Number of Worker	Avg. OT (sec)	SMV (sec)	Daily Output per shift (in pieces)	Remark
1.	Label Attach	S/N M/C	4	4	69.15	82.98	325.38	Below Target
2.	Hemming	5-Trade	4	4	66.18	79.41	340.01	Below Target
3.	Preparation			4	15.38	18.45	1463.41	Above Target
4.	Measurement	Meter		4	14.00	16.80	1607.14	Above Target
5.	Manual Work			4	16.35	19.62	1376.15	Above Target
Total			8	16	181.06	217.3		

The problems of this production process are clearly shown by using the following charts:

Flat sheet production order per shift = 750 pieces per one shift.

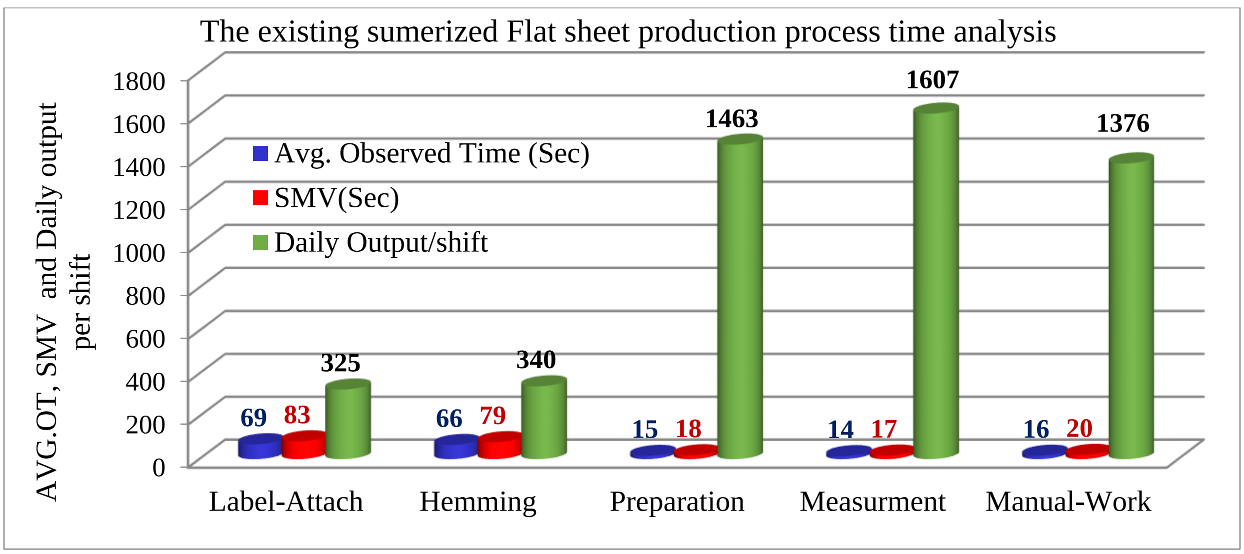


Figure 5. 21 The existing Avg. OT, SMV, and daily output/ shift chart for flat sheet product

The above chart shows that the existing production process of the case garments flat sheet operation is not line balanced. So, this chart indicates that there is a big gap between the production targets and the existing production outputs per shift. Thus, this garment has been faced many challenges for flat sheet (one of the main export products) operations. These are idleness of machines & workers, bottlenecks, low operator performance, long lead times, etc. which leads the company to low productivity and decreasing export values.

5.3. Proposed Solution for the case Garment's Productivity Improvement

5.3.1. A proposed solution for working method, flow, and waste analysis

By analyzing the existing production process in detail for each operation activities with related to the overall working method, movements/ motions of operators & transportation, and each operation time were considering under these improvements. Because, solving the problems or the production waste related to working method, motion, movement and time are the primary aims of both the lean and work-study techniques. Hence, to develop the most practical, economic, and effective method for this garment company is mandatory to improve their export production volume. Therefore to develop a new & better working method can be achieved by eliminating these production wastes, related to method, movements/ motion, and each operation time, because non-value adding activities are not add any value for the final products and their customers' requirements. This new or proposed working method, motion, movement & operation time is developed using the principles of 5S, standardized work (SDW), SMED (combine operations), and method study. Because, it is improved by a combination of eliminating non-value adding activities, combine some parts, changing the sequences of the existing production process, and simplifying the content of indirect activities. The existing data (collected by observation, measuring, and recording) analysis indicates that the production sequences, the movement, each operation time, and methods have been arranged improper ways specifically the spreading machine wasn't arranged properly, this leads to creates, backtracking, bottlenecks, long lead time, workers work fatigue or dissatisfaction (due to the complexity of production process), low production output. In general, by considering different improvement alternatives for select the best working methods, motions, and material & workers movements with less lead time for each production operation. This proposed garment production working method, production process, movements, and motions from inspection (starting) to store (end of the production) are shown in Figure (5.22).

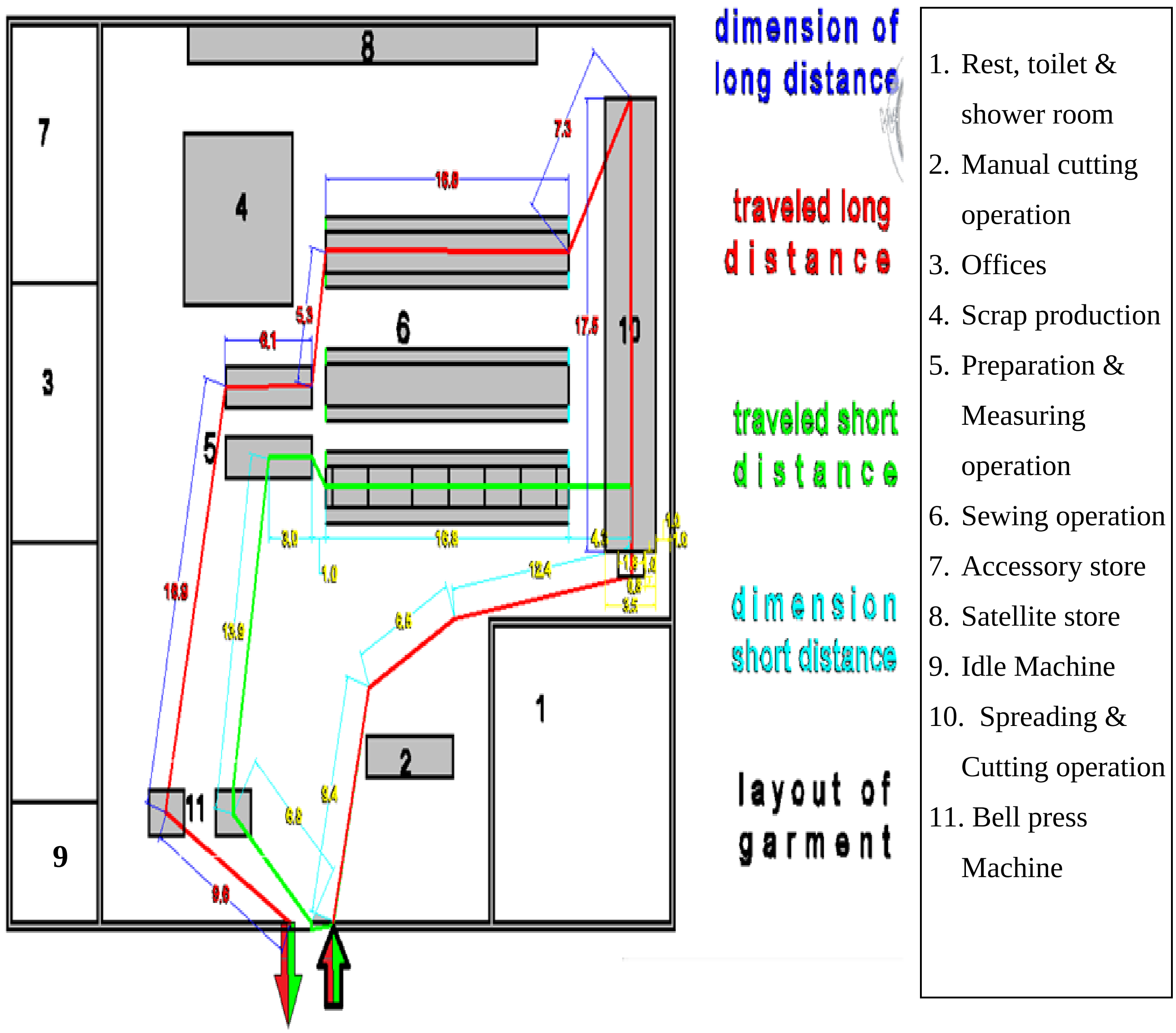


Figure 5. 22 The proposed production process (working method) of the case garments

Table 5. 17 The proposed material type flow process chart of the case garment

Flow process chart	**Material type flow chart**				
Chart number Sheet number	Summary				
Subject charted Used for quilt cover (140 * 220 cm size)	Activity		Present	Proposed	Saving
	Operation	○	12	12	
Activities Sewing, cutting, label attach, packaging to store Production process: proposed	Transport	⇨	5	4	1
	Delay	D	3	1	2
	Inspection	□	2	2	
	Storage	▽	1	1	
Size or distance of garment production	Distance (m)		131.8	99.3	32.5
Operation Time	Time (min)		150.54	102.54	39
Approve by date	Cost				
	Labor				
Charted by date	Material				
	Total				

Description	Distance (m)			Time (min)	Symbol					Remark
	Mini	Max	Avg.		○	⇨	D	□	▽	
Inspection								●		
Transport to cutting operation	28.3	28.3	28.3	11		●				LD
Waiting for Spreading operation	1	1	1	3			●			
Spreading operation	3	18	10.5	44	●					
Cutting operation	2.60	2.60	2.60	20	●					
Transport to Sewing operation	4.3	7.3	5.8	3		●				Reduced
Label Attach	2	2.5	2.25	1.14	●					
Preparation	2.25	2.25	2.25	1.30	●					
Side Seam	2.25	2.25	2.25	1.20	●					
Box making	1	2	1.5	1.30	●					
Preparation and measurement	2.25	3.25	2.75	1.05	●					
Button Hole	1	1.5	1.25	1.40	●					
Button Attach	2.25	2.25	2.25	2	●					
Manual Work	3	3	3	1.15	●					
Leveling and Preparation	6	6	6	5	●					
Overall Inspection	2	3	2.5	5				●		
Transport to bounding on bell press	13	16	14.5	2		●				
Bonding and Packaging	2.4	2.4	2.4	5	●					
Transport to Store	6.8	9.6	8.2	2		●				
Inspection on Store									●	
Total	85	113	99	114	12	4	1	2	1	

Table (5.17) shows that after eliminating non-value adding activities and improper arrangement of the garment production process becomes well organized and most of the unnecessary movement, the motion that has to travel a long distance can be minimized. But, only one production line (from the entrance of the production to the new spreading cutting operation) distance & activities have not been eliminated, while it was reduced. And also each operation time can be reduced efficiently. The proposed production line distance and the value of non-value adding activities have been reduced & eliminated effectively.

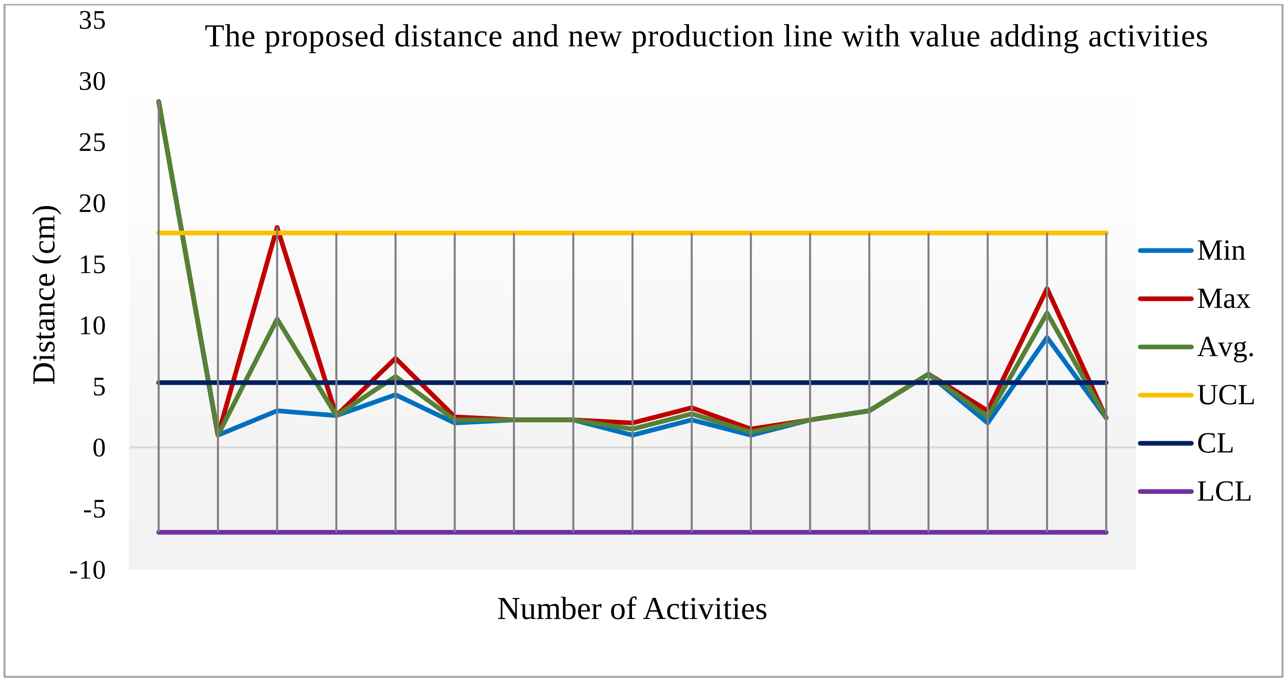
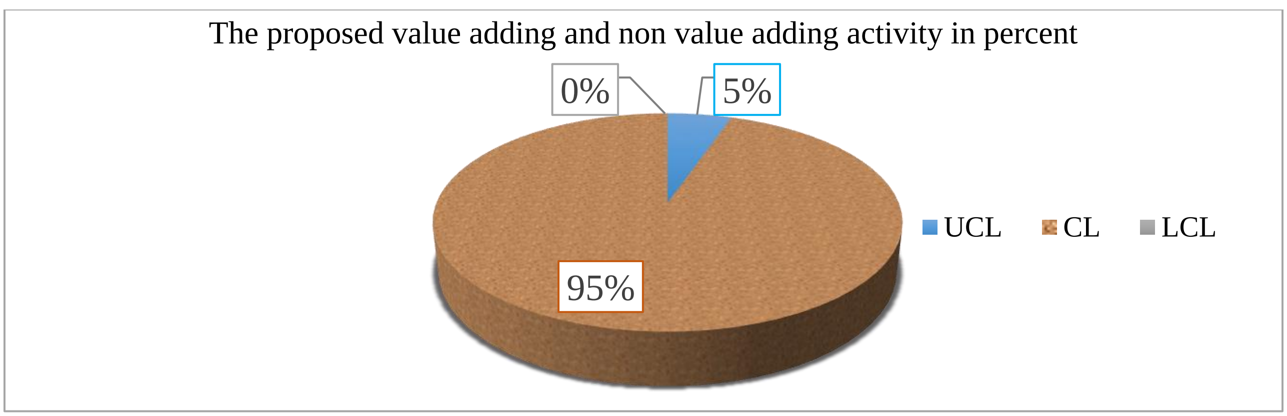
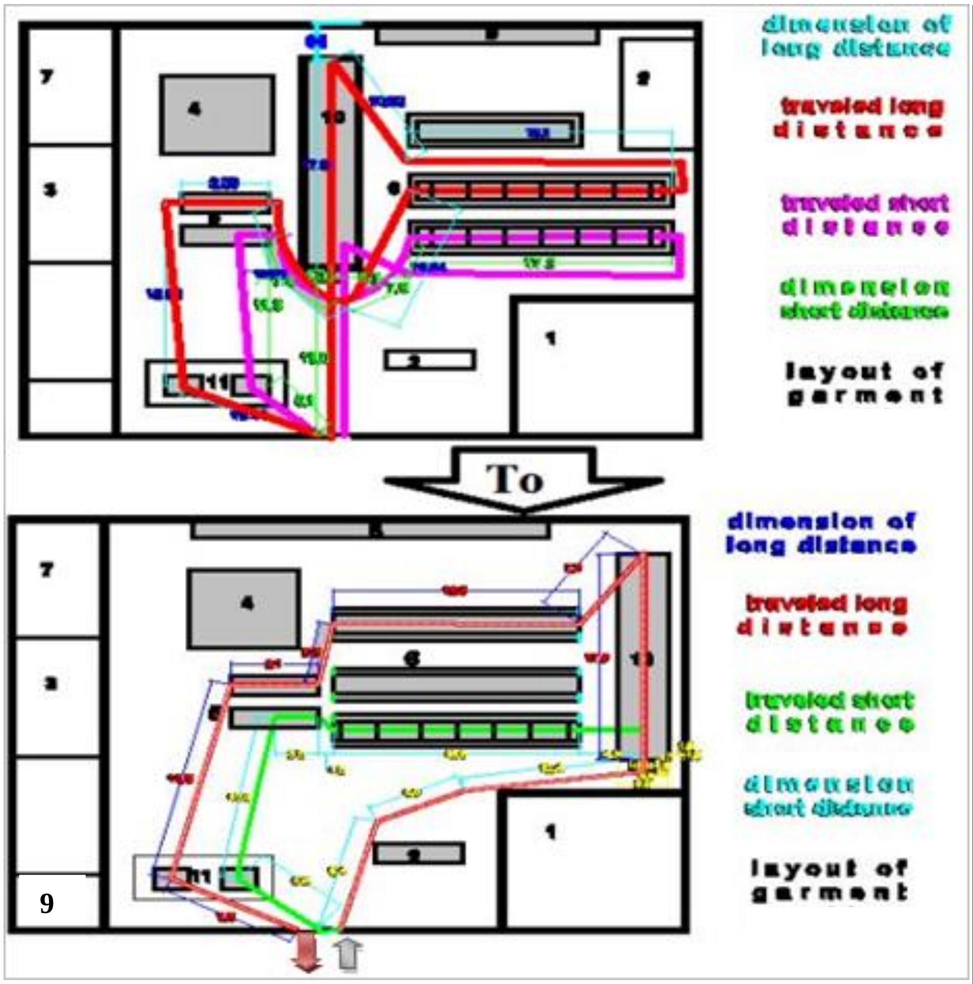


Figure 5. 23 The proposed distance and value-adding activity chart of the garment production



This chart clearly shows that the value-adding and no value-adding activities with a short distance for the movement of the garment production process. And also, to indicate in numbers from the existing total activities (21) of 9 activities are non-value adding activities which means it covers about 43%, but after improvement, only 2 activities are out of control (non-value adding activity, but these activities did not remove & which considering as a value-adding activity, because it is the best alternatives for smoothing the production line improvement) limit. But didn't have any activity under a lower control limit.

The comparison between the existing and the improved working method, movements and the production flows is clearly shown in the following Figure.



Main Activity

1. Rest, toilet & shower room
2. Manual cutting operation
3. Offices
4. Scrap production
5. Preparation & Operation
6. Sewing operation
7. Accessory store
8. Satellite store
9. Idle machine
10 Spreading & cutting operation
11 Bell press machine operation

Figure 5. 24 The comparison between the existing and the proposed working method for garment

This Figure indicates that the existing total production process of the case company working method arrangements with its detailed activities, including each operation activity, production flows, the distance of each operation movements, non-value adding activities (waste), value-adding activities and its clearly shows the main problems with related to unnecessary motion, movement, work method, backtracking, bottlenecks, long operation time and complexity of the work. Hence this leads to the company low productivity, dissatisfaction of workers & customers.

However, the proposed work method or the new assembly flows of the case garment production process is shown in Figure (5.24). And most of the existing production problems or production wastes can be solved. And also each production activity's detailed improvement is clearly shown.

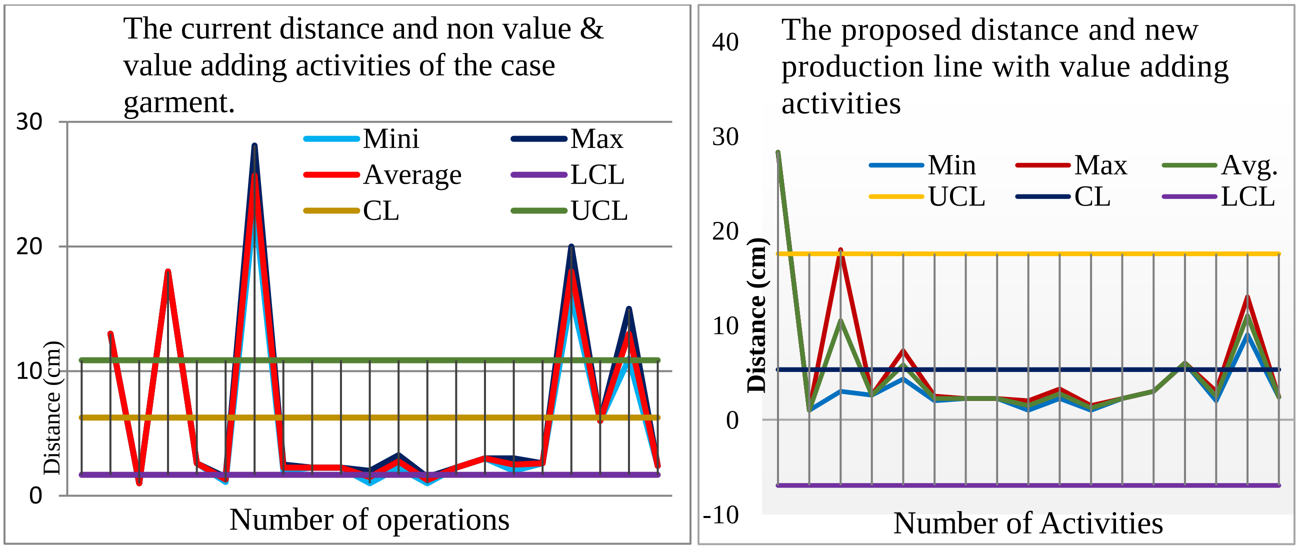


Figure 5. 25 The comparison between the existing and improved distance & activity chart

As a summary, the above figure shows that there is a significant change between the existing and the improved garment production process. Because, when to compare the existing distance of each activity movement is very high and non-value adding activities concerning the long distance is also high (totally 9 activities = 43%) and value-adding activities only is 12 (57%). But after improvement the total distance is reduced from 131.8 – 99.3 meters = 32.5 meters can be reduced per one movement and there is an average of 20 movements of each operator per one shift. So, 20 * 32.5 = 650 meters per one shift per day can be reduced. And also, non-value-adding activities are reduced from 43% to 5%, value-adding activities increased from 57% to 95%. Production time is also reduced see in the time analysis part. In general, to maintain a new method is used to monitoring how an effective improved working method is and how personnel has adapted is very important. It is sometimes overlooked to check what effect the new method has on the other activities. For instance, it may be that while the new work method is successful in eliminating a bottleneck in a particular area, the bottlenecks have moved elsewhere in the process. By periodic checking the new method and its effects, the management can ensure that overall efficiency is improving rather than deteriorating. So, this study has been a real & detailed investigation of the case garment problems and can be solved based on real data (direct recording & measuring), facts, and considering standards.

5.3.2. The proposed solution for production time analysis

To improve the productivity of the case garments of the main exports products, which are Quilt cover and Flat sheet products by using time study, Takt time, cycle time and improper working methods by using method study and some lean tool. Thus from the time study part, the following activities are to be solved as:

- Improve line balancing: which is used to reducing idleness of operators machines (eliminating waiting), maximizing the operators'& machine capacity utilization, can create smooth production flows by reducing non-value adding activities or movements. This leads to getting additional products by using the same resources that have been used previously.
- To identify low-performance operators and to develop training opportunities for these low-performance garment workers. Sewing operators are the most valuable resources to the garment industry. Hence, the cases garment must work on developing operators' skills were required. Because training does not cost rather it is an investment "said by many experts". Subsequently, production from an operator depends on his/her skill level to the task. Due to low skill operators is consumed higher resources i.e. time and can produce fewer outputs.
- Setting individual operators targets by using time standards: instead of giving equal targets to all operators working in a line, give individual targets as per operators' skill level and capacity. It helps to set an achievable target for each operator because this will use to improve the individual efficiency of the operators. As a result, it is used to eliminate the lost time and off standard time.
- Improving the existing working methods of the case garment: to reducing the distance which is not added any value for each operation and is used to reduce unnecessary movements, motions, and transportation time by avoiding non-value-adding activities.
- Helps to reduce bottlenecks: a constraint for smooth flow of operation, limits the flow of production rate, productivity and efficiency are usually termed as the bottleneck. This can be reduced using line balancing or time study. Because line balancing can be improved using time study. In general, applying these theoretical solutions changed to practical details using the reliable data recorded by using scientific tools and procedures. These details are shown in the following tables, figures, and charts.

Case -1: Proposed solution for Quilt cover production time analysis

Under this part manly considering how to improve daily production output, how many workers/ operators are required, how to reduce waiting time, lead time using the standard time.

Daily output (Quilt cover) per shift for each operation calculated as:

Daily output for each operation = $\frac{\text{Total Working time}}{\text{Each Standard Time}} = \frac{7:30 \text{ Hrs} = 27000 \text{ Sec.}}{\text{Standard Time}}$

New Daily output per shift = $\frac{\text{Existing Daily Output} * \text{Number of new operators}}{\text{Number of existing operators}}$

Number of new operators = $\frac{\text{Existing operator} * \text{ Number of Order/target}}{\text{Daily output (Quilt Cover)}}$

First to discussing for the label attach operation as

The number of new operators required is = $\frac{2 \text{ operator} * 800 \text{ pieces per Shift}}{616 \text{ pieces}} = 2.597 \cong 3$

New Daily output per shift = $\frac{616 \text{ pieces} * 3 \text{ operators}}{2 \text{ operators}}$ = 924 pieces per shift can be produced.

For side seam operation

Number of new operators = $\frac{4 \text{ operators} * 800 \text{ pieces/shift}}{462 \text{ pieces}}$ = 6.926 ≅ 7 operators are required.

New Daily output per shift = $\frac{7 \text{ operators} * 462 \text{ pieces}}{4 \text{ operators}}$ = 809 pieces per shift can be produced.

Thus, by following the same steps to calculate for all operations and to get the following summarized table: after line balance of the Quilt cover production (140 x 220 cm size) table:

The target order per shift = 800 pieces/ per one shift (totally have two shifts, which is 1600 pieces).

Table 5. 18 The main export product of the case garment production after line balanced

S/ No	Operation Type	M/C Type	Number of M/C is required		Number of operators required		Avg. OT (Sec)	SMV (Sec)	Daily Output per shift (Existing) in pieces	Daily Output per shift (new) in pieces	Remark
			Existing	New	Existing	New					
1	Label Attach	S/N	2	3	2	3	37	44	616	924	Achieve Target
2	Preparation	-			4	3	18	22	1239	929	Achieve Target
3	Side Seam	5-Trad	4	7	4	7	49	59	462	809	Achieve Target

4	Box-Making	S/N	3	4	3	4	35	42	649	865	Achieve Target
5	Preparation & Measuring	Meter			4	2	14	17	1588	794	Approach to target
6	Marking	-			2	2	19	23	1166	1166	Can help line 9.
7	Button Hole	B/H M/C	1	1	1	1	24	28	957	957	Achieve Target
8	Button Attach	B/A M/C	1	1	1	1	19	22	1205	1205	Can help line 5.
9	Manual Work	-			4	2	16	19	1388	694	Train the Operator
	Total		11	16	25	25		275			Success

This Table shows that time study is an effective improvement technique to solve bottlenecks of garment production with or without extra resources usage and can be meeting the production targets of the company. Hence, these findings indicate that the problems related to production time can be solved without using additional resources that the company to inquire. This means the garment industry can be improving its production capacity by effectively utilized its existing production resources including machines (i.e. idle M/C), and human resources, etc. In general, this improvement was clearly shown in the following charts:

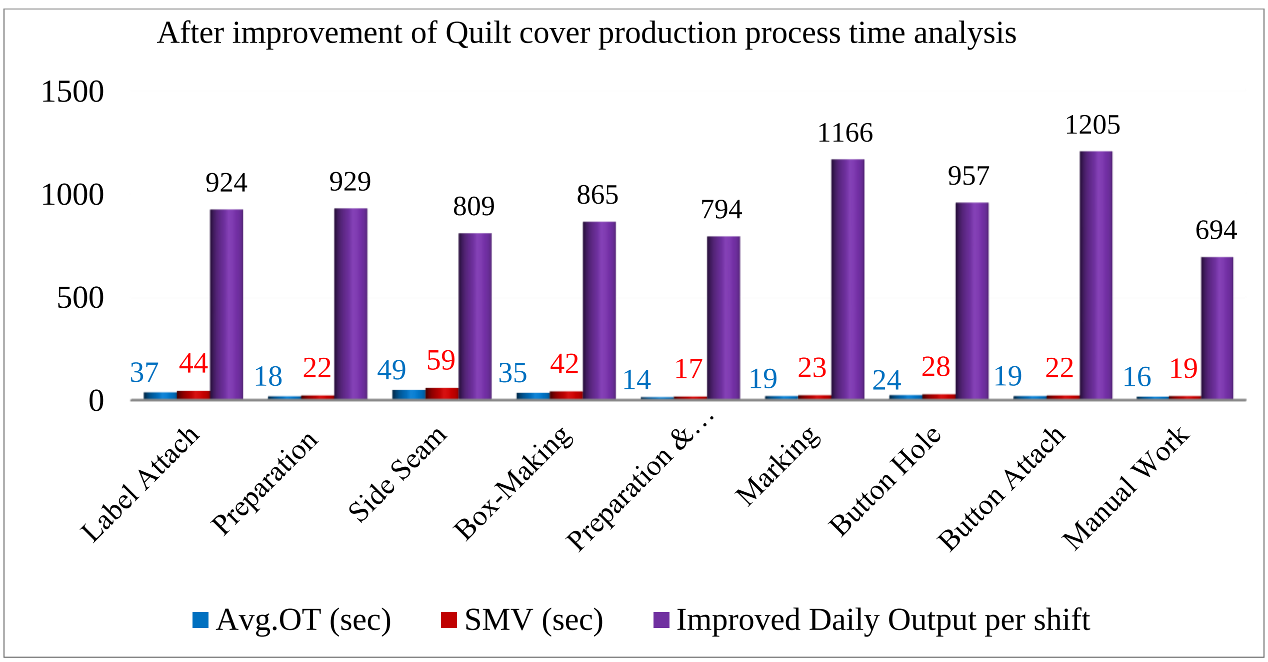


Figure 5. 26 The chart shows that line balanced of Quilt cover production process

As a summary line balancing using time study is an effective technique to enhancing a significant garment production improvement, with a little change or without using additional resources of the company. So, this improvement comes by using the existing resources effectively utilized, including using the existing idle machines, the existing number of workers as it is (by giving short-term training & assigning the operators based on the operation loads that studied in this research).

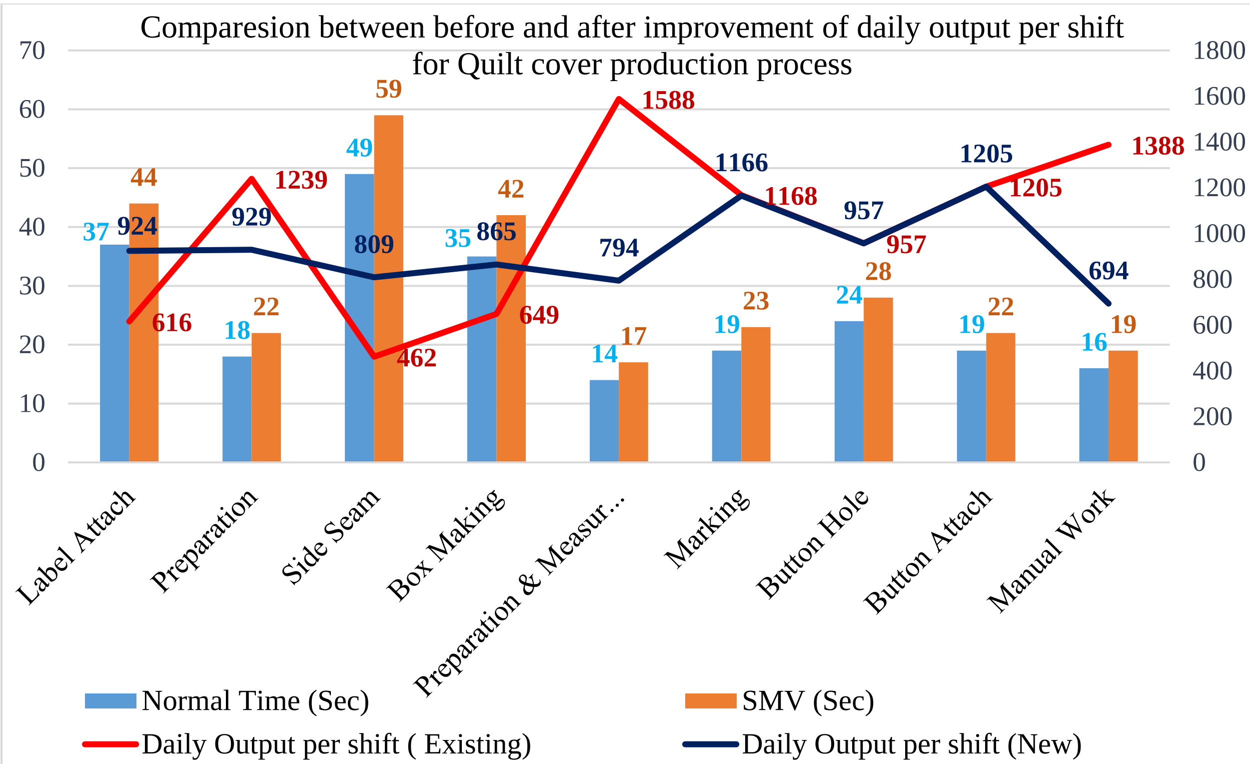


Figure 5. 27 The compares ion b/n the existing & improved production process of Quilt cover

This chart is clearly shown the compares ion b/n the existing Quilt cover production process of the case garment's i.e. operators daily output of each operator per shift, NT, SMV, and Avg. OT, and develop a new production line by finding existing bottlenecks of the production line.

Case 2: Proposed Solution for Flat Sheet Production Times Analysis

Using the following formula to calculate the Flat sheet production process improvement

$$\text{Daily output for each operation} = \frac{\text{Total Working time}}{\text{Each Standard Time}} = \frac{7:30\text{ Hrs.} = 27000\text{ Sec.}}{\text{Standard Time}}$$

$$\text{New daily output} = \frac{\text{Existing daily Output} * \text{Number of new workers}}{\text{Number of existing workers}}$$

$$\text{Numbers of new workers are required} = \frac{\text{Existing worker} * \text{Number of order/target}}{\text{Daily output (Flat Sheet)}}$$

First calculate the new required workers, machines, and the proposed daily output per shift for each Flat sheet (export product) operation process of the case garments as:

The calculation for Label Attach operation

The new worker required for label attach = $\frac{4 \text{ workers} * 750 \text{ pieces/shift.}}{\text{Existing daily output } (325)}$ = 9 workers, which means there are 5 additional workers to require for this production line to achieve its targets, and these workers can be got by rearranging the idle workers in their production.

New daily outputs for label attach = $\frac{325 \text{ prices} * 9 \text{ workers}}{4 \text{ workers (existing)}}$ = 731 pcs/ shift is produced

The calculation for preparation operation

The new worker required = $\frac{4 \text{ workers} * 750 \text{ pieces/shift}}{\text{Existing daily output } (1463)} = 2$ workers are required

New daily output = $\frac{1463 \text{ (existing daily output performance)} * 2 \text{ (new workers)}}{4 \text{ workers (existing)}}$ = 732 pieces per shift can be produced. Similarly, the remaining operations are calculated and their details are shown in the following table.

The target order per shift = 750 pieces specified by the company

Table 5. 19 Proposed solution (line balancing) for Flat sheet product time analysis

No	Operation Type	M/C Type	Number of M/C required		Number of workers required		NT (Sec)	SMV (Sec)	Daily Output per shift (Existing)	Daily Output per shift (New)	Remark
			Existing	New	Existing	New					
1.	Label Attach	S/N	4	5	4	5	69	83	325	731	Approach to target
2.	Hemming	-	4	5	4	5	66	79	340	765	help the 1st line
3.	Preparation				4	2	15	18	1463	732	Approach to target
4.	Measurement	Meter			4	2	14	17	1607	804	help the 3rd line
5.	Manual Work	B/H/ M/C			4	2	16	20	1376	688	The shift leader can helps this line.
Total			8	10	20	24					

As a whole, these improvements can be achieved by considering two alternatives: the first alternative is using the existing resources effectively by re-arranging their production sub-lines without hiring workers (adding additional resources). Therefore the first two lines increase the production volume of label attach & hemming operations from 325 pcs to 569 pcs and 340 pcs to 595 pieces respectively. This means the productivity of this production line can be increasing by 43%. The second alternative is to require additional 4 workers & machines, but these workers can be got from the excess number of shift leader workers and the cutting operation workers by giving short term training or they can be hiring 4 workers either temporary or permanently during this operation, due to the opportunity of low wage workers (monthly wage is $35- $60) of the garment sector. Consequently, using one of these two alternatives the company can be achieved its production targets by inquiring less production cost because the proposed daily outputs per shift are almost half of the existing one. As a result, the proposed flat sheet production process is clearly shown in the following bar chart as:

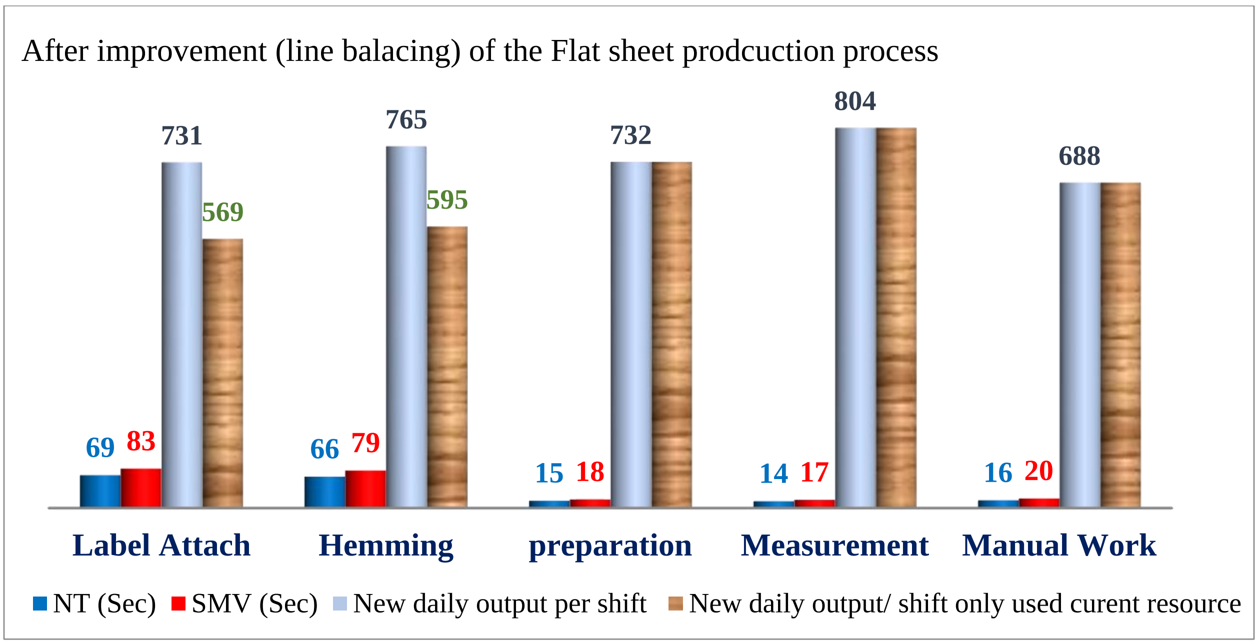


Figure 5. 28 After line balancing of the flat sheet production chart with its time and daily output

In summary, the existing Flat sheet production process of the case garments has not been smooth flow due to bottlenecks, this leads the company to low production output, long delivery time, ineffective resources utilization, less competent in the global market share, inquired high production cost for idle machines & workers and decrease the contribution of Ethiopian garment industry export market share values. So, if the company applying these studies in practices properly, they can be achieving the production targets and can solve these problems as well. Because the data was collected by direct recording of each operation in detail by taking a long time and considering both its working condition & standards. So, the difference between the existing and the improved production process of Flat sheet products is shown in the following Figure:

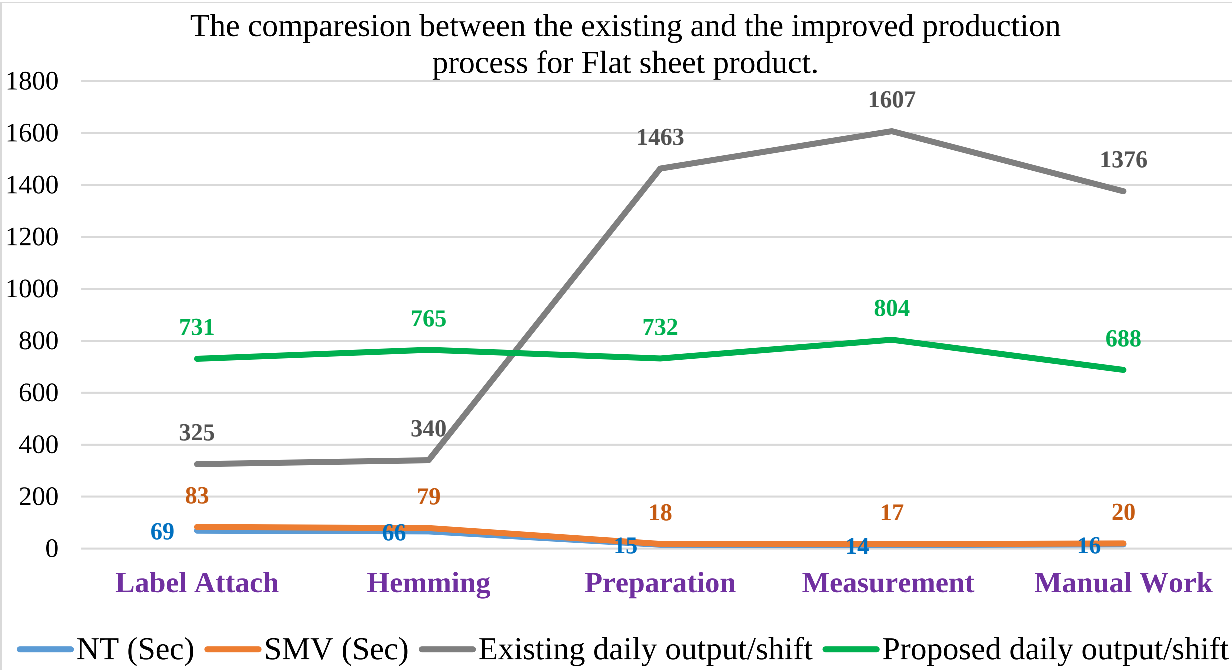


Figure 5. 29 The compares ion of the existing & improved production line for flat sheet product

This Figure clearly shows before improving the production process of the case garments specifically the Flat sheet production line is not balanced. Because currently, the company can be produced less than half of the production targets. So, this improvement has been attractive for improving the productivity of the case garments by using the existing production resources effectively or by adding some extra resources (workers & the idle machines). But in both ways, the improvement has been enhancing a significant change.

In summary productivity improvement using integrated techniques and tools are important issues for enhancing the productivity of the Ethiopian garment industry. This study tries to investigate the productivity factors of Ethiopian garment industries and discussed them in detail by taking a specific case company. However, in this case, the company has been faced many productivity factors including internal, external, and lean wastes. But, from these factors didn't address by this study, so, the primary aim of this research was to identified the most significant factors that are frequently occurred in the case garment's and the investigation were focused on this critical factors by using an appropriate data.

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

Productivity improvement is an important issue in the textile and garment industry. The profit earning of these manufacturing industries are largely depending on productivity improvement. The garment is one of the basic needs of mankind and currently, the garment industry is a modern marketplace in a truly global industry. Hence, the Ethiopian garment industry and the case company need continuous productivity improvement to survive in the global market share. Because these garment industries are faced multidimensional productivity factors and these factors range from human to method to control to process to external productivity factors. But all these factors do not have an equal effect on productivity for each garment industry, even in the case company. And the resources are limited to solve all those factors associated with productivity. Thus, deciding the intervention areas & which are enhancing a significant change for productivity improvement is very vital. Hence, this investigation focused on the search of the existing critical problems of productivity in the Ethiopian garment industry, specifically the selected garments that to enhancing productivity by using an integrated LM (lean wastes) and work-study tools including line balancing, work standardize, time study, method study, and total working method & process improvement related with kaizen and 5S. LM is a continuous improvement method & mainly focuses on identifying and eliminating eight activities of wastes, whereas the work-study techniques focus on reducing the production time, eliminating non-productive processes, reducing fatigue, and setting standards to increasing productivity for both workers and the case company. This study has been conducted many papers, literature, & prepared questionnaire, direct observing, recording each operation time, detail activities, input defects, and measuring the production floor space (distance) for time study, lean wastes, and working method improvement respectively. Because these data were used to analyzing the internal productivity factors related to high waiting time, unnecessary movement, motion, and high input defect, inappropriate production process, long transportation flow, unbalanced work distributions of the case company that reducing productivity. The questionnaire form was designed to collect the data from the case company, which was used for identifying the major productivity factors (both direct & indirect), and to assess the correlation & regression between the dependent variable (productivity) and independent variables including improvement tools, productivity factors, and wastes. As a result, the analysis shows the there is a strong correlation and significance value between them depending on the value of ‘r’ and p-value respectively. Consequently, the overall finding of this study can solve the critical productivity factors of the case garment’s and it is also used as a benchmark for other Ethiopian garment industries that have been to faced similar problems. Because, this research can be reducing non-value adding activities (waste) including unnecessary motion, waiting (idle time), production process and transportation; reducing bottlenecks, backtracking, and production cost; increasing the utilization of workers, machine and space; can create best working method & production flows; increase operators efficiency; investing garment input defects and external productivity factors effectively. Thus, the results of the study show that can be reduced non-value adding activities from 43% to 5% and value-adding activities increased from 57% to 95%, bottlenecks are reduced from 3 to 0, to create better working method & production flows, one of its results is reducing total garment operation activity distance to 32.5 meters per one full movement per workers and average movement of each worker is 12 in one shift (32.5*12 = 390 meters per shift per worker). The existing actual daily output in percent for Flat sheet and Quilt cover products is 43.3%, and 57.7% pieces per shift, but after improvement (only using existing resources) it can be increased 75.8% and 100% pieces per shift respectively. And can be set standard time & daily outputs for each operator in the garment production effectively as a result it can save 315 minutes for Quilt cover products to achieve their production targets of 800 pieces per shift and 537 minutes for Flat sheet products to achieve their targets 750 pieces per shift, this indicates that before improvement to required additional one shift to achieve the targets. So before this improvement, the company inquired about high production costs. Finally to conclude that implementing these integrated techniques helps to endless productivity improvement for the Ethiopian garment industry as well as the case garment’s, due to all productivity factors can be solved under these integrated techniques. But not, achieved the overall improvement of garments using a single tool and develop a model.

6.2. Recommendation

Most of the problems of low productivity of this sector and the case garment have been identified in the study and separated to which importance should be given; the residual thing is the recommendation of the way which helps to reduce these productivity factors and to improve the productivity of Ethiopian textile and garment industry.

Thus, the following recommendation should be well-thought-out.

- Productivity is one of the major determinants of competitiveness in global market share. Hence, both the sector and the case company should be developed & manage their productivity in a well-organized and sustainable system used to achieve the GTPs plan and to compete in the marketplace.
- Currently, ETIDI and the case company hadn't been an integrated system that supports improving the productivity of this sector and try to apply only a single technique/ tool and develop a simple model that to solve those productivity factors. This overemphasizing that, these multi-dimensional productivity factors (both internal & external) of the textile & garment industry has been solved using this approach is leading to incorrect judgment and costly mistakes. Hence, this may misdirect the improvement of productivity efforts. Therefore, both ETIDI and the case company should be focused on solving these factors using integrated tools/techniques and try to solve both the internal & external productivity factors at the same time to enhance the overall productivity improvement.
- It is recommended for ETIDI, to increasing productivity in this sector, that should be working on the following points: to develop well- organized training center for workers in these industrial zones; try to create an appropriate integration system b/n these industries with other related organizations; to give more attention on local cotton production; set standards for workers wage as a country based on facts, to form an expert team that supports of this sector.
- It is strongly advised for the case company to apply this study effectively. Because, it should give priority to increasing daily output; improving operator efficiency & working method; to reduce human fatigues, wastes, distance, idle time, and cost; can create fair work distribution b/n workers; to reducing quality defects; effectively utilized resources & space. And this company should be searching a new market place for improving the existing export product price, infrastructure & utilities, it requires to restructure the HR development center and quality department plus to assign qualified expert that to support for the implementation of this study.

Therefore, if implementing this study the company has been enhancing a significant change in productivity.

- Management of ETIDI and the case company should be committed to setting goals, targets, and awareness to workers and allocation of resources to implement this study. And also, it is better to change the old production equipment; to motivate workers by giving incentives & to develop their skills by giving training; to improve the integration & coordination b/n workers, management and other related organizations.
- By involving the government, stakeholders, academicians, and researchers, ETIDIs and the case company should fight to mitigate the external productivity factors that affect this sector's productivity at the national level. And try to solve these productivity factors that did not address by this analysis using integrated techniques & tools of lean & work-study to improve their productivity.

6.3. Future Research Work

Ethiopian service and manufacturing industries are the basic economic elements of the nation, so, using these integrated techniques to developing an appropriate method that cares about improving productivity in this industry is the research area that would be considered in the future. And this study, specifically, focused on Bahir Dar Textile Share Company (garment), but, that it is beneficial to implement and to see the impact for other Ethiopian garment industries. And also, it needs a detailed investigation on ergonomics assessment in all Ethiopian garment industry including the case company. Finally, it is better to design transportation belts for the sewing production process.

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APPENDIX

Appendix I – Recorded Data for BDTSC, Garment Defects

I- Eight-month garment production inputs & output defects in the case company in 2019/20

Eight-month garment input (fabrics) defects							
S/No	Month	Accepted (meter)	Accept in %	Rejected (meter)	Reject in %	Cumulative of defective	Cumulative in %
1.	October	133427	68	42840	24	42840	14%
2.	September	124150	73	33424	21	76264	25%
3.	June	142101	73	38639	21	114903	37%
4.	November	156019	74	39977	20	154880	50%
5.	April	156336	78	34036	18	188916	61%
6.	August	207028	81	38586	16	227502	74%
7.	May	205726	83	34153	14	261655	85%
8.	July	298919	85	46145	13	307800	100%
Total		1423706	76.88	307800	18.38		

II- Recorded data for the average of three months (July, November & October 2019/20) garment input defects

	Average three month (July, November & October 2019/20) garment input defects (fabrics)					
	Defect types	Accepted	Defects (m)	Defects in%	Cumulative	Cumulative in %
1.	Miss print	26540	7724			
2.	Color variation	23967	6806			
3.	Shade variation	23661	5945			
4.	Oil	22518	5449			
5.	Color contamination	25365	5367			
6.	Hole	20918	4954			
7.	Miss picks	19929	4215			
8.	Selvage tear	16443	3845			
9.	Short width	19686	3404			
10.	Grease	17144	3053			
11.	Machine stoppage	12897	2780			
12.	Temple mark	11365	2385			
13.	Back print	17111	2143			
14.	Crease	18195	2021			
15.	Screen blockage	13153	1863			
16.	Miss end	14944	1568			
17.	Slack	6900	1243			
18.	Spot	11626	1025			
19.	Rust	16348	982			
20.	Long-tail	15758	769			
21.	Other garment defects i.e. cutting, sewing & labeling	2109	2109			

Appendix II – Survey Questionnaire

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAiT)

School of Mechanical and Industrial Engineering

Graduate Program in Industrial Engineering

Survey Questionnaire on Bahir Dar Textile Share Company, Garment's (BDTSC)

Prepared By: Mequanent Ewnetu

Email: mequanent1613@gmail.com

Advisor: Dr. Ermias Tesfaye

Co-advisor: Mr. Fitsum Getachew (Ph.D. candidate, Industrial Engineering stream- AAiT)

Thesis Title: Assembly Works Productivity Improvement for Garment Production Industry through the Integration of Lean and Work-Study in the case of BDTSC, Garment.

The objectives of this questionnaire are to assess the existing productivity factors and improvement practices of the case company and these factors are affecting their productivity.

Hereby, I would like to be express my gratefulness for your committed cooperation to answer this attached questionnaire. And all the questions are well designed for quick and easy response.

Finally, this questionnaire is conducted for MSc. Thesis. Hence, I promise you that the information is got from this questionnaire will be reserved confidential and will not be transferred to other parties for any other purpose. If you have to need further clarification, please contact me at the above address.

I - Respondents information

i. Gender ___________Male _______________Female

ii. Current position in the company_________________

iii. Qualification______________________ 1 = Diploma; 2 = BSc/BA; 3 = MSc/MA; 4 = PhD; 5 = **Others (specify)** ____________________

iv. Field of specialization ___________________

v. Work experience in this or other related company (in years) ___________________

II - Company Profile

1. Name of the company ___________________________
2. Ownership of the company: 1 = Private; 2 = Public; 3 = Private & public ___________
3. Number of working time per shift __________and number of shift per day ______________
4. Market segment: Local ☐ Export ☐ Local and Export ☐
5. Total number of employees ___________________________

III - The assessment of existing productivity management practice of the case garments

1. Does the company set its goals and its targets for its productivity?______(if yes 1, if no 2)
2. Does the company identify problems of its productivity improvement? _______(if yes 1, if no 2)
3. Did the factory operate in its full capacity?____________ (if yes 1, if no 2)
4. Which types of production wastes are frequently occurred in your garments? ________ please give a rank using five scales. Use the symbol (x) for each waste with respect to each scale. Where 1 = Always, 2 = Usually, 3 = Often, 4 = Sometimes, and 5 = Never

S/No	**Waste Types**	1	2	3	4	5	**Symbol**
1.	Overproduction						WT1
2.	Inventory						WT2
3.	Defects						WT3
4.	Over-processing						WT4
5.	Inappropriate motion						WT5
6.	Unnecessary transportation						WT6
7.	Waiting						WT7
8.	Unitized employees knowledge & skills						WT8

5. Please rate the impact of each internal productivity factor that affected the existing production process of your garment industry, using three scales. Use the symbol (**x**) for each process with regard to each scale, where 3 = high impact, 2 = medium impact and 1 = low impact.

S/No	**Internal productivity factors**	**1**	**2**	**3**	Symbol
1.	Limited and low-quality inputs				IPF1
2.	Inappropriate working method & process flow				IPF2
3.	Long lead time				IPF3
4.	Poor working culture				IPF4
5.	Low skilled workers				IPF5
6.	Old machines and equipment's				IPF6
7.	Low production managerial capability				IPF7
8.	Poor system integration (both internally & externally) from other organizations, institutes, etc.				IPF8
9.	Low workers wage				IPF9
10.	Less export price of the product				IPF10
11.	Unbalanced workload distribution between workers				IPF11
12.	High non-productivity time (idleness, downtime & setup time for both machines and workers)				IPF12
13.	High product defect, rework, and scraps rate				IPF13
14.	Bad working environment				IPF14
15.	Lack of information technology				IPF15
16.	Frequently power failure				IPF16
17.	Lack of training for the workers and managers				IPF17
18.	Poor product design				IPF18
19.	Low motivation and morale of employees				IPF19
20.	High employees turnover				IPF20
21.	Lack of maintenance				IPF21
22.	Lack of incentive schemes				IPF22
23.	Lack of store for both inputs & outputs				IPF23

Please specify if others: ____

6. Please give a rank to the impact of each production process on the productivity of your garment industry using three scales. Use the symbol (x) for each process concerning each scale. Where, 3 = high impact, 2 = medium impact, and 1 = low impact

S/No	**External Productivity factors in the process**	**1**	**2**	**3**	**Symbol**
1.	Poor infrastructure and utility center				EPF1
2.	Government rules and regulation				EPF2
3.	Customer dissatisfaction				EPF3
4.	Lack of market opportunity				EPF4
5.	Sales and marketing department				EPF5
6.	Procurement and property administration				EPF6
7.	Human resources & development center				EPF7
8.	Finance and accounting				EPF8
9.	Supply chain department				EPF9
10.	Company management & staffs				EPF10
11.	Product design & development department				EPF11
12.	Research planning and development center				EPF12
13.	Quality control department				EPF13
14.	Maintenance department				EPF14
15.	Employees complain center				EPF15
16.	Transportation department				EPF16

7. Please indicate which of the productivity improvement techniques and tools (lean & work-study) were implemented for your garments. Use the symbol (x) to indicate. Where 1 = applied and 0 = not applied

S/No	**Lean Manufacturing Techniques & Tools**	**0**	**1**	Symbol
1.	Value stream mapping (VSM)			LMT1
2.	5S			LMT2
3.	Kaizen			LMT3
4.	Total productivity maintenance (TPM)			LMT4
5.	Total quality management (TQM)			LMT5
6.	Single minute exchange dies (SMED)			LMT6
7.	Standardized work (SDW)			LMT7
8.	Just-in-time (JIT)			LMT8
9.	Six Sigma (6 Sigma)			LMT9
10.	Poka-yoke			LMT10
11.	Cellular layout			LMT11
12.	Line balancing			LMT12
13.	Kanban (pull system)			LMT13
14.	Automation (Jidoka)			LMT14
15.	Production labeling			LMT15
16.	Muda (waste)			LMT16
17.	Ergonomics work			LMT17
18.	Visual display & control			LMT18
19.	Ishikawa Diagram			LMT19
20.	Cycle time			LMT20
21.	Flow production			LMT21
22.	Small lot size			LMT22
23.	Teamwork & training			LMT23
24.	PDCA (plan-Do-Check and Act)			LMT24
And under Work-study techniques				Symbol
25.	Method study			WST1
26.	Work measurement			WST2
27.	Time study			WST3

Appendix III - Hosmer and Lemeshow Test

Hosmer and Lemeshow Test			
Step/Iteration	Chi-square	df	Sig.
1	.000	1	1.000
2	3.479	6	.747
3	14.152	8	.078
4	7.414	8	.493
5	12.268	8	.140
6	20.327	8	.009
7	295.983	8	.000
8	.646	4	.958
9	.000	5	1.000