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Students' Musculoskeletal Disorders Assessment Using RULA

Atam Kumar*
Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Pakistan
Email: atamkumar2018@gmail.com
ORCIDiD: https://orcid.org/0000-0002-0197-8532
*Corresponding Author

Bharat Lal
Department of Computer Engineering, Modeling, Electronics and Systems, University of Calabria, Italy
Department of Electronic Engineering, Mehran University of Engineering and Technology, Pakistan
Email: bharat.lal@dimes.unical.it
ORCIDiD: https://orcid.org/0000-0001-7795-4601

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Abstract: Classroom and laboratory infrastructure, food quality, and the environment cause many health issues to the students at colleges and universities, like back pain, eye issues, shoulder pain, and pain in the spinal cord. These problems affect many students' physical and psychological capacity, and students lose enthusiasm and intelligence. This study was conducted at Mehran University of Engineering and Technology (MUET) to identify the ergonomic problems of students from attending lectures in class, performing different experiments in laboratories and workshops, and food quality at the canteens. This study focuses on ergonomic awareness and following rules and regulations for students and university administration. This research is conducted based on different questionnaires and the Rapid Upper Limb Assessment (RULA) method. Through questionnaires, we analyzed students' physical and mental problems. The survey was conducted at the before mentioned university from a total of 104 random students. Using the RULA method, we take data from different postures of students while performing practical work in computer laboratories, mechanical workshops, and other laboratories. After analysis, it is found that the RULA score is almost 7, which is dangerous for health and further survey shows many health problems through questionnaires. It is suggested that universities should follow the ergonomics rules, make a good environment for classes, laboratories, and workshops also improve the food quality at the canteen to mitigate the health problems in students.

Index Terms: Musculoskeletal disorders, MSDs Ergonomic, Back Pain, Neck Pain, Students' posture, RULA, Health, MUET.

1. Introduction

Ergonomics is the science that focuses on utilizing facts of human abilities and skills in supporting a running gadget that makes humans capable of staying and working on a higher system, namely by achieving the desires needed via powerful, efficient, secure, and additionally comfy. Ergonomics is not the most straightforward important for enterprise work, but the pupil's sitting position also wishes to be recognized so that the pupil is secure in the school room. Court cases about employees' frame postures are widespread, and this is due to the lack of awareness among workers about the dangers of running in a work environment that is not always ergonomic. Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance. The terms 'ergonomics' and 'human factors can be used interchangeably, although 'ergonomics' is often used about the physical aspects of the environment, such as workstations and control panels, while 'human factors' is often used about the wider system in which people work [1]. This research will focus on gaining knowledge of the ergonomics risk of Mehran university chairs. The chairs of the university's training, canteens, library, workshop, and labs are less cozy for the scholars and students to sit for lengthy periods. Uncomfortable chairs and food quality at the canteen will motive fitness problems together with pains in different frame components such as the neck, eye, shoulder,

spinal cord, knees, legs, and so forth. In the labs and classrooms, there is a need to change seating arrangements, lighting, place of a board, and multimedia because those are growing more fatigue and infected also causing many health issues and humidity. At Mehran University, 70% of university students do not pay attention to ergonomics guidelines and policies, there is no proper guidance or awareness study conducted to deal with such issues. Therefore, this study highlights the ergonomics problem at MUET and provides awareness to the students, teachers, and administration staff.

2. Literature Review

Musculoskeletal disorders (MSDS) are problems that purpose signs of ache in diverse frame locations consisting of the neck, shoulders, wrists, hips, knees, and heels [2]. Low back ache (LBP) is a prime fitness hassle, and LBP afflicts a third of the grownup populace at some time in their lives; approximately 12% to 44% of human beings have LBP at any given time and an estimated factor prevalence of 33% amongst workplace workers [3]. Workplace for employees depends on various behavioral patterns while operating in a static sitting role for more time using a small range of muscle groups of their hands, wrists, and arms; and are vulnerable to poor body posture. Such operating situations generate musculoskeletal issues, which can result in uneasiness or aches, which has an awful effect on existence. "LBP among office workers" is an attractive topic among researchers because of its high occurrence in this particular group. In [4] a survey performed among Dutch running organizations and office employees, musculoskeletal problems, particularly LBP, were related to lengthy-duration illness absence. At the same time as the ever-increasing utilization of computers within the administrative center has improved the velocity and accuracy of records processing, its effect on workers' fitness because of over-usage cannot be omitted. Essential fitness issues like WMSD and RSI must grow to be not unusual phenomena. Given that, in universities today, most activities are completed with computer systems, the students, personnel, and professors are unaware of the risks of using computers over a significant duration each day. Work-related musculoskeletal disorders are a not unusual health challenge and the primary source of occupational infection in the arena. Together with the associated fitness risks, the economic loss due to such disorders influences not only the individual but also the enterprise and society [5]. This looks at changes performed on the university to become aware of hazard factors and quantify postural strain. To research their working posture, this observation uses two physical evaluation strategies. The strategies are questioners and speedy higher Limb evaluation [6]. Musculoskeletal problems (MSDS) are increasing daily, especially in the neck and higher limbs. In the workplace, workers are one of the concerns of managers of organizations and occupational health and ergonomics engineers [7]. In addition, the superiority of MSDS in growing countries was reported to be between 15% and 70% relying on the form of computer paintings and the duration of touch with the computer notebook and Lower back pain (LBP) was the most stated of those disorders; paintings-related Musculoskeletal disorders (WMSDS) are a common fitness situation and a significant source of occupational infection during the arena. At present, MSDS are one of the maximum apparent troubles ergonomists encounter within the place of business all over the international. Medical situations identified as musculoskeletal or mental/intellectual (hereafter "mental") problems are a prime cause of sick depart, threatening the welfare of individuals and the economics of organizations and society. Swedish facts show that the two diagnostic classes account for more than 60% of certified work-associated health lawsuits, with "I will leave longer than 90 days" [8].

Most ergonomic intervention studies are designed to look at the consequences of the reduction in applicable threat elements impacting the individual employee, while ignores the fitness outcomes of measures to enhance competitiveness and productiveness. The growing electricity of capital markets, globalization of monetary and product markets, thereby increasing the competition sector, and fast technological trade create pressures for high performance at both company and man or woman levels. Low lower back pain has been widely mentioned as being of considerable health and economic difficulty in industrialized nations [9]. Some authors have been blanketed in this review notion that a terrible sitting posture at faculty may additionally produce back and neck ache in the grownup running life, at the same time as others commented that the school classroom is also a workplace; its workers, i.e., its pupils are the grownup people of the day after today. Comparing the superiority of LBP between populations has become more challenging over the years because of sizeable methodological heterogeneity across studies and difficulties in acquiring genuine populace estimates. WHO (World Health Organization) states that these issues are because by several dangerous factors such as character elements, employment, and mental elements. The process elements in the query are awkward postures, static and repetitive movements, temperature, and vibrations. Psychological elements have monotonous work performance, little social interplay, and an absence of work manipulation. Besides the painting's postures of the employees, the posture of students sitting at the same time as attending the lecture can also have a significant impact on the future, and these studies will increase awareness of studying the ergonomics hazard of university chairs.

Musculoskeletal problems and pain are principal issues globally in Europe and Sweden, causing human suffering for the character and financial burdens for groups and societies. Amongst musculoskeletal issues, LBP and neck pain account for approximately 70% of incapacity [10]. One of the ordinary chances in industries is manual material along with the U.S. branch of hard work; managing is defined as Seizing, protecting, grasping, turning, or otherwise working with the hand or palms. Arms are worried simplest to the volume that they are an extension of the hand, along with

turning a switch or shifting vehicle gears [11]. In today's ever-evolving enterprise environment and unpredictability of human elements, hazard evaluation in an enterprise might be essential to securing the enterprise's economic future by ensuring the protection of its paintings pressure and getting rid of damaging operating conditions. There are threat elements associated with an everyday place of work, especially for people who have to do with manual fabric handling in a conventional warehouse putting [12] fabric coping with is an invariable a part of any production or provider operation, and there is continually a substantial human input to those operations in terms of physical load. The bodily load is the effect of force inputs for the duration of material dealing with operations from the interaction with cloth dealing with a system or the cloth [13]. The guide cloth dealing with is the chance undertaking which includes lifting and reducing the objects, pushing and pulling. Each manufacturing enterprise considers ergonomics the elaborate primary troubles that reason musculoskeletal disorders and the everyday health of personnel [14]. However, repetitive MMH activities, incorrect transfer position, and techniques in addition to heavy loads could chance the employees of an extreme case of decrease again ache (LBP) [15]. According to the study in [16] Musculoskeletal disorders of the upper limbs are one of the maximum frequent occupational issues among dental health care employees, and have psychological and social, in addition to physical outcomes. Research work in this area are the maximum important and the highest commonplace motives for misplaced workdays, expanded prices, and occupational issues in developed and growing countries [17]. Most of the ergonomics evaluation research so far had been carried out on industrial people; only a few studies have taken into consideration evaluating the operating postures of the team of workers, students or professors in universities who are uncovered to prolonged sitting.

3. Research Methods

After reading the literature, questioners were set for the survey form the students and data has been collected through questioners, therefore, this research is also based on questioners regarding ergonomics. Google form platform is used for the data collection. Further categorized into the four sections: Classrooms, Laboratories, Canteen, and Library. In every section, questions were asked according to the category. Total 104 random students take part in the survey.

a) RULA

Fig.1. Demonstrate a rapid assessment of individual worker exposure to ergonomic risk factors associated with upper extremity musculoskeletal disorders. The RULA Ergonomic Assessment Tool accounts for biomechanical and postural stress requirements for work tasks/neck, torso, and upper extremity requirements. Observe the position of each body segment, the greater the deviation from the neutral posture, the higher the score for each body part. Risk is calculated on a score from 1 (low) to 7 (high). The classification of this posture and strength and the impact level to evaluate. From this figure, the RULA score is considered at different angles depending on the given posture: neck

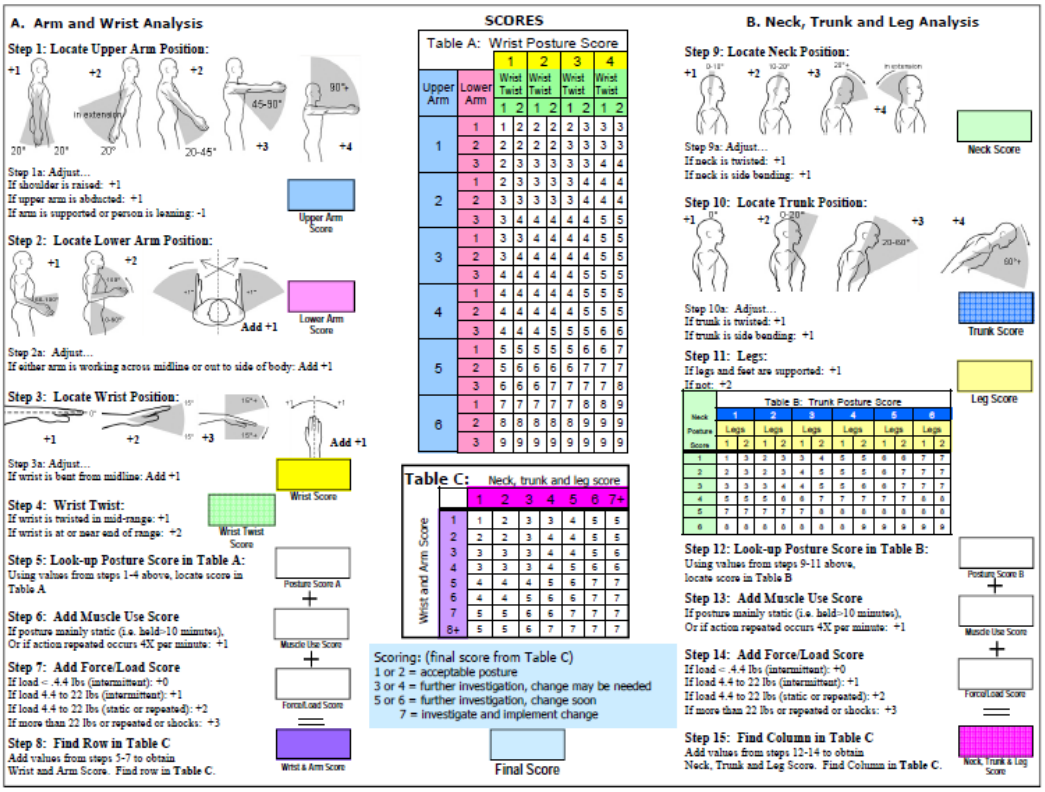

Fig. 1. RULA score analyzing table [18]

position, torso position, arm position, and wrist position. Finally, we add up all posture scores and analyze if there are any problems.

RULA is the method that is used in ergonomics for analyzing different working postures. We analyze employees' work using RULA; firstly, provides a method of screening a working population to assess exposure to a significant risk of work-related upper extremity disorders. Secondly to identify the muscular effort associated with working postures and excessive forces while performing static or repetitive work, which may contribute to muscle fatigue. Thirdly to provide a simple scoring method with an action level output that identifies an indication of urgency. And moreover, provides a user-friendly assessment tool that requires minimal time, effort, and equipment.

Table 1. Procedure for calculating the RULA score

RULA Scoring	
Score	Level of MSD Risk
1-2	Negligible risk, no action required
3-4	Low-risk change may be required
5-6	Medium risk, further investigation, change soon
6+	Very high risk, implement change now

4. Result and Discussion

Chairs used in classrooms, Canteens at Mehran University are still not ergonomically best and are not adjustable height, the canteen's food is also not healthy, and other workshops require personal protective equipment (PPE) and are stiff. Chairs are often lamented by students, who also complain about the food. This study responded by the number of students who randomly did activities. Two methods of data analysis have been used here: RULA and Survey.

Fig. 2. Students performing different practical work in lab

5. RULA Method

The following RULA tables give different scores of various numbers of students by which it can be analyzed whether he/she working in good postures or not.

Table 2. RULA assessment of wrist Posture score

Wrist Posture Score									
		1		2		3		4	
				Twist wrist					
Upper Arm	Lower arm	1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	4	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	4	4	4	4	4	9	9	9

Posture Score A	Muscle Use Score	Force/Load Score	Wrist&Arm Score
4	+ 1	+ 0	= 5

Table 3. RULA assessment of Trunk Posture Score

Trunk Posture Score												
Neck Posture Score	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Posture Score B	Muscle Use Score	Force/Load Score	Wrist&Arm Score
8	+ 1	+ 0	= 9

Table 4. RULA assessment of Neck, Trunk, and Leg Score

Neck, Trunk, Leg Score								
Wrist/Arm Score		1	2	3	4	5	6	7+
	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8	5	5	6	7	7	7	7
Wrist Arm score (Neck, Trunk, and leg score) = 5+ Medium risk, Need investigation and change soon								

After applying the RULA method, all respondents in the study scored 7 points, indicating that immediate postures should be corrected as they will lead to future health problems. This value is due to the student's sitting area, laboratory work, and workshop positions. Students who sit and work in various labs can trace back to nonadjustable height chairs, standing postures in labs, nonadjustable height in workshops, and working conditions. The chair's seat and back are not soft, and the curvature of the chair is not ergonomically suitable. From this method, all activities should be improved as soon as possible. Otherwise, it becomes dangerous for students.

6. Questioners

Randomly, we received 104 responses from Mehran university students. According to the collected responses, many students face many problems that can cause serious health problems. An online Google Form does this for surveys. These are divided into four sections: classrooms, canteen, libraries, and laboratories. In these sections, questions such about seating posture, seating arrangement, food quality, ergonomic perception, and a variety of other ergonomics-related questions. Some of these questions are listed below.

7. Questioners Responses

7.1 Students age

Most of the students are between 20 and 21 years, and about 30 percent are aged between 21 to 22 years. Approximately one-fifth of students are aged between 18 to 19 years. In contrast, only seven percent of students are above 23 years.

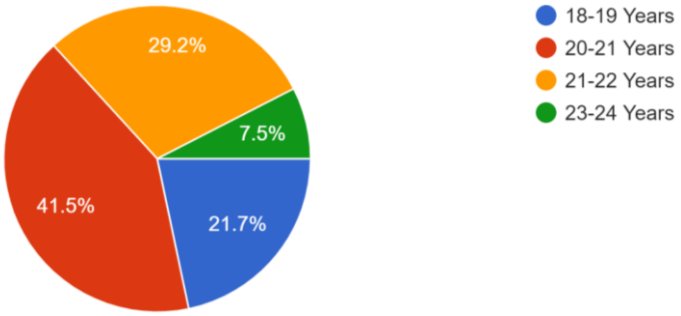

Fig. 3. Students' age chart

7.2 Approximate Height:

Figure 4 shows that most students are taller and between 5.5 to 6 feet. One-third of students' heights are above five and less than 5.5 feet, and only twelve percent of students' heights are between 4.4 to 5 feet. At the same time, no one is above six feet.

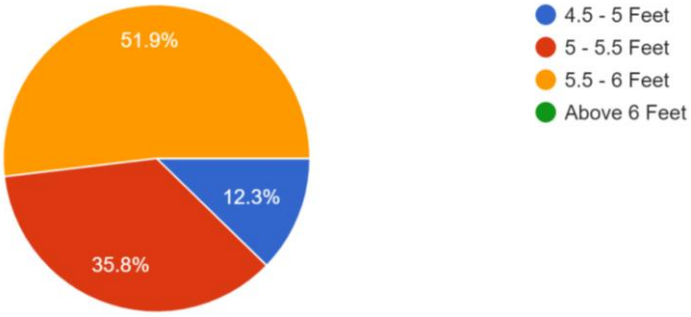

Fig. 4. Students' height chart

7.3 Part of the body becomes more fatigued when operating the machine.

About two third of the students are facing back bone pain while operating any machine during their laboratory practicals; the legs are the second most fatigued part of the body. Two to fifteen percent of the students face other problems like shoulders, knees, arms, and hands. At the same time, only one percent of the students face other problems such as hip, head, and other situation dependents.

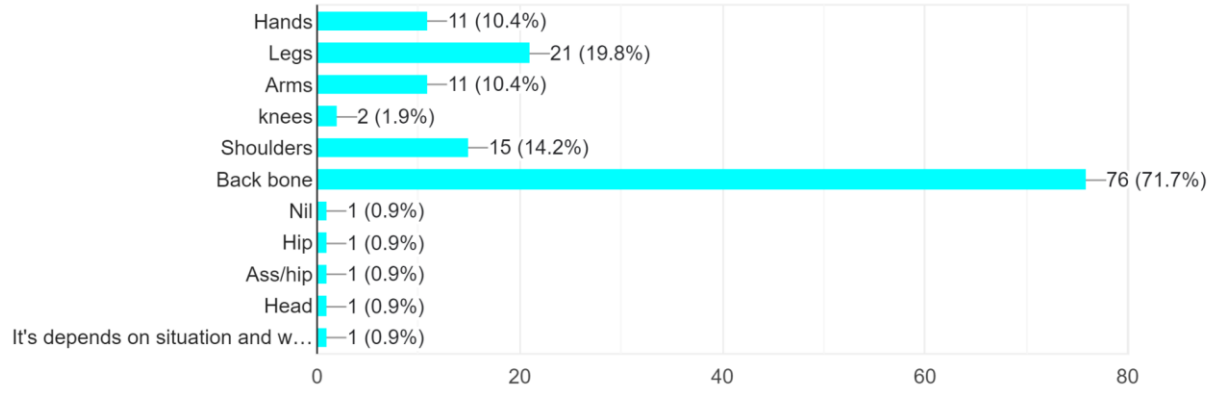

Fig. 5. Body part fatigue chart

7.4 Can the lab chairs be adjustable according to our height?

Most students responded to this question as average, while the second highest response was uncertain. However, thirty percent of the students respond to this question as confident. As a result, some departments' infrastructure is excellent while others are not.

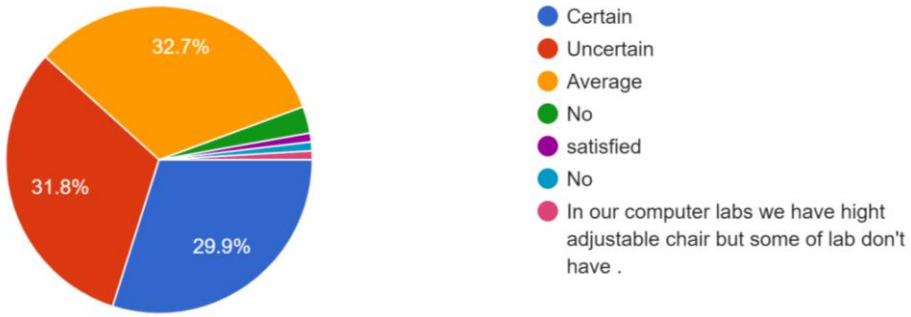

Fig. 6. Chair's position and adjustment chart

7.5 While I am looking at multimedia and feel pain.

Most students face neck pain while looking at the multimedia display during the lectures, eyes pain is the second most pain during the same, and the spinal cord comes the third. However, only one person responds to this question as no pain.

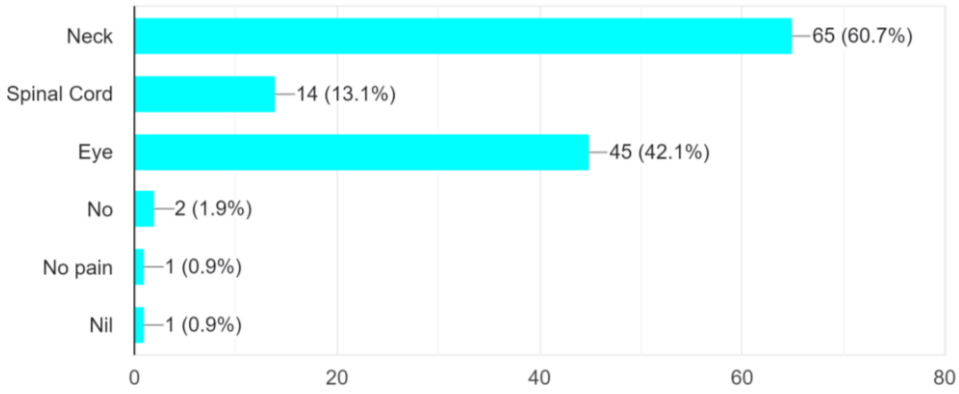

Fig. 7. Feeling pain while looking at the multimedia chart

7.6 Is the height of the classroom desk adjustable?

About half of the students responded to this question as the height of the classroom desks is adjustable, while forty percent responded as no, and eight percent contributed to other answers.

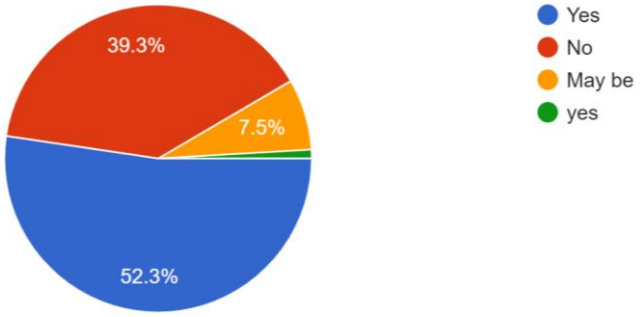

Fig. 8. Classroom desk adjustable response chart

7.7 Food quality of our canteen?

Different canteen services available at the university, about thirty-five percent of the students responded to this question as canteen food needs improvement at the same time a second significant part of the students satisfied from canteen food, and 22.6 percent responded as average. However, only 11.3 percent were satisfied with the food and responded as excellent.

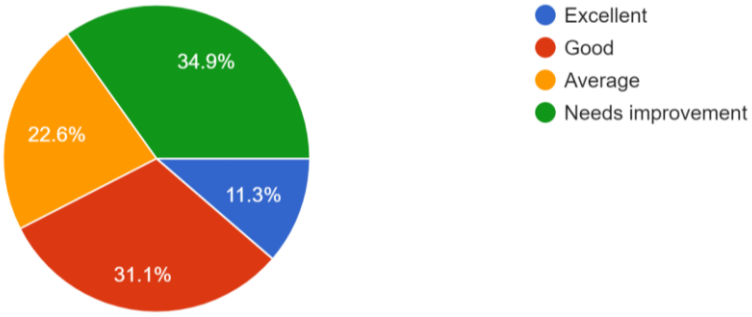

Fig. 9. Canteen food service response chart

7.8 Is there any ergonomic guidance given by teachers or any other person in the university?

Half of the students are facing ergonomic guidance from either teachers or other staff, about twenty-three percent are facing it somehow, and 30 percent are not facing this problem.

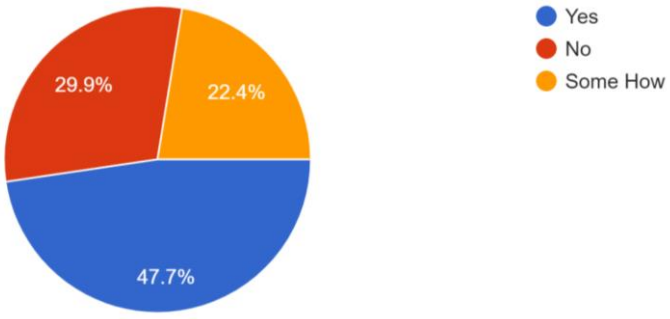

Fig. 10. Ergonomic guidance response chart

From the questions, it can be concluded that classroom and workshop chairs are not soft and adjustable to the height of students. From other questions, we observe that students have problems like back pain, neck pain, eyes, shoulders, etc. Food quality is not good; therefore, these all risks can cause health issues. As mentioned, RULA methods used for Upper limb assessment contain such as back pain, neck pain, or shoulders. Questioners are also giving us information about all these problems, and another thing is that questions also give us that food quality is not good and nobody is giving awareness, training, or knowledge about ergonomics. Therefore, University management should take serious action to improve all these things contributing to physical and psychological issues for students. Students do not know about human factors engineering, so university management and teacher should have given knowledge and training about ergonomics so they can keep quiet about health issues.

8. Conclusion

This study is providing basic knowledge of ergonomics, and awareness of ergonomics to the students, teachers, and staff. From the study, it can be concluded that Mehran University of Engineering and Technology is not providing awareness about ergonomics to the students and also not following proper rules and regulations of ergonomics, due to that students are facing back pain, knees, neck, and eyes problems, which can cause health issues in future. This study was taken from all over the Mehran University through 104 respondents using questioners and by applying RULA methods to get the score of students working in laboratories and workshops. According to the RULA assessment, the total score is 7, which indicates a hazardous situation. Therefore, university administration should take serious action and improve all systems to keep students safe from health issues.

9. Limitations and Future Recommendations

According to the study and results, the university administration should provide the proper awareness/training about ergonomics to the students, teachers, management, and canteen management. Every department should create a diverse and flexible environment that supports students and teachers' diverse needs and abilities and also combine height-adjustable chairs with height-adjustable desks to allow students to optimize their working height while sitting and standing. Students need to work in the proper posture to reduce the chances of any fatigue or hazardless. The administration needs to arrange a good position for multimedia, machines, and board height where they stand up and move around in a good position. Also, canteen management should improve their food quality as students cannot be affected. This study is based on responses from random students at Mehran University of Engineering and Technology, and if the number of participants increases, it may cause different results. The main limitations of this study are that respondents are limited, further it can be accurately analyzed the problems by conducting survey from the students and faculty members as well.

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Authors' Profiles

Atam Kumar is currently working as a final year student in the Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Jamshoro, Pakistan. His research interest in Ergonomics, Lean Manufacturing and Six Sigma, and Quality Control

Bharat Lal is Ph.D. Scholar at Department of Computer Engineering, Modeling, Electronics and Systems, University of Calabria, Italy. He is also working as Lecturer at the Department of Electronic Engineering, Mehran University of Engineering and Technology, Pakistan. His research interests include Wearable Computing, IoT, Compressed Sensing and Health Care Applications.

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Review Article

Evaluating the Role of IT Innovations in Enhancing Logistics and Supply Chain Management Effectiveness: A Review Paper

Atam Kumar[1*], Muhammad Danish[2]

[1]Department of Mechanical, Energy and Management Engineering, University of Calabria, Rende, Cosenza, Italy
[2]Department of Mathematics and Informatics University of Calabria, Rende, Cosenza, Italy

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***Corresponding author:** Atam Kumar
Department of Mechanical, Energy and Management Engineering, University of Calabria, Rende, Cosenza, Italy

Abstract

Supply chain management (SCM) is crucial for companies looking to enhance their business processes, with information technologies playing a significant role in revolutionizing SCM. This paper analyzes modern technologies used in SCM, focusing on logistics, information technology, and supply chain management. It explores how technology is utilized in various sectors where SCM is prevalent. Previous research demonstrates a wide array of technologies used in logistics and SCM, with this analysis highlighting a few key ones. The study reveals that new technologies greatly improve SCM by enhancing quality, efficiency, effectiveness, productivity, and reducing costs. It also investigates the diverse effects of technologies on SCM and logistics, showcasing real-world case studies of successful technology implementation. Overall, the analysis emphasizes the importance of contemporary technologies in advancing organizational progress, particularly in SCM optimization. It provides valuable insights into the benefits and practical applications of technological advancements in SCM, while also acknowledging their disruptive potential.

Keywords: Supply Chain Management, Logistics, Information Technologies, Innovation, Organizations, Impact.

1. INTRODUCTION

1.1. Supply Chain

Supply chain management is one of the most essential aspects of doing business. Many people outside the instant community do not realize this, as the average consumer often only feels the impact. Remember those times when the item you wanted wasn't available at your favorite clothing store or grocery store, remember how many times you got a "good deal" at the end of the season, remember your sudden increase in gas prices due to scarcity, remember those times when your e-commerce website promised stock but couldn't send the requested product or sent you the wrong product or a recall saves you time when your custom product you are significantly delayed. All the above and several other experiences that consumers regularly go through are a direct consequence of the supply chain practices that companies follow. Unlike business-to-consumer transactions, supply chain operations have an immediate impact on business-to-business transactions. In the late 2000s, due to problems in the largely outsourced supply chain for the 787 Dreamliner, Boeing suffered significant delays in launching new aircraft and incurred costs of more than 2 billion USD to support and accelerate the supply of components. Less than two years after delivering the first Dreamliner 787 in 2011, Boeing was ordered to stop production of the plane due to battery quality problems. In 2007, Mattel had to recall tens of millions of toys made in China, epitomizing concerns about the quality of foreign products. While some companies suffer the consequences of poor supply chain management, companies like Amazon, Walmart, and Zara consistently outperform their competitors thanks to their excellent supply chain capabilities [1].

Supply chain management (SCM) is concerned with the coordination and management of an organization's supply chain. Note the plural in “Chains”: Organizations may operate multiple supply chains that work together to serve different segments. For example, in defining logistics, maintenance, repair, and overhaul (MRO) of military systems in an operational area can be managed through separate supply chains. Similarly, in industrial logistics, there may be a specific supply chain

for different combinations of markets, consumers, products, or even seasons [2].

Since Keith Oliver, a consultant at Booz Allen Hamilton, coined the term in 1982, supply chain management has evolved from a simple understanding of logistics into a three-function business enterprise, multi-functional, complex, ranging from supply and demand forecasting to distribution and beyond. Supply chain management is such a broad topic that people often come up with a different definition based on their personal experiences. For example, supply chain management includes managing the supplier base, determining what to outsource and whom to hire, and managing relationships with different suppliers. For others, it all depends on how the different companies in the distribution channel or value chain are integrated in terms of information systems and inventory management practices. In a sense, all these definitions are like blind men defining an elephant according to its different organs. A complete definition of supply chain management can be given as follows.

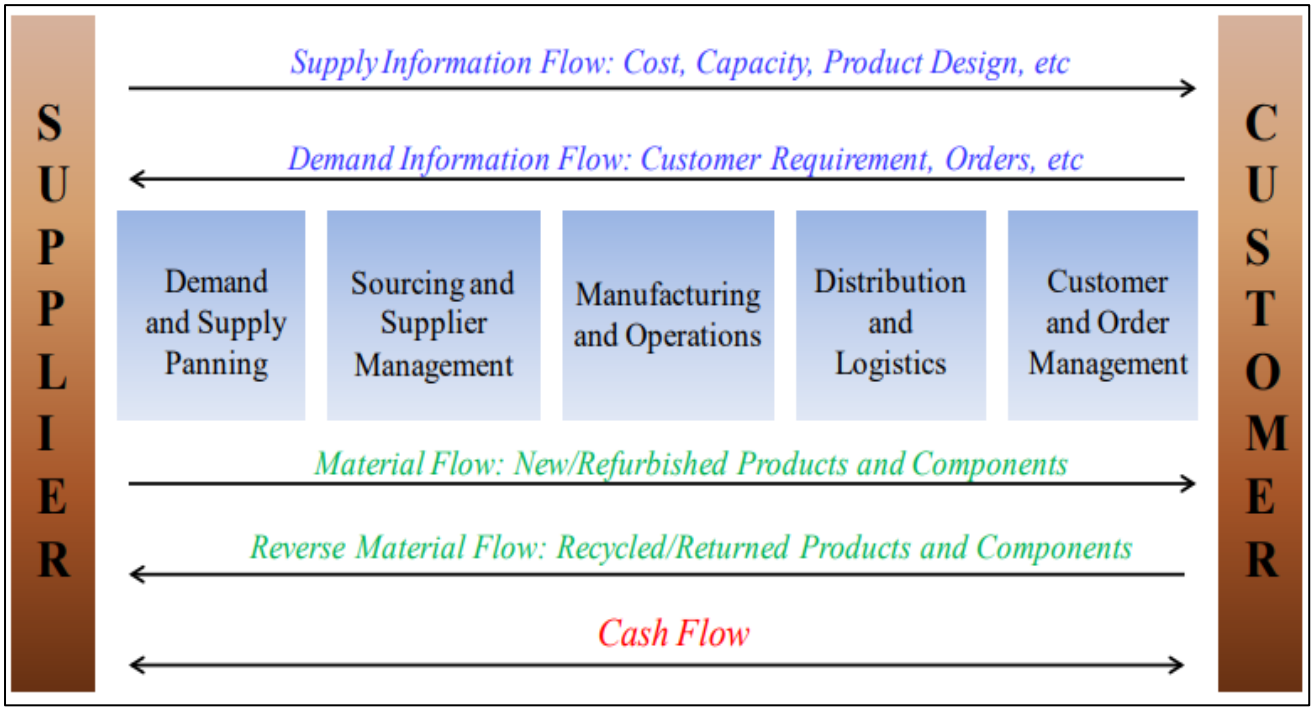

Figure 1: Supply Chain Process [1]

A supply chain is a set of entities involved in designing new products and services, sourcing raw materials, converting them into semi-finished and finished products, and delivering them to final customers. Supply chain management is the effective management of the end-to-end process from the conception of a product or service to the moment it is sold, consumed, and ultimately disposed of by the consumer. This comprehensive process includes product design, sourcing, planning, and forecasting, manufacturing, distribution, fulfilment, and after-sales support [1].

1.2. Logistics

According to a broad definition, logistics is the study within an organization of the management and implementation of activities related to the flow of tangible goods from source to point of use, consumption, or disposal to achieve the organization`s goals. To achieve this goal, logistics requires the collection, integration, and processing of data from multiple sources to plan, organize, and control activities such as processing, production, packaging, storage, and distribution.

The words “logic” and “logistics” both come from the Greek term logos, which means “order”. However, while the word ‘‘logic ‘‘is of direct Greek origin, the word ‘‘logistics ‘‘first entered Medieval French as ‘‘logis ‘‘, meaning ‘‘accommodation ‘‘, and then English. The origins of logistics were purely military in nature. This discipline was born from the study of methods to ensure the accurate supply to the army of food, ammunition, fuel, etc.

The importance of logistics became clear during the American War of Independence (1775–1783) when the lack of adequate supplies for the 12,000 British troops overseas during the first six years devastated morale. Of the army and contributed to their ultimate defeat. In modern times, logistics played an important role in World War II, which helped the Allied powers succeed. In modern times, the key concept in defining logistics is the supply chain, defined as the set of processes, infrastructure, equipment, and personnel that

ensure that a particular vehicle or weapon is fully operational on the battlefield [2].

1.3. Information Technology (IT)

Information technology (IT) is defined as "the science and activity of using computers and other electronic equipment to store and send information" [3].

"Many areas of public health, including vital statistics, surveys and research, surveillance, epidemiology, surveys, laboratory technology, maternal and child health, and environmental health, use information technology (IT) to achieve its goals and objectives. Informatics includes the use of computers and communications, converting data into information and knowledge [4].

"Most modern businesses rely heavily on information systems, from employee emails to database management and e-commerce websites. Hospitals must manage large patient databases. Universities have vast networks to manage. Even a small home-based cookie business needs an order-tracking system. The American Information Technology Association reports that 92% of IT professionals work for non-IT companies" [5].

Today's businesses face the disruptive forces of global competition, rapidly evolving customer needs, and the accelerating pace of technological change that is straining the ability to sense and respond. Responding to market changes becomes necessary. These skills are even more important for companies that must identify and communicate market changes and coordinate responses to these changes across the entire integrated supplier chain [6].

Significant advances in information technology have occurred across all sectors, including changes in logistics and supply chains. Rapid data transmission is a result of information technology in supply chain management, leading to increased collaboration. Information technology helps restructure the entire distribution system to achieve higher service levels, reduce inventory, and reduce supply chain costs. The evolution of IT has given businesses unprecedented opportunities to gain a competitive advantage. Therefore, IT investment is a prerequisite for any company to survive in the market. Supply chain management (SCM) involves the flow of products and information between member organizations in a supply chain. Recent developments in technology allow organizations to easily obtain information at their premises. There are three distinct benefits to developing an inter-organizational supply chain information system: cost reduction, productivity, innovation, and product/market strategy [7].

Modern supply chains and logistics face many challenges related to urban and rural demand, such as how to use competitors as collaborators, increase visibility, and incentivize multichannel, trade-off between analytics and if/then modelling, complexity optimization, and indirect attribution capabilities. Spending, variable metrics targets, and incentives aligned to desired outcomes. Practitioners face challenges such as how to manage complexity closer to customers and how logistics operations can support them, especially how logistics managers can Act as the commander of an information control tower. To address these challenges, it is necessary to design strategies and evaluate points of difference with the support of information technology (IT) [8].

IT infrastructure by itself does not differentiate a company from its competitors because IT applications are increasingly standardized. However, improved business performance and sustainable competitive performance can be achieved when IT infrastructure is used to meet customer-defined organizational needs. IT infrastructure can have a significant positive impact on a manufacturing company's supply chain efficiency when it allows the company to benefit from IT-sharing capabilities. These shared capabilities can help companies create capabilities that are unique, difficult to imitate, and non-substitutable [9].

It has been observed that there are so many problems occurs in various supply chain system as forecasting means predicting future demand, increased cost, lead time increase, labour shortage, delays, poor logistics management or inspection, and quality control. Nowadays IT is the best solution for problems. This study analyses problems related in supply chain management system and logistics system, review previous studies of IT implemented system and compare its impact or effect on modern era.

2. LITERATURE REVIEW

The electronics industry faces rapid market changes, fierce competition, rapid technological innovation, and growing environmental awareness among customers. Therefore, there is an essential need for companies to develop the necessary agility to survive in this competitive environment. Flexibility exists in supply chain networks and can help companies gain a competitive advantage. Previous studies have emphasized that supply chain agility (SCA) focuses on promoting innovation, flexibility, and speed, which subsequently reduces production costs [10].

Faced with increasing global competition, manufacturers are looking to develop sustainable competitive performance to improve their competitive position. Competitive performance can come from many different sources, such as product and service differentiation based on price, quality, or service, but it is most sustainable when it is difficult to imitate. Computer communication represents a potential source of difference. In a company with competitive performance driven by IT, IT systems ensure fast

communication both internally and with external suppliers [11].

In general, technology itself is not a rare or heterogeneous resource. However, computer-sharing capabilities, in the way they are implemented, can be unique and difficult to imitate These two aspects of IT shareability have been used to explain how companies can use IT infrastructure deployment to effectively improve organizational capabilities. The first dimension called the computer scale, represents the degree to which a manufacturing company can provide a transparent, accurate, and consistent flow of information within the company and with suppliers. The second aspect, called computer coverage, is the extent to which a company's computer network connects and supports various functions at different levels within the company, connecting the company to its suppliers. Provides and supports the relationship between the company and its suppliers [12].

In this business environment, organizational processes and product innovation are major business challenges and critical to business success. Innovation is defined as "the adoption of an internally created or acquired device, system, policy, program, process, product or service that is new to the adopting organization. Creating and maintaining a competitive advantage has become a matter of continuous innovation and business innovation. In the past, companies focused on reducing costs and improving quality to gain a competitive advantage. But today, “companies must be able to innovate at the edge of the world” and create and commercialize new lines of products and processes that push technological boundaries, advancing rapidly as their competitors catch up [13].

Information systems, by informing managers about agents' actions, can reduce agents' opportunism and affect the bounded rationality of participants by reducing Contract and supervision costs. IT can reduce coordination costs and reduce transaction risks. It aims to create a less risky relationship between parties by promoting information exchange or by replacing investments in highly specific assets with investments in IT/IS. Imperfect information, an essential aspect of TCE, leaves open risk. Opportunistic behaviour on the part of suppliers. With transparent systems, IT has the potential to reduce imperfect information and uncertainty and has a protective function by reducing information asymmetry and developing group rules among partners. Empirical evidence for the above arguments about the role of IT integration in reducing transaction costs was supported by a study in which B2B e-commerce systems supporting inter-organizational systems were discovered to help reduce transaction costs [14].

An external focus in the use of IT is a critical success factor in responding to market changes and new opportunities. However, this type of usage requires a more complex set of organizational and management capabilities, which is necessary when IT is used only to automate business processes and improve internal efficiency. The environment is associated with the rules of business response in terms of organizational structure and capacity. According to the stochastic and evolutionary perspectives, firms that deviate from these “optimal” responses perform worse and are likely to exit the industry in the long run. In principle, because investments in IT can enable easy adaptation to unstable market demands, changing customer needs, and new market opportunities, dynamic, resource-rich environments will require greater IT deployment to support external IT capabilities. In contrast, in resource-scarce environments, companies are expected to derive greater economic value from developing internally focused IT capabilities, given their importance in enhancing efficiency [15].

Supply chain flexibility is defined as the ability of target companies to match demand with supply in collaboration with upstream and downstream members of the supply chain. The company's innovation capacity role, in addition to producing products and services, is also to promote technology and information. Little attention is paid to innovation capabilities in the supply chain management process. Innovation capacity is the means of accepting or applying innovation concepts to the organization. It is the process of developing a new concept and is used to commercialize products and bring these innovations to market. Innovation ability has a positive impact related to competitive advantage, in which innovation ability can be measured from the aspects of product innovation, process innovation, service innovation, and organizational innovation. New. Regalia said there are four innovations, which are market innovation, radical innovation, incremental innovation, and technological substitution. Meanwhile, competitive advantage includes superior aspects of quantity and quality of financial, physical, and human resources as well as superior management and technical capabilities and favourable location. Stoic said the product design innovation market involves significant changes in key organizational elements. Organizational innovation is the set of new ideas, methods, and organizational goals that support success in the marketplace. Organizational innovation is a key factor considered to achieve competitive advantage and ensure long-term success in market competition. Furthermore, innovation is social change. Organizations with innovation capabilities can respond to environmental changes faster than innovative organizations and thus have high performance. In the age of data and IT developments, companies must innovate and interact with the market. Dimensions of organizational innovation include product innovation, process innovation, and administrative innovation. Anna V and Anatoly K argue that there are five dimensions of innovation capacity, which are financial, human, technological, information, and organizational [16].

3. Role of IT in Logistics and Supply Chain Management.

The role of IT in supply chain management is very important. There are many applications of information technology in supply chain management. It provides tools to gather relevant information and break it down for proper analysis. In addition to helping implement it to achieve optimal supply chain performance. Data is essential for supply chain operations. Mainly because it provides a basis for supply chain managers to make decisions.

So, real-time information is the key to good supply chain management. With deep insights into the different stages of the supply chain, decision-makers can strategize, manage, and align processes to achieve sourcing, inventory goals, production, etc. These are all points that show us the importance of IT in the supply chain. Management and use of IT in supply chain management.

3.1. Integrated and coordinated supply chain

Supply chains can operate effectively when they are well-integrated and coordinated. It accomplishes this important task by integrating multiple technologies and combining them to optimize the supply chain. These technologies make data collection possible, easier, and much more accurate. Ultimately, this enables accurate and detailed data analysis to make sound business decisions.

3.2. Increase productivity.

Smooth information flow, new technology, and effective communication increase the productivity of all units in the supply chain. It's like an introduction to the product movement. In addition, the IT department establishes a link that continuously transmits the necessary information.

3.3. Cost Reduction

It allows for optimal use of assets and resources. Past data is used to study trends. And technology is used to analyse it to fine-tune performance. When resources are used optimally, they help reduce costs. The role of IT in SCM is becoming more and more important as it motivates all parties to use their respective resources in the most cost-effective way possible. When IT is used properly, overall costs are significantly reduced.

3.4. Product improvement

Furthermore, IT includes tools and applications that can be used to achieve early awareness. In a market where customers always want something new, the product will have to evolve, or it will no longer be in demand. So, to stay in business, you need to introduce product improvements and innovations as soon as possible.

3.5. Supply chain visibility

Therefore, the information that builds the entire supply chain is visible to supply chain managers. The way information is passed from one employee to another and its impact on others are used by managers to make strategic decisions [16].

4. Technologies used in supply chain and logistics systems

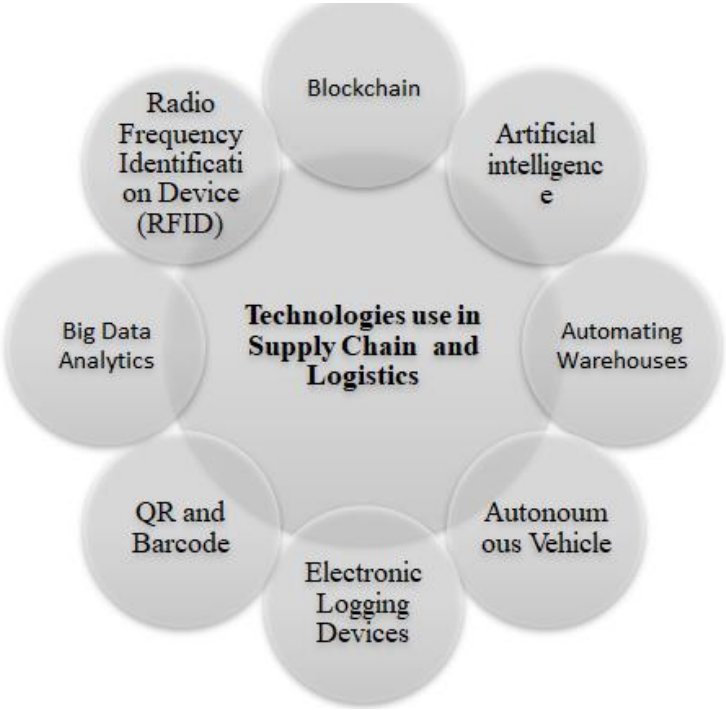

Figure 2: Technologies used in Supply Chain and Logistics [17]

5. Impact of Technologies on Supply Chain Management and Logistics.

5.1. Impact of Blockchain Technology on Supply Chain Management and Logistics.

International Business Machines (IBM) defines Blockchain Technology (BCT) as an immutable, shared ledger that facilitates the process of recording transactions and tracking assets within a business network, which can be visible or invisible to reduce risk and minimize costs. BCT provides instant, shared, and fully transparent information to authorized networks that can track production, accounts, orders, and payment statuses with end-to-end details. According to Brook Banks and Parry (2022), Blockchain-based platforms provide shared trust, reduce data duplication, and improve supply chain visibility. The key elements of BCT are immutable records, smart contracts, and data management using distributed technology [18].

The connection of individual blocks to these pointers creates a chain of blocks called a Blockchain. The main benefits of Blockchain are decentralization, cost reduction, scalability, or making transactions efficient, and distributed rather than decentralized. According to Baja, technology, IT systems, and operational efficiency are the most important factors in BCT. Blockchain security relies on digital identity and cryptography. BCT can contribute to important supply chain goals. According to Fernandez, the benefits of Blockchain-based supply chains are significantly greater than conventional supply chains. Members of the supply chain collaborate to add value to the material flow with the essential goal of meeting the needs of the end customer. According to Kouhizadeh, the four main capabilities of Blockchain are transparency and traceability, reliability and security, smart contracts, and incentives. Different people view supply chains differently [18].

Some of the positive impacts of BCT are discussed as follows:

- By implementing smart contracts, BCT enables real-time order settlement and automation of production tasks. Additionally, BCT ensures that ripple effects in OSCM are minimized, thereby minimizing disruptions caused by model changes.
- BCT services ensure data and resource allocation, system security and confidentiality, confidentiality, authentication, and integrity. BCT is significantly more secure than conventional IoT systems or conventional security services thanks to its ability to improve cyber security and deliver superior performance.
- BCT enables efficient business process management through smart contracts by combining the control flow and business logic of business activities across organizations. Blockchain can also be integrated with smart contracts for hyper-connected logistics, where the mechanisms are supported by triggers and act as a connection between business applications and the Blockchain.
- Using digitalization and smart contracts to ensure collaboration between all stakeholders, integrating BCT will transform OSCM's organizational structure.
- By integrating BCT with SC, Blockchain improves quality, productivity, and cycle time, creates new business opportunities, and drives product differentiation. There have been many studies on the effectiveness of using BCT to regulate prices and destroy products.
- Using Blockchain in OSCM not only improves efficiency and reduces costs, but also improves interaction between all participants. In addition, it increases trust and simplifies related business procedures.
- BCT drives supply chain resilience by minimizing the impact of disruptions using a proactive and preventative approach to risk management while providing multi-layered protection for OSCM networks. The decentralized structure of Blockchain facilitates the identification of network and organizational risks associated with each OSCM function.
- By enabling process automation, eliminating the middleman, and enabling real-time tracking through data management, traceability, and privacy approaches, all this [18].

5.2. Impact of AI on Supply Chain Management and Logistics

AI is having a huge impact on supply chain management. Logistics companies that manage supply chains can benefit from AI`s ability to monitor freight movements at scale and predict shipping needs. With the help of AI, supply chain managers now get a clearer picture of the entire system, make smarter decisions, and provide more attentive customer service. The impact of artificial intelligence on supply chain management performance. And knowledge of supply chain management. The components of an expert system are described by Kodiak (2019) as: Knowledge reorientation, which is where knowledge is framed, interface engine, which describes the knowledge acquisition and control strategy, allows the system to collect data and knowledge aims to solve supply chain management problems.AI is increasingly being applied to supply chain management to improve performance from an Agile and Lean perspective. Many companies are investing in digital solutions to optimize their supply chain operations. Figure 3 illustrates the global adoption rate of AI in manufacturing and supply chain companies. The literature has shown that AI can give businesses the ability to respond quickly to changes in demand, reduce waste, and improve collaboration and customer satisfaction [19].

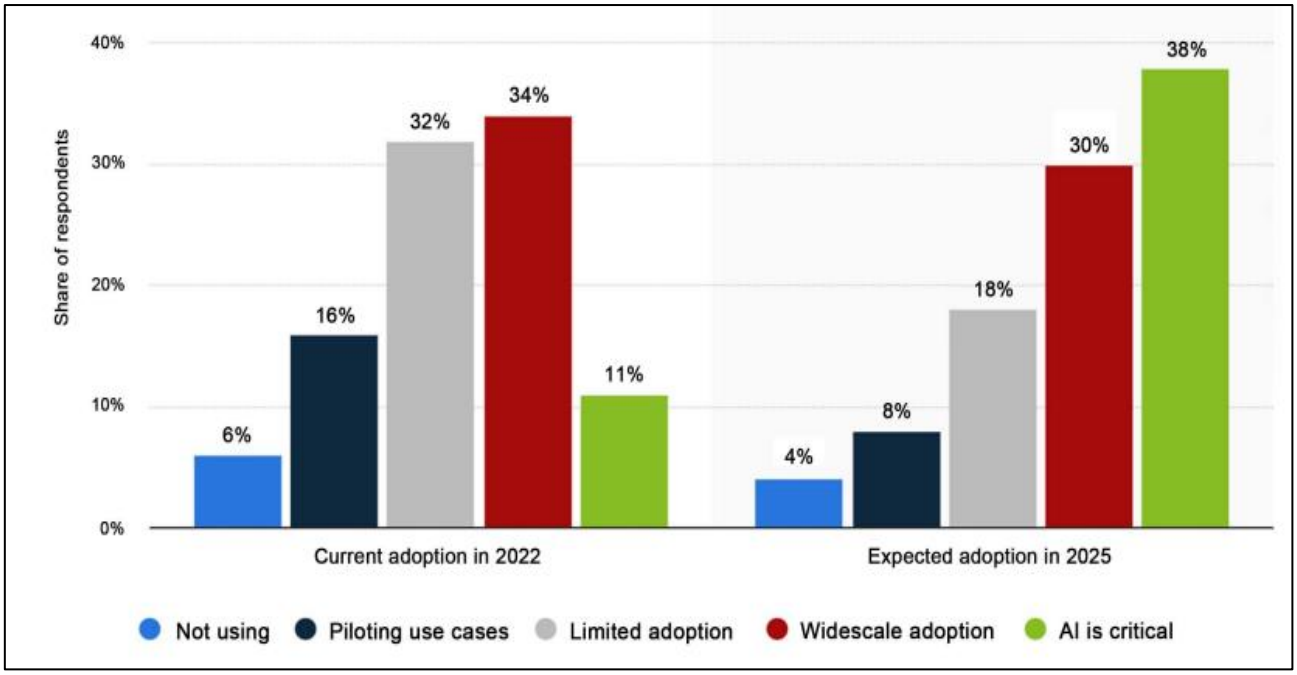

Figure 3: Global AI adoption rate in supply chain and manufacturing business (2022 and 2025) [19]

5.3. Impact of Automating Warehouse on Supply Chain Management and Logistics.

Warehouse technology and automated systems can help solve warehouse and supply chain problems cost-effectively. The right technologies can increase efficiency by improving inventory control and picking accuracy, warehouse flexibility, responsiveness, and safety and security. By combining different technologies, items can be easily moved around the warehouse and stored in their respective locations. We`ll also look at some current and emerging technologies and how they can improve your inventory planning and optimization strategy [20].

5.4. Warehouse Management Systems (WMS)

The most resilient supply chains use systems that can process big data and provide advanced analytics and real-time insights. Radio-frequency identification (RFID)--based warehouse management systems can help you collect, transfer, verify, and update bulk data about the location of your goods. It operates in real-time from ingestion to dispatch and delivery, reducing labour intensity and scanning errors. Automating the warehouse management process can eliminate the need for manual inventory tracking. Improving inventory management processes can also help make the most of storage space by tracking the flow of goods through the warehouse. Combining big data, advanced analytics, and real-time insights with a modern ERP system can help you optimize your supply chain and improve its resilience [20].

5.4.1. Automated Guided Vehicles

Automated guided vehicles (AGVs), such as smart forklifts and pallet carts, are increasingly used to move inventory around warehouses. They travel digitally, loading and unloading goods without the need for human drivers.

Depending on your warehouse and ordering process, a mix of vehicles can support your warehouse team [20].

5.5. Impact of Bar Code and QR Code on SCM

A barcode is a series of parallel lines of varying thickness and space between them. These bars are nothing more than Information elements in an encrypted form that can be read by a scanner. Information printed in bar form includes code, country code, manufacturer name, product details, production date, material content, etc. The detailed information is used on the user side for inventory management. THE Barcodes are used in many industries such as the pharmaceutical industry, large shopping malls, consumer goods, electricity, manufacturing, etc [21].

The Bar Coding Offers the Following Advantages:

- Easy identification of inventory/stock items during storage, pickup, inspection, and dispatch.
- Reduce paperwork/documentation and processing time leading.
- Reduce human error.
- Increases logistics system productivity through speed, accuracy, and reliability [21].

5.5.1. Impact of Bar Code Technology on Operations of Logistics and Supply Chain Management

Supplier sourcing materials are assigned a bar the code contains information about the item name and batch number, production date, order number, serial number, etc. The information contained in a barcode

helps with the identification and tracking of ingredients. The information decoded by the scanner will be stored immediately in a central computer allowing real-time updates of inventory records [21].

Processing- During the order processing the bar code will help in keeping the identification of items based on their date of entry into the warehouse or store. This will ease material storage and dispatch [21].

Production- During the production process the identification of in-process and finished items becomes easier due to bar coding. The various batches at different stages of production can be easily tracked [21].

Distribution-During distribution, the barcode helps in identifying and tracking the transit of finished goods to the customers [21].

5.6. Radio Frequency Identification (RFID)

RFID is automatic identification and data capture (AIDC). RFID-based systems enable contactless reading and are effective in manufacturing as well as other environments where barcodes cannot exist. This system is used as an alternative to barcodes to transmit inventory data to readers via radio waves. RFID wireless system in which information is exchanged between the tagged object and the reader [21].

An RFID System Is Comprised of the Following Components as Mentioned Below,

- One or more radio frequency tags (RFTs), including semiconductor chips and antennas.
- One or more read/write devices are also called readers.
- Two or more antennas, one on the tag and one on the reader.
- Application software and host computer system [21].

5.6.1. RFID has a Significant Impact on the Logistics and Supply Chain of Many Sectors

Increases manufacturers' ability to easily manage inventory levels. Enhance complex distribution systems for National Defence activities. Enhance the Indian Postal Service's sophisticated tracking and delivery operations. Enhance tracking, logistics, and planning in the manufacturing industry. And deploy automatic toll collection on the road network [21].

5.7. Impact of Big Data on Supply Chain Management.

Big data is transforming supply chain management by providing insights that enable better decision-making and improved operational optimization. With the increasing availability of data and technological advances, supply chain managers can leverage big data to gain a competitive advantage in the marketplace.

Using big data Supply Chain Managers can:

Improve demand forecasting capabilities**.** Optimize production planning and scheduling**.** Increase transportation efficiency**.** Reduce supply chain risk [22].

Big data analytics facilitates collaboration between different stakeholders in the supply chain, including suppliers, manufacturers, distributors, and retailers. By sharing data and relevant information, companies can improve coordination, synchronize production schedules, and optimize inventory levels [23].

6. Case Studies

6.1. Case Study of Lenovo by Using Blockchain Technology

Communication Verify and record activities and transactions and perform intelligent data collection and processing purchasing as well as implementation, thereby improving the service capacity of the supply chain. The present study examines Lenovo`s use of Blockchain technology to enhance supply chain management and proposes a conceptual model for a Blockchain-based approach. We chose Lenovo as a case study because it is a global leader company recognized for its supply chain excellence. Lenovo has established strong relationships with upstream and downstream partners, and there is no doubt that its supply chain technology deployment strategy and supply chain management provide top advice for various industries [24].

6.1.1. Background Information

Lenovo operates in 180 countries and regions and operates 35 factories worldwide. Lenovo sets up a complex supply chain network. For example, LCFC Electronic Technology Co. (Hefei), company the world`s largest personal computer (PC) factory, handles 30,000 rolls of electronic components Raw materials go through a fully automated warehouse system every day and transfer more than 2000 types of raw materials every four hours, which means any potential problems in production of spare parts can disrupt the supply chain. LCFC factory (Hefei) is actively developing products of the fourth industrial revolution, such as intelligent production planning, joint production planning, Blockchain-based supply chain collaboration, and more Innovative applications, significantly improving production efficiency. At the beginning of 2023, LCFC Factory (Hefei) was successfully selected for the list of ‘‘top factories ‘that represent the highest level of global smart manufacturing. Previously, to ensure the stable operation of the entire supply chain, Lenovo worked together with its suppliers and equipment manufacturers and had to assign large numbers of workers to complex tasks, Time-consuming tasks include checking accounts and tracking order statuses. Since 2017, Lenovo has applied Blockchain technology into the supply chain by proposing a supply chain integration model chain and Blockchain (hereinafter referred to as the dual chain

integration model. It applies a server operating model to integrate information flow, logistics, and flows capital in its supply chain, ensuring greater transparency in all production activities stage. After 5 years of development, Lenovo has made outstanding progress in research and development by Applying the combination of Blockchain and supply chain (see Table 1) [24].

Table 1: Lenovo's practical exploration of the Blockchain application [24]

Step in the Process	Main Achievement
Technical preparation	From 2016 to 2017, Lenovo began to conduct technical research on blockchaining, exploring the landing direction and application direction, mainly focusing on the application in the financial industry at the beginning
The "dual-chain integration" model is proposed	In 2017, a "dual-chain integration" model was proposed based on the similarity between supply chain structure and blockchain structure.
Small-scale application in the server business	In 2018, Lenovo began to carry out a small-scale application in the server business, using blockchain technology to establish a trusted sharing mechanism among Lenovo, foundries, and suppliers
Summarize experience and try to establish industry standards	Released "Lenovo Blockchain Technology White Paper" in 2018, "Lenovo blockchain white paper supply chain solution" in 2019, and "Blockchain supply chain Collaborative Application White Paper" in 2020

It addresses the challenges that traditional supply chain operations face, such as inefficiencies, lack of data transparency, and poor traceability. As a result, it significantly improves the operational efficiency of companies participating in the supply chain and ensures effective information sharing. After reviewing the development of Blockchain technology and related literature on the application of Blockchain technology in the field of supply chain management, we found that there is a lack of Blockchain applications in related fields focusing on focusing on improving supply chain collaboration efficiency. By interviewing key business and technical personnel, we explored the challenges Lenovo faces in its business operations and supply chain management related to applying Blockchain technology to solve related issues. To help other companies in the industry better learn from Lenovo`s practices, we have summarized and summarized Lenovo's technical solutions into the data layer, contract layer, and application layer, and explained the content and functions that need to be implemented in each layer form a three-layer architectural model of a supply chain information system based on Blockchain technology.

The conceptual model proposed in this article focuses on the possibility of developing Blockchain technology applications from the perspective of supply chain collaboration and provides basic direction and content that needs to be considered for it to be usable. It is worth emphasizing that our case study primarily examines collaboration issues in the context of Lenovo's operations, focusing solely on the Blockchain mechanism rather than the characteristics of the IT industry. However, Blockchain technology still faces some challenges in supply chain collaboration, which will be gradually resolved in future research and practice. First, data privacy protection must be improved. However, sharing real business data across the supply chain has value in the realm of supply chain collaboration.

Second, the adoption of Blockchain-based supply chain collaboration needs to be further encouraged. Compared with finance, certificate of deposit, pure tracing, and other application system 2023, 11, 299 21 of 25, Blockchain-based application in supply chain collaboration requires complex advanced technologies. However, few companies are willing or willing to adopt this application, so effective promotion among companies in the upstream and downstream supply chains still needs to be achieved. Fourth, the application standards of related technologies need to be clarified, because the international community currently attaches great importance to Blockchain standardization. However, regarding application scenarios in supply chain collaboration, existing research on applicable standards for related technologies is still incomplete. Therefore, in the future, typical innovative applications for promoting Blockchain on a large scale can be considered and the logic of Blockchain-based supply chain scenarios can be further clarified [24].

6.2. Case Study of Artificial Intelligence (AI)

Logistics companies that manage supply chains can benefit from AI`s ability to monitor freight movements at scale and predict shipping needs. Since the beginning of 2010, AI applications have exploded in popularity, creating both enthusiasm and anxiety about the future of the world of work and business administration. The supply chain literature seems to be catching up with some recent efforts to integrate modern AI methods into its core research, even as companies

adopt AI and invest in AI solutions to improve their end-to-end supply chain operations. AI is defined as a computer network that can simulate human intelligence while making decisions about how to approach a business problem. AI helps design thinking in business systems and learns from data to gain insights without human intervention. With the help of AI, organizations can identify weaknesses in their supply chain management and allocate resources accordingly. By quickly tapping into customer expectations, analysing the market, using failure modes, optimizing internal and external supply chains, and encouraging a more innovative workforce through automating routine tasks, AI has the potential to help businesses create the best products possible. Most supply chains have faced new levels of resilience during the COVID-19 crisis as they face the challenge of managing increasingly complex tasks. The components of an expert system are described by Kodiak (2019) as Knowledge reorientation, which is where knowledge is framed, the interface engine describes the knowledge acquisition and control strategy, allows the system to collect data and knowledge aims to solve supply chain management problems. Rule-based, fuzzy, framework-based, and hybrid methods are some examples of expert system approaches that can be used in combination with each other to achieve optimal results from AI in supply chain management. According to Jakupović`s (2014) research, expert systems work very well in domains where human intelligence can be formally organized. In recent years, there has been growing interest in applying AI techniques to the modelling and simulation of complex systems in supply chain management. Agent-based computational techniques can be a valuable tool for describing the interactions of system components and analysing performance in real-world supply chain management scenarios [25].

6.3. Case Study Regards Electronic Lodging Devices.

Initially, the most obvious impact was on price. Without the ability to circumvent the law, carriers cannot squeeze more productivity out of drivers. It has become more difficult for carriers to carry out similar transport operations in less time. Direct impact on exchange rates and prices. Another impact is on capacity. This new mandate may have weeded out non-compliant businesses. Additionally, drivers are creatures of habit, so these new rules and regulations may cause motorists to complain. The new regulations may have prompted some drivers to explore new and different employment opportunities. This mandate could cause problems for carriers in an already difficult driver recruitment and retention market. In the new ELD environment, driver wait and hold times have a direct impact on supply chain performance and on-time performance. The days of having to wait 3-4 hours to charge are long gone. If shippers want their goods to arrive on time, they need to adjust their shipping method. Keeping drivers at the docks for hours reduces their productivity and therefore affects their punctuality. Shippers will need to respond and manage driver loading times appropriately. Arresting drivers will remain a major problem. Drivers are paid to drive, and if time in port is wasted, carriers rush to charge for time spent in detention. In short, this mandate is good for the industry. Awareness of the changes will help shippers and carriers respond to this new environment together. Shippers should pay attention to the ELD mandate and respond to this new shipping environment. Here are some simple ways to collaborate and adapt to your carrier base and shipping methods. Discuss your service provider`s compliance with the mandate and identify potential impacts on your business. Discuss transit times on rails. Has your carrier been traveling for hours on one of your shipping routes? If so, discuss plans to restructure lane zoning and/or planning to meet your transportation parameters. Work closely with your carrier partners and internal teams. Remember that being prepared and ready to load your shipment will help your carrier meet transit times and reduce potential detention times. Work with your internal shipping team to become a “preferred shipper.” Carriers prefer to work with shippers who are organized and efficient. Again, the driver is paid to drive. These opportunities will also reduce wait times and therefore maximize your driving hours in the lane. If you are aware of and adapt to this new environment, you can manage these impacts and position your supply chain for success [26].

6.4. Case study of Warehouse Management System.

A warehouse is a facility in the supply chain to consolidates products to reduce transportation costs, achieve economies of scale in manufacturing or purchasing, or provide value-added and shortened processes. Warehouses are facing a variety of challenges: increasingly integrated and shorter supply chains, globalized operations, more demanding customers, and ongoing technological changes. A warehouse management system or WMS is primarily intended to control the movement and storage of materials in a warehouse and process related transactions including shipping, receiving, putting away, and picking. Warehouse management system 'WMS' is a database-based computer application designed to improve warehouse efficiency by directing cuts and maintaining accurate inventory by recording warehouse transactions. The system also directs and optimizes inventory based on real-time information about trash usage status. They often use automatic identification data collection (AIDC) technology, such as barcode scanners, mobile computers, wireless local area networks (LANs), and Radio Frequency Identification capabilities (RFID) to effectively monitor product flow. Once data is collected, there is real-time mass synchronization or wireless transmission to a central database. The database can then provide useful reports on the status of goods in the warehouse. The main function of a warehouse control system is to receive information from a higher-level host system, usually a warehouse management system, and translate it for daily operations. A warehouse control system is typically the interface used to manage

processes, people, and equipment at the operational level [27].

RFID technology is applied to support the collection and sharing of data in the warehouse. Implementing RFID technology requires a thorough analysis of the costs and benefits of implementation. RFID can improve the self-checkout process in retail stores, so it can reduce inventory costs through more efficient shelf replenishment. RFID technology can support business process redesign; improve data quality; real-time data collection; and synchronize and share information between actors in the supply chain. Implementing RFID can also provide additional benefits such as reducing losses due to shoplifting and increasing the use of point-of-sale applications.

This case study conducted at India`s largest retail company, which has developed expertise in supply chain management of consumer products such as fashion, food, and general merchandise. The company operates from 60 strategically located centres, serving over 2,600 stores spread across India. Of the three warehouses studied, one had an automated WMS and the other two were managed manually and had a high cycle time of 773 minutes. The retail chain has three other warehouses serving a total of 14 stores across South India. With the company planning to add more stores and establish a centralized warehouse, the chain will become less efficient. To improve efficiency, a study was conducted to analyse the impact of implementing WMS in these warehouses. The research begins by understanding the current state of warehouse operations. Value stream mapping was used for this purpose. Value stream mapping is the simple process of directly observing the flow of information and documents as they occur and summarizing them visually. The value chain includes all the steps, value-added and non-value-added, required to move a product or service through the stages of the process. Next, a future system map (if needed) is developed to design a lean process through the elimination of root causes of waste and process improvements, all of which led to deployment. At these warehouses, goods are received in large quantities and stacked on shelves. Even though scanners are used to receive goods in these warehouses, they are still considered manual warehouses. Many sellers who supply warehouses still send goods directly to stores and then to warehouses due to infrastructure and capacity limitations. The current process has a cycle time of 773 minutes, of which 537 minutes are non-value added. Because it follows a continuous rotation process, goods must be stored on the floor until dispatched. The amount of goods that can be stored directly corresponds to the total floor space available. Minimal racking was available to store “return to vendor goods”. With limited available infrastructure, it was difficult to track and retrieve these items. As shown on the map, the processing cycle time is reduced to 236 minutes. On-value-added time was reduced to 95 minutes. The process-wise improvements are shown in Table 2.

Table 2: Performance Improvement at Warehouse after WMS Implementation [27]

Process	Time Saving per Order (in minutes)	Process Improvement (%)
Receiving	159	68
Put-Away	14	36.84
Picking	49	77.78
Packaging	35	68.62
Dispatch	424	94.2

6.5. QR codes

One of the key benefits of using QR codes for inventory management is the ability to track inventory in real time codes can be used to track the movement of products in the warehouse, from receipt to shipping. As products move through the warehouse, QR codes can be scanned to update location and quantity.

Three Ways You Can Use QR Codes in Your Warehouse

Receiving:

One of the most important stages of inventory management is the receiving process. This is where products are received and checked for accuracy and quality. By using QR codes, the receiving process can be streamlined, saving time, and reducing the risk of errors.

When products are received, they can be tagged with a QR code that includes information about the product, such as name, SKU, and quantity. QR codes can be scanned to update inventory systems and track product movements in the warehouse. This process can be more streamlined by using a mobile app that scans QR codes and updates the inventory system in real-time.

Picking and Packing:

Pick and pack is another important step in warehouse inventory management. This is where products are picked from the warehouse and packaged for shipping. By using QR codes, the picking and packing process can be made more efficient and accurate.

Each product can be labelled with a QR code that includes order information, such as the order number and quantity of product needed. Warehouse staff can scan QR codes to check products and update the inventory system. This process can be more streamlined by using a mobile app that scans QR codes and provides picking and packing instructions to warehouse staff.

Shipping:

Shipping is the final step in inventory management. This is where products are packaged and shipped to customers. By using QR codes, the shipping process can be made more efficient and accurate.

Each product can be labelled with a QR code that includes shipping information, such as delivery address and service provider. When products are shipped, QR codes can be scanned to update inventory systems and track product movements. This process can be more streamlined by using a mobile app that scans QR codes and generates shipping labels and delivery slips [28].

6.6. Global Positioning System (GPS)

The logistics and supply chain sectors are an essential part of the global economy. They involve planning, managing, and executing the movement of goods and resources from one point to another. These industries are famous for their complexity, resulting from the different players, the many modes of transport used, and the need for on-time delivery.

In recent years, GPS tracking devices have been a game changer in the logistics and supply chain industry. These devices provide real-time shipment tracking, monitoring, and analytics, delivering greater efficiency, cost savings, and improved customer satisfaction.

6.6.1. The Impact of GPS Trackers on the Logistics and Supply Chain Industries

GPS tracking devices provide real-time tracking and monitoring of shipments, vehicles, and assets, allowing businesses to manage their supply chains more effectively and efficiently. By tracking shipments and vehicles in real-time, businesses can gain valuable insights into their operations, including the location and condition of goods, fleet performance, and potential delivery problems or delays. Using real-time tracking data, businesses can optimize their routes and schedules to minimize idle time and reduce fuel consumption, resulting in significant savings. Additionally, GPS tracking devices can help businesses reduce the risk of theft or loss by providing alerts and notifications if assets or shipments deviate from the expected route or location. With real-time tracking and monitoring, businesses can provide customers with accurate, up-to-date information about their shipments, including estimated delivery times as well as any delays or problems. In addition to these benefits, GPS tracking devices can also help businesses comply with regulatory requirements and improve their environmental sustainability. By optimizing their routes and schedules, businesses can reduce carbon emissions and improve environmental performance. Additionally, GPS tracking devices can help businesses comply with regulations related to driver safety and vehicle maintenance by providing data on driving behaviour, vehicle performance, and vehicle needs.

Future of GPS trackers in logistics and supply chain

The future of GPS trackers in logistics and supply chains looks promising with the continuous advancements in technology. Here are some potential developments to look out for:

Integration with other technology: GPS trackers will likely be integrated with other technologies such as sensors, IoT devices, and machine learning algorithms. This integration will provide more accurate, real-time data allowing businesses to make informed decisions.

Artificial intelligence: Artificial intelligence (AI) is becoming increasingly popular in the logistics industry, and GPS tracking devices are no exception. AI algorithms will enable businesses to analyse large amounts of data collected by GPS tracking devices, helping to optimize delivery routes, improve supply chain visibility, and reduce costs.

Predictive analytics: Predictive analytics will be a game changer in the logistics sector. GPS trackers can provide real-time data on shipment location, temperature, and other important factors. By analysing this data, businesses can predict potential delivery delays, identify shipping behaviour patterns, and optimize supply chain operations.

Blockchain Technology: The use of Blockchain technology in supply chains and logistics is growing in popularity, and GPS tracking devices can play an important role in this regard. By combining GPS trackers with Blockchain technology, businesses can create a secure, transparent, and tamper-proof supply chain network.

Autonomous technology: GPS tracking devices are already being used in autonomous vehicles, but this trend is expected to continue. With the rise of autonomous trucks and delivery drones, GPS tracking devices will play a vital role in ensuring these vehicles reach their destinations safely and efficiently [28].

7. CONCLUSION

From this review study it has been observed that Logistics and supply chain management have been significantly impacted by technology, enabling organizations to boost productivity, reduce costs, and boost customer happiness. It has given businesses using cutting-edge technology a competitive advantage. Additionally, it has served as a platform for the creation of innovative products and services. Automation, AI, IoT, and Blockchain and other technologies that are causing change in the market. The adoption and use of technology in the supply chain and logistics sectors will keep growing. These recently described technologies are currently accessible and will significantly enhance your supply chain. Future developments that will impact supply chain management and logistics are likely to increase as technology develops.

8. Limitation

This study just overview of previous studies and focuses on which technologies are used in supply chain and logistics and what is the impact of those. In this study no authentic data means new data has been taken from any service or manufacturing system but it has been analysed from the previous studies or case studies data. If this study takes data from any supply chain system or logistics, then there may be other results, but previous studies suggest these results.

9. Future Recommendation

It suggests that the next researcher go to various supply chain and logistics firms and find out technologies used there and collect the data according to their usage and then compare the results of all firms' data. After doing a comparison, decide what is impact of technologies in the supply chain and logistics system.

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Identify Main Challenges in Human Resource Departments and Suggest the Remedial Actions: Case Study

Atam Kumar [a*], Hafiz Karim Bux Indher [b], Rab Nawaz [c]

[a] *Department of Engineering Management at the Università della Calabria, Rende, Cosenza, 87036, Italy,*
[b] *Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Pakistan,*
[c] *Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Pakistan.*

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ABSTRACT

HRM is a crucial field that manages the relationship between employers and employees, including hiring, training, and evaluating their work output. It faces numerous challenges, including employee engagement, leadership development, health, onboarding, new hiring training, HR effectiveness measurement, compensation, and benefits. Technology changes can also lead to financial losses. Retraining and upskilling unskilled employees is another issue. This paper aims to identify the biggest challenges in HRM and identify solutions to decline them. The methodology used is Google Forms to make questionnaires, collected data with 80 responses from employees in Pakistan and Italy. The study identifies several challenges, including change management, leadership development, HR effectiveness measurement, recruitment and selection, training, employee engagement, relationship building, and poor communication. The most significant challenges are change management, leadership development, and HR effectiveness. To address these, the study proposes remedial actions based on employee feedback, such as employee training, skill development, right recruitment and selection, team cooperation, and continuous monitoring. However, the study has limitations, such as the HR department being the main hiring department and the study is based on online questionnaires, if the data is taken physically from the companies, then there may be a few changes in results.

1. Introduction

HRM is the science and practice of managing the relationship between employers and employees, including hiring, training, using, and evaluating their work output [1]. An organization's strategic use of human resource management requires a deep understanding of human behavior and the ability to effectively manage it [2]. It is a crucial field in organizational sciences, but its understanding of behavior in and out of organizations requires a variety of viewpoints. While HRM and I/O may overlap, there may be distinctions between the two. If

* Corresponding author email address: atamkumar2018@gmail.com (Atam Kumar).
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labor relations and HRM are included in IR, HRM may be the only viable branch for the future[1]. This is a specialized field that focuses on designing innovative programs, policies, and activities to enhance individual and organizational objectives and assess needs[3]. It enhances an organization's abilities, expertise, productivity, collaboration, dedication, and results, making it crucial for achieving organizational goals. It shapes employees' attitudes and behaviors, strengthens employer-worker bonds, and encourages creativity and invention. HRM helps businesses achieve their goals while inspiring employees to contribute to the organization's success [4]. The digitalized functions scale will be used to evaluate the role of human resource management in planning, hiring, performance management, and learning and growth [5].

The HRM components that significantly impact an organization's bottom line are challenging to adapt and compare due to an unresolved issue with HRM assessment items, which hinders the comparison of findings across different studies [6]. HRM functions include staffing, performance, change management, and administrative tasks. Staffing activities involve planning, hiring, training, and retention of employees. Performance activities focus on optimizing performance through labor relations, union-management interactions, and incentive programs. Change management involves hiring, training, and handling disputes. Administrative tasks maintain records and ensure legal compliance. These functions are essential for a company's success [7].

Empirical studies reveal a strong correlation between performance and HR practices across various industries and nations. HR procedures significantly enhance employee performance, helping organizations achieve their goals. Therefore, companies should view their HR procedures as a crucial tool for leveraging workers' performance to achieve their objectives. This rich body of literature highlights the importance of HR practices in enhancing employee performance [4]. HRM, or employee management, has undergone significant transformation in the public sector over the past 20 years, particularly for professionals. These professionals, due to their knowledge, expertise, and abilities, have greater discretionary authority in the workplace. New Public Management (NPM) reforms have impacted professionals in various ways, revealing trends in their impact. The special issue aims to present the crisis of professionalism and expand on research on new challenges public sector workers will face in the 2020s, emphasizing the need to consider the context and environments they interact with [8].

HRM must adapt to changing company requirements and sociopolitical and economic settings by creating strategies, guidelines, and procedures. HR professionals aim to establish themselves as business partners, supporting organizational strategy and responding quickly to changing business realities, strengthening their role within organizations [9]. HR management's tactical and strategic responsibilities are crucial for successful staff management in the banking sector. HR should establish relationships with professionals and senior executives to fulfill this strategic role. HR should ensure specific, logical, and efficient activities to manage people-side issues effectively [10].

Employees are crucial for a company's social and human capital growth and sustainable human resource management (HRM). Sustainable HRM focuses on long-term goals and outcomes without compromising profitability, including employee and environmental care, participation, development, external partnerships, flexibility, adherence to labor laws, cooperation, equity, and equality. It is a better strategy for real HR management [11]. The

increasing competitiveness of businesses is putting pressure on staff functions to reallocate resources to areas with greater economic impact. This may lead to downsizing, outsourcing, automation, or elimination of functions. However, the HR department is not well equipped to measure its influence on company performance, and the conceptual links between HR and business performance are not adequately defined. Therefore, attempts to refocus HR may not be well-received [12].

The World Wide Web has revolutionized information access in organizations, enabling HR management to adopt B2E solutions and streamline processes. Strategic HR organizations are increasingly utilizing electronic HR technologies to reduce administrative responsibilities, allowing HR practitioners more time for strategic activities [13]. Beyond trying to match HRM practices to the organization's strategic direction, Fisher (1989) identified three primary problems. First and foremost, given the increasing trend towards globalization, HR directors need to be prepared to handle cross-border concerns including expatriation and the benefits of implementing HRM methods in other countries. Second, due to the significant increase in mergers and acquisitions, HR executives need to retrain their skills to assist with the post-merger/acquisition process. Third, Fisher contended that American companies have been compelled to adopt a "lean and mean" strategy due to foreign acquisitions or competition. As a result, several organizations have resorted to alternate work arrangements including downsizing. Thus, HR directors need to become more proficient in handling problems like layoffs and the administration [1]. New technology advancements and increased accessibility of HR data enable businesses to effectively utilize internal and external data for decision-making, such as identifying and selecting skilled personnel and designing effective training programs [14].

1.1. Goal of study

The human resources department faces numerous challenges, including employee engagement, leadership development, health, onboarding, new hiring training, HR effectiveness measurement, compensation, and benefits. Technology changes can also lead to financial losses. Retraining and upskilling unskilled employees is another issue. These challenges are among the top ones affecting organizations.

1.1.1. **Aim:** Find the biggest challenges in HRM and identify solutions to decline them.

1.1.2. Objective

1.1.2.1. To analyze HR problems.
1.1.2.2. To identify why challenges, occur in HRM.
1.1.2.3. To identify what can be the impact of those challenges.
1.1.2.4. To assign future solutions or reduce those problems.

2. Literature

An organization's human resources must possess highly competitive capabilities, including the ability to gather, process, and apply information, react appropriately to opportunities, mitigate risk, and decrease financing. These capabilities should include physical characteristics, moral and spiritual qualities, social and psychological qualities, and highly competitive talents, all of which contribute to the overall success of the organization [2].

In 65% of participating organizations, HR departments are referred to as Human Resource Management Departments, often in large IT, financial, and service sectors. In 12.2% of these organizations, the HR manager is a vice president. HRM strategies align with business

strategies in half of these organizations. Primary responsibilities include staffing, wage determination, compensation, training, health-related issues, performance evaluation, payroll design, transfers, promotions, catering services, transportation services, job security, and career planning[15].

HRM plays a crucial role in strategic management and has been recognized as a key component in CSR/S agendas. Global practitioners have developed best practices for effective engagement, supported by professional associations like the Society of HRM (SHRM), the Chartered Institute of Personnel and Development (CIPD), and the Australian Human Resource Institute (AHRI), highlighting the importance of HRM in CSR/S initiatives [9].

2.1. General Challenges can be faced by the HR Department.

In today's dynamic and complicated corporate world, human resource management (HRM) faces several obstacles. Among the principal challenges are:

2.1.1. **Talent Acquisition and Retention:** HR departments face significant challenges in finding and retaining top talent due to competitive markets and changing workforce demographics, necessitating constant adaptation of retention, and recruiting techniques.

2.1.2. **Employee Engagement and Motivation:** Organizational success relies on engaging and motivating its workforce through HR's focus on creating a supportive environment, offering professional advancement opportunities, and recognizing and rewarding employee achievements.

2.1.3. ***Managing Diversity and Inclusion:*** Human resources must create a culture that values fairness, inclusion, and respect to effectively manage a diverse workforce, addressing prejudices and fostering an environment of acceptance and belonging.

2.1.4. **Adapting to Technological Changes:** HR departments must adopt technology to enhance decision-making, communication, and process efficiency, but implementing analytics, AI, and HRIS requires thorough planning and careful consideration of consequences.

2.1.5. **Workforce Planning and Succession Management:** Organizational continuity relies on anticipating future skill needs, identifying critical talent, and creating succession plans. HR and leadership must collaborate to maintain talent pipelines and align workforce planning with strategic objectives.

2.1.6. **Managing Remote and Flexible Work Arrangements:** The shift towards remote and flexible work arrangements presents both opportunities and challenges for HR. They must establish policies and procedures to support remote work, maintain productivity, and foster collaboration while addressing issues such as work-life balance and isolation.

2.1.7. **Legal and Regulatory Compliance:** HR departments must stay abreast of evolving labor laws, regulations, and compliance requirements to ensure the company operates ethically and avoids legal issues, including employment contracts, data privacy, workplace safety, and anti-discrimination legislation.

2.1.8. **Employee Well-being and Mental Health:** The COVID-19 pandemic has underscored the need for increased support for employees' mental health, emphasizing the need for HR to provide resources, programs, and a supportive environment to help overcome stress and burnout.

2.1.9. **Managing Change and Uncertainty***:* In today's rapidly evolving business environment, HR plays a crucial role in managing change by assisting workers in adapting to new practices, providing support, and facilitating communication.

2.1.10. **Cost Control and Budget Constraints:** HR departments aim to maximize human capital return while managing financial constraints, balancing recruitment, retention, and development with cost management measures, ensuring a balanced approach to human capital investment.

2.2. HRM Challenges in Startup Companies

Human resource management is crucial for startups, but many entrepreneurs overlook it. Startups face HR issues such as hiring staff, creating policies, securing management support, and firing underperforming employees. It's essential to understand the specific challenges each presents and why they are important for a startup, even if it's in its infancy. By implementing a strong brand strategy and addressing these HR challenges, startups can ensure their success and maintain a competitive edge.

The following are some of the most typical HR difficulties faced by startups

2.2.1. Lack of Management buy-in

Startups tend to prioritize hiring based on directives and ignore HR compliance, seeing HR operations as a superfluous expense. Since the company will create its own culture and principles, HR needs to educate founders on the value of corporate culture. To prevent the organization from developing its own culture and values, the company must maintain control over the situation and direct the culture towards the goals that have been established.

2.2.2. Documentation of policies

Before employing staff, the HR department should ensure that all policies—including those about vacation, attendance, and job descriptions—are clearly stated. Supervisors must be aware of the regulations that apply to their size. A pamphlet detailing expected conduct and company policies should be sent, as well as an employment offer that must be accepted and signed. This way, everyone will have a record in case there are any disputes.

2.2.3. Hiring

Hiring talented workers is a major difficulty for companies, not just in HR but also in other areas of the company. Referrals are frequently used to hire early personnel, which may result in over-hiring or overpaying. Particularly in cases when firms receive financial help, an accomplished HR leader may put in place essential procedures to guarantee that the top candidates are employed at the most competitive price.

2.2.4. Failure to provide training and development.

A defined growth path and a commitment to training are essential for employee engagement and retention. Low-cost strategies are promoting conferences, having in-house specialists teach workshops and cross-training. Mentoring programs increase employee satisfaction, and new businesses should offer networking possibilities[16].

2.3. The main challenges can be faced by HR departments.

2.3.1. Leadership Development

Leadership development theory focuses on individual qualities, conduct, and skills for effective leadership. It has evolved to include contingency theories, understanding leadership circumstances, and the relationship between leader and follower [17]. Leadership development incorporates international markets, economic trends, and the Asia-Pacific Rim. Leaders learn global interdependence and the importance of staying current. Career development programs use the Internet for global promotion and knowledge gathering [18]. Leadership development involves self-awareness of values, beliefs, character, spirit, and personality, focusing on the individual's beliefs and values. It involves formal and informal interventions to break down leadership into teachable elements [17].

Effective leadership is crucial for organizational success, and leadership development is now seen as a process that emerges from relationships between collaborators and leaders, rather than just individual skills. This paradigm presents more challenges in designing and implementing leadership development strategies compared to previous decades [18]. Developing leaders in organizations is a significant competitive strategy component, involving senior personnel and requiring significant time and resources. Stakeholders include government, professional organizations, corporate universities, consulting companies, and business schools [19]. Formal and informal leadership development approaches focus on human qualities and abilities, with formal methods enhancing decision-making and informal practices promoting group competence and growth [20].

2.3.2. Change Management

Change management is a systematic approach to managing change, involving the development and implementation of strategies, structures, processes, and technology to adapt to external shifts and facilitate efficient company transitions, involving collaboration among managers, executives, and frontline employees. Change management involves continuously updating an organization's capabilities, direction, and structure to meet the evolving demands of internal and external consumers, requiring the right managerial abilities and approach [21].

Change management helps individuals embrace change while overcoming initial resistance. Factors preventing change include organizational inertia, conventional culture, cost, past reaction methods, and unconscious resistance from organizations, which can hinder transformation. Change is a multifaceted process that involves altering technology, structure, decision-making, and management systems to achieve organizational objectives, involving factors like triggering, strategies, confusion, and paradigm. Change management strategies often involve leadership, member communication, education, training, full organizational engagement, continuous reinforcement, and one-on-one counseling to handle resistance to change. Change management techniques, including organizational objectives, transformational leadership, engagement, communication, and education, impact organizations. Recent studies focus on sustainability strategies and encouraging creative conduct, with Lewin's work being the first investigation.

Research on management strategies to reduce individual resistance has been the focus until recently. Change management aims to change members' behavior and perception to achieve goal performance. Key components include engagement, leadership, communication, education, training, and counseling. This research categorizes change management into four

main components: role-playing, training, direct member engagement, and communication. It emphasizes clear plans, mutual collaboration, inter-level communication, education, and effective leadership. The study also suggests vision, communication, systems, employee engagement, education, leader behavior, and organizational structure as additional elements[22].

2.3.3. Organizational Performance

Organizational performance, often associated with effectiveness, efficiency, and improvement, is influenced by clear objectives and the achievement of observable, quantifiable, valuable, and personally significant objectives. Performance, defined by McCloy, Campbell, and Cudeck (1994), refers to actions or behaviors relevant to the organization's objectives and is not a result or consequence of actions or behaviors. Conceptual clarity is a challenge in understanding organizational performance. Performance is multidimensional, with various components identified based on co-variation and inter-correlation with other factors. However, there is no single definition for organizational performance due to studies in various disciplines, including organizational behavior, public administration, psychology, and human resource management, which have addressed the idea in their respective areas, leading to various definitions in the literature [21].

Organizational performance, despite being a frequently used dependent variable in organizational research, is a complex and poorly defined concept, with the struggle to define performance in strategic HRM and other areas for a long time [23].

3. Theoretical Framework

Fig. 1 shows the theoretical framework of this study, including the first introduction of HRM, the goal that defined objectives and aims according to the problem statement of the study and the challenges that occur in the HRM department, sorting out the literature review of a study based on challenges means general challenges and main challenges. Here there are so many challenges that occur in any HR department those can be general or main, general means those can occur in any industry but their impact is not much more only those can be find out at everywhere, but the main challenges are those which occurs on any specific point or industry and their impact is a lot means due to these impact industry/organization can be in loss so here in this study sorted out a few main and general impact on HR departments.

The methodology used in this paper, the author made questions (Google Forms) and shared them with different organizations and took data from employees and the HR department through Google Forms. Questions are made based on challenges that can impact any organization. The study collected 80 responses from various organizations having areas are employees of companies in Pakistan and a few in Italy. After collecting data analyzed data and found the main challenges that can occur in companies due to HR department based on collected data. In the questions author also added the question of how can resolve the problems that can occur due to challenges in HR departments, so we analyzed the answers of responses, compared the solutions procedure of employees, and found the best solution to eliminate those problems.

After that, the author discussed the analysis, found the main challenges that can impact on HR department, and the find best solution to improve the HR department. Finally, conclude the study with limitations of the study and future recommendations.

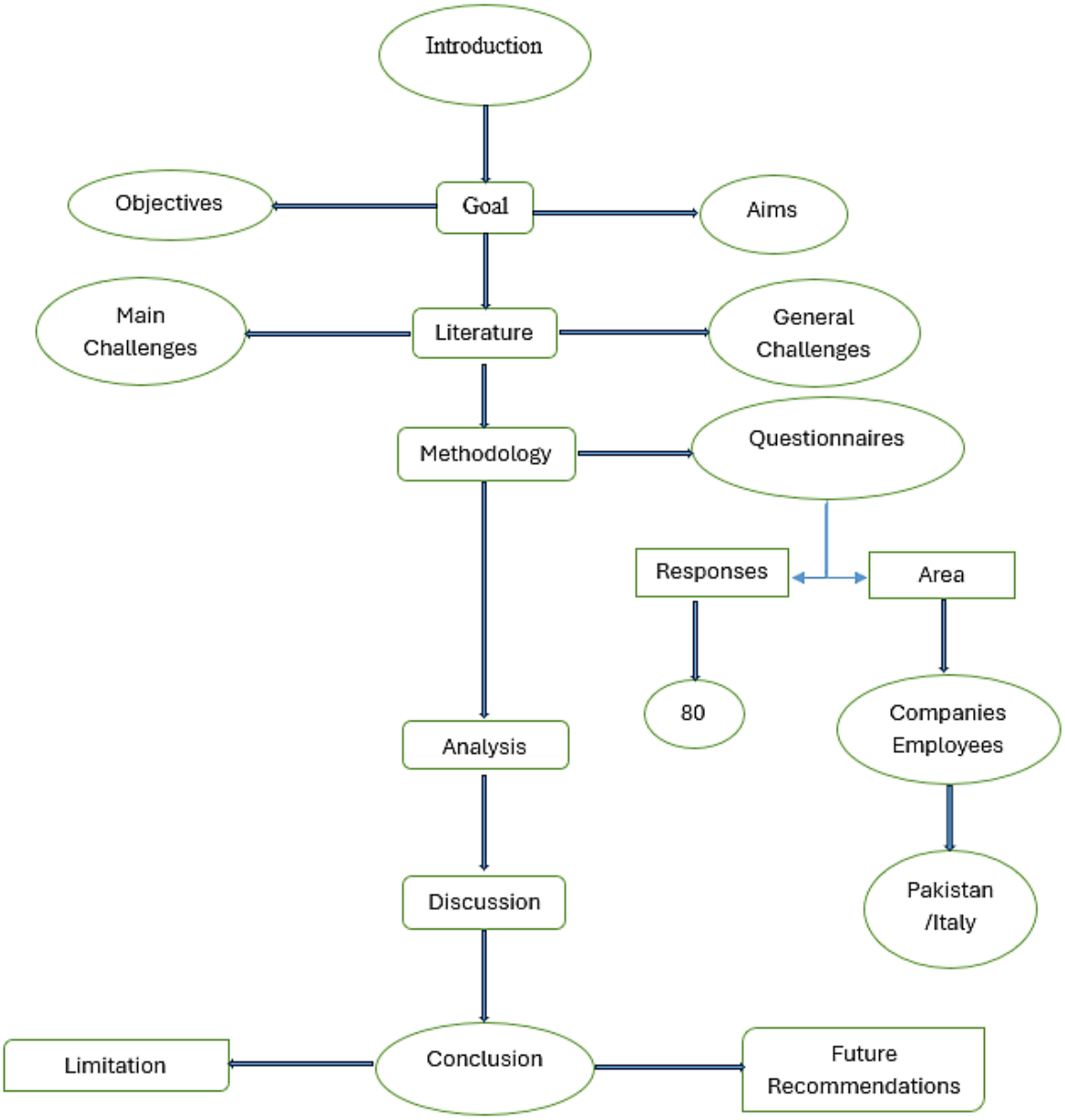

Fig. 1. Theoretical Framework of Study

4. Analysis

Table 1. Responses of employees

The impact of the HR department on the organization	Impact of change management	Impact of leadership development	Impact of innovation	Impact of best recruitment of employees
Positive	4	4	3	3
Positive	4	5	5	5

The impact of the HR department on the organization	Impact of change management	Impact of leadership development	Impact of innovation	Impact of best recruitment of employees
Positive	5	5	5	4
Positive	3	3	5	5
Positive	4	4	3	3
Positive	5	5	5	5
Positive	1	2	4	3
Positive	4	5	2	3
Positive	4	4	3	4
Positive	1	1	1	1
Positive	4	3	3	4
Positive	2	3	5	5
Positive	3	3	2	5
Positive	3	5	5	3
Positive	4	5	5	5
Positive	3	3	4	2
Positive	4	5	4	5
Positive	5	5	5	5
Positive	5	3	4	5
Positive	4	4	4	4
Positive	5	5	3	3
Positive	3	3	3	3
Positive	5	5	5	5
Positive	3	5	4	4
Positive	5	4	4	5
Positive	1	1	3	3
Positive	3	3	5	3
Positive	1	1	1	1
Positive	4	5	3	4
Positive	3	5	5	5
Positive	4	4	5	5
Positive	4	5	4	4
Positive	4	4	3	4
Positive	4	4	5	5

The impact of the HR department on the organization	Impact of change management	Impact of leadership development	Impact of innovation	Impact of best recruitment of employees
Positive	4	4	4	4
Positive	5	4	4	3
Positive	4	5	4	5
Positive	5	4	3	4
Positive	3	4	4	4
No any	3	4	4	4
Positive	5	5	5	5
Positive	3	3	4	3
Positive	5	5	4	4
Positive	5	4	4	4
Positive	4	4	5	5
Positive	4	4	4	5
Positive	3	5	4	5
Positive	5	5	5	5
Positive	4	4	5	5
Positive	4	3	2	2
Positive	5	4	1	3
Positive	4	3	3	3
Positive	3	1	3	1
Positive	4	2	4	5
Positive	4	4	1	4
Positive	5	5	3	5
Positive	3	3	4	4
Positive	4	4	4	5
Positive	5	5	5	5
Positive	3	4	2	3
Positive	4	5	4	4
Positive	3	4	3	3
Positive	5	4	4	5
Positive	3	4	4	5
Positive	4	4	4	3
Positive	5	5	5	5

The impact of the HR department on the organization	Impact of change management	Impact of leadership development	Impact of innovation	Impact of best recruitment of employees
Positive	5	5	5	5
Positive	5	4	4	4
Positive	4	4	1	4

Table 1 is data collected through questioners now here the first question is about the overall impact of the HR department on organization means the contribution the data shows a 99% impact of the HR department which means the HR department plays a crucial role in any organization. The second question is about the impact of change management, here questions are based on a linear scale (1 to 5), 1 is a very poor impact, and 5 is a very strong impact now if look at the data there is a strong impact on any organization if there is change management in HR departments it is almost more than 60% because almost responses selected 3, 4 and 5, so we can consider it has a very strong effect. Another question is the impact of leadership development the data shows leadership development also affects almost about 50% of, responses selected almost 3, 4, and 5 so we can consider it has a strong impact. Another question is about the impact of innovation, here innovation means the implementation of new technologies and how they can affect the overall organization and HR department, so in the data, most responses are 2, 3, and 4 we can say that it also impacts on the organization not strong but it has good impact means if there used innovative technologies or any other innovation ideas been implemented then these may impact on organizations. The last question is related to recruitment and selection in the data most responses are 3, 4, and 5 so we can consider it is also having a strong impact on any organization, which means if the HR department does good recruitment and selection of employees then the organization could be good, so best recruitment also impacts on the organization.

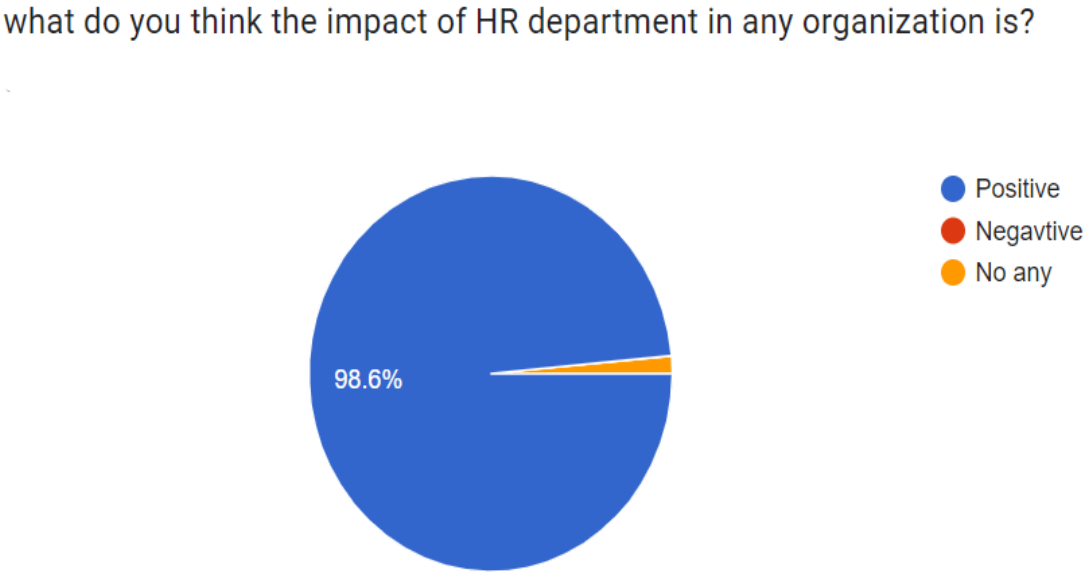

Fig. 2. Impact of the HR department on organization

Fig. 2 is the summary of the overall impact of the HR department on the organization so the figure shows a 98.6% impact on the organization. It means the HR department plays a vital role in any organization and it has a positive impact on any organization.

Fig. 3. Challenges faced in an organization related to the HR department.

Fig. 3 shows the most challenges faced in an organization related to the HR department. In the graph the most impacted challenge is change management means a change in anything in an organization or HR department then it is a big challenge according to employees' data. It has almost 48% impact on the department so if there is any change in the organization then it is one of the big challenges. The second big challenge is leadership development. According to the graph leadership development also plays a crucial role, it is almost 40% means this is also one of the big challenges. Another challenge is HR effectiveness measurement the graph shows almost 30% impact on the organization. These are the main challenges according to the data but also looking at the graph other challenges can affect an organization like organizational effectiveness 25%, recruitment, and selection 20%, Training and development is also 20%, employee engagement 15%, Lack of relationship building is 155 and poor communication is 10%. So other problems can affect any organization.

Fig. 4 shows the remedial action of challenges here in the graph almost 56% need employee training means if the employee's training is good then there can be no challenge in the department. Another remedial action is the right recruitment and selection of employees if we look at the graph it is about 50% means it plays a vital role if the HR department hires the right employee for the right job at the right time, then can be taken the action against any problem. Another remedial action is skills development so here it is about 40%, employee training and skill development are consistent means if the organization trains the employees and develops the skills employees then these can take action against any problem. Another remedial action is team cooperation which is about 30% so if the team is cooperative then they can take action collectively to find any challenge and can reduce that. Last but not least remedial action is continuous monitoring, which is about 15% so if management does monitor every time, then there are a few possibilities to make the organization better.

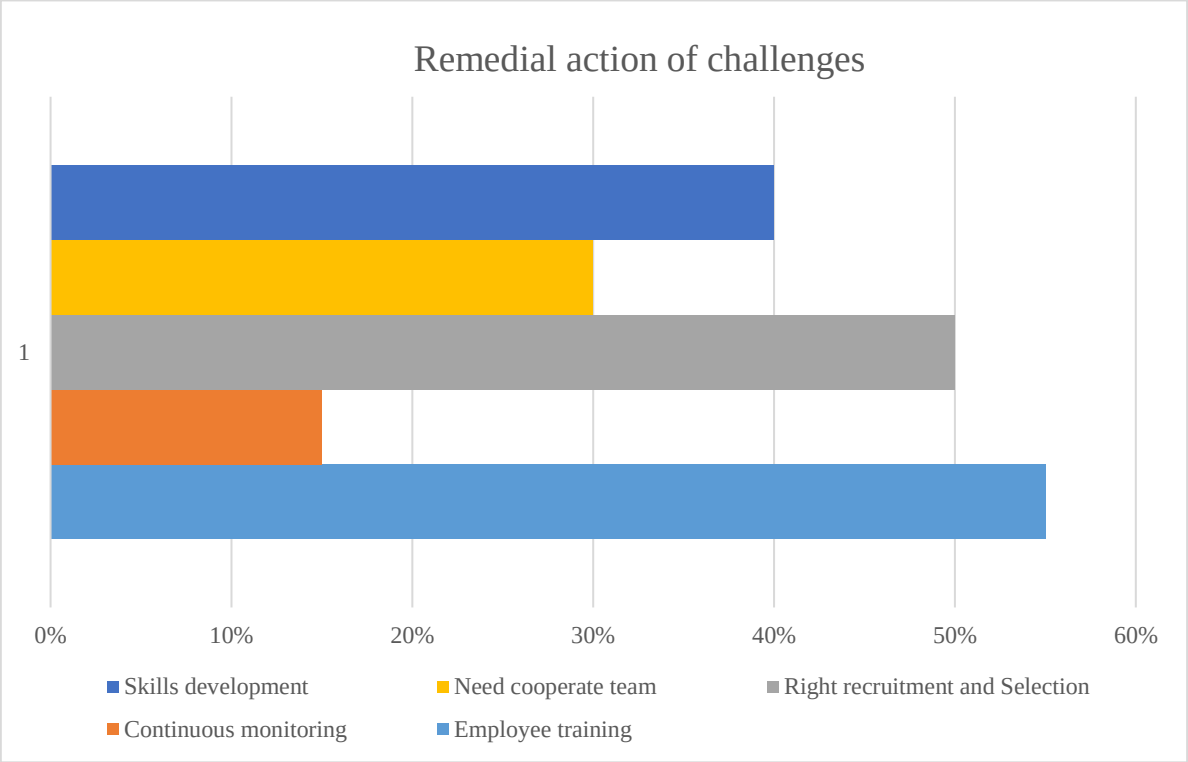

Fig. 4. Remedial action of found challenges.

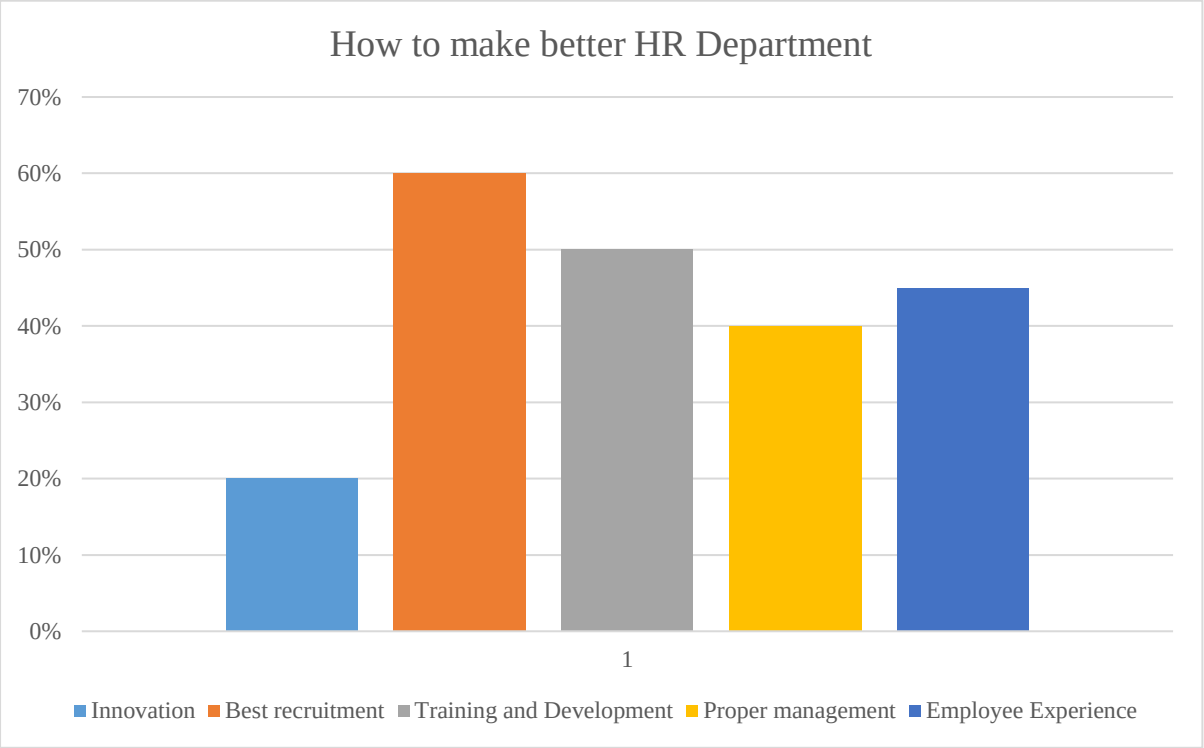

Fig. 5. Factors to make better HR departments.

The above figure 5 shows how to make it better for HR departments in the graph innovation is about 20% means if the department implements any innovative ideas or

technology then there is the possibility to make it better. The best recruitment is the most important factor that can make a better organization. Look at the graph that it is about 60%. Another factor is training and development, which is also a good factor to make the organization look at the graph which is 50%. Another factor is proper management is also to make better organization in the graph it is about 40%. The last factor is employee experience, which is about 45%, which means this also can make the organization better.

5. Discussion

As mentioned above, this study is based on questions and collected data through Google Forms from employees of companies that mostly belong to Pakistan, and a few are in Italy. After collecting the data, the study analyzed that the HR department plays a vital role in every organization because Human resources (HR) is the division of a business responsible for finding, recruiting, screening, and training job applicants. From the data, it shows that this department has a positive impact on any organization/company. This study found that various challenges can occur in any organization. Those challenges have been identified by employees who are working in industries. We used linear scale questionnaires 1 to 5 (1 is very poor and 5 is very strong), based on this scale, we collected data on most challenges that can impact any organization. The employees responded to these challenges; change management, leadership development, HR effectiveness measurement, organizational effectiveness, recruitment and selection, Training and development, employee engagement, Lack of relationship building, and poor communication. Out of these challenges, the most effective are change management, leadership development, and HR effectiveness, all others are also impacting but the most impact on the department is these. Look at the figure and description of the figure percentage of each problem mentioned.

To reduce these challenges the author took remedial action by collecting data from employees, the author mentioned the question of how we can remove these challenges so after analyzing their responses study concluded that there is a need for employee training means if the employee's training will be good then there can eliminate any challenge occurs in the department. It is the best action to reduce the problem if employees are trained already or we train them then the organization can take action against problems. When the employees are trained and their skills are good, there is also skill development remedial action. Right recruitment and selection of employees also play a vital role in the starting hire is good and hired employees will be best then those can reduce any problem because they are familiar with everything. If the HR department hires the right employee for the right job at the right time, then can be taken the action against any problem. If the team is cooperative means if any employee faces any problem, then the whole team supports reducing that problem which is also a remedial action called “Team Cooperation”. Continuous monitoring also can contribute to reducing any challenges. If the management team monitors continuously then there may be fewer problems or challenges that can occur because continuous monitoring resolves problems every time.

To make better HR departments many factors can be considered but according to employees' responses we mentioned a few and those are Innovation, Best Recruitment, Training and development, Proper management, and Employee Experience. Here from the analysis recruitment and selection and training and development are the major factors in making a better HR department and organization because hiring the right employee will do best for the organization and that employee can implement new ideas and also can reduce any

problems/challenges if organization will face. Training and development are also the main factors because if employees are well trained then those can be beneficial for the organization, and they can develop any new or innovative thing for the organization and also can reduce any problem because they are well aware of everything or activity which are involved in the organization. The given figure to make better HR department showing in the form or percentage we can look at the figure and the description defined their actual findings. Other factors innovation, proper management, and employee experience are also important in any organization that can do better for the HR department and organization. If the organization implements new technologies or innovative ideas according to the modern era, then the organization can be good, and the HR department can be good for fulfilling its responsibilities. Proper management of the department and organization also can do better HR department because the actual thing is management if the management is good then there is a small possibility to occur any problems if the problem occurs then the experienced employees can eliminate the problem effectively.

Here is the summary discussion that HR departments are very crucial in any organization so finding the main challenges in the department must be reduced by using any remedial action or factor considered in the study. There may be a lot of other technologies, remedial actions, factors, etc. to do the best organization but in this study, we analyzed based on employee reviews and mentioned here.

6. Conclusion, Limitations and Future Recommendations

6.1. Conclusion

The study, based on data from employees in Pakistan and Italy, highlights the critical role of the HR department in organizations. It identifies several challenges, including change management, leadership development, HR effectiveness measurement, recruitment and selection, training, employee engagement, relationship building, and poor communication. The most significant challenges are change management, leadership development, and HR effectiveness. To address these, the study proposes remedial actions based on employee feedback, such as employee training, skill development, right recruitment and selection, team cooperation, and continuous monitoring. To enhance the HR department and overall organizational effectiveness, factors considered as innovation, proper management, and employee experience are emphasized. Recruitment and selection, along with training and development, are identified as major factors for improving the HR department and organization.

6.2. Limitations

According to other studies, this study has also limitations; First, actually, the Human resource department is the main department hiring the employees this study was taken based on online questioners so there is a possibility in the responded a few employees are not well aware of the HR department, if this study takes place physically in different companies and visit the HR department to take the data then that data should be effective. Second, this study got only almost about 80 responses if the responses are more than a hundred means many responded then there is also the possibility of changes in results. Third the remedial actions are the basis of employees' responses. If we visit the industries and HR departments to find the how can be best solutions for facing the challenges in industries, then there is also the

possibility of changing remedial action. But normally given challenges and remedial actions is possible to make better decisions.

6.3. Future Recommendations

Finding the limitations of the study in the future author should have to take actual data mean visiting the organizations/companies for taking the data, finding the main challenges facing the industry due to the HR department, finding better remedial actions to reduce challenges, and find the better decision for improvement of HR department.

There is a possibility of innovative technologies in the future because now it is a modern world so if in the future any HR department implements new technologies then that can have the best impact on organizations. The authors must find and implement innovation in organizations and then find the challenges if there is occurring and give suggestions to take action against those problems by using technologies.

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Analysis of Risk Factors for Work-related Musculoskeletal Disorders: A Survey Research

Atam Kumar*
Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Pakistan
Email: atamkumar2018@gmail.com
ORCID iD: https://orcid.org/0000-0002-0197-8532
*Corresponding Author

Hafiz Karim Bux Indher
Department of Industrial Engineering and Management, Mehran University of Engineering and Technology Pakistan
Email: karim.indhar@faculty.muet.edu.pk
ORCID iD: https://orcid.org/0000-0001-9031-2013

Ali Gul
Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Pakistan
Email: aligul1269220@gmail.com
ORCID iD: https://orcid.org/0000-0002-4241-4987

Rab Nawaz
Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Pakistan
Email: lanjwanirabnawaz2017@gmail.com
ORCID iD: https://orcid.org/my-orcid?orcid=0000-0002-5013-9794

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Abstract: In the world ergonomics is involved everywhere, where is work there is a risk factor. Musculoskeletal disorder (MSDs) is a major risk factor in human life because it affects bones, joints, muscles, and connective tissues of whole human body parts such as the neck, shoulder, arms, wrists, hips, legs, thigh, knee, ankles, etc. so mainly our study focus on musculoskeletal disorders. This study there has used questionnaires in four factors those are socio-demographic, psychological, occupational, and biomechanical. In these factors number of questions were included in the data has been collected. In addition, there was the Nordic section in questions from that we analyzed the pain in different parts of the human body. The study concentrated on the business, education, industry, and healthcare sectors in Hyderabad, Kotri, and Jamshoro. University students and teachers, retail salespeople, manufacturing industry workers, nurses, doctors, nursing assistants, and other health professionals comprised the sample group. The questionnaires were fully completed by 50% of the respondents, resulting in a sample of 116 workers. The majority of the participants were private employees with one to fifteen years of experience in teaching or caring. In this study data has been analyzed through Co-relation between four factors with the Nordic section and ANOVA test through excel and it gives the value of p is also less than 0.05 so we cannot reject the null hypothesis. Over this study it has been analyzed that population is evolving in problems and there should be the proper implementation of ergonomics and safety rules. Test gives the values are not significant and null hypothesis should not reject and it should be improving.

Index Terms: Ergonomics, Musculoskeletal Disorder (MSDs), Health, Problems, Students, Doctors, Dentist, Employees.

1. Introduction

Ergonomics is the study of how to operate in a way that minimizes physical and mental strain, as well as the risk of disease and injury, which can result from repetitive motions, poor posture, or overuse of muscles. An ergonomics programmer in the workplace might strive to prevent or deal with accidents and illness by removing or reducing workers' exposure to the risk factors associated with WMSD.

Musculoskeletal diseases, often known as MSDs, are a significant issue in the workplace. Despite the abundance of information, there is still a great deal of conjecture and argument over the nature of MSDs[1]. Even though MSDs

seldom have an accurate clinical pathology diagnosis, the body is nonetheless harmed and rendered unable to function properly as a result of having them[2,3]. In 1997, the NIOSH, which is part of the Centers of CDC, conducted a review of the evidence on MSDs that are associated with the workplace[2,4].

Table 1. Ergonomic Definition

Author	Definition of Ergonomics
Te-Hsin & Kleiner	The term "ergonomics" may have originated from the Greek terms "ergo" and "nomics," which both imply "work" or "labor." Ergonomics is a branch of research that focuses on adapting instruments, procedures, and physical workplaces to the abilities and requirements of employees.
Tayyari & Smith	A branch of science that deals with the achievement of the optimal relationships between workers and their working environment
Lee	To promote compatibility between humans and systems
Fernandez	To design the workplace, equipment, tool, machine, product, system and environment and taking into consideration the human's

People who suffered from MSDs missed an average of 8 days of work, whereas those who suffered from non-fatal accidents and illnesses missed an average of 6 days of work. MSDs are a group of painful and inflammatory conditions that affect muscles, ligaments, and joint peripheral nerves[5]. Lack of compression disorders, and osteoarthritis, MSDs are common in many countries, and they cost a lot of money and lower the quality of life[6,7]. Still, MSDs are the most common type of work-related illness, making up a large number of registered work-related illnesses in the US, Nordic countries, and Japan.

1.1. Musculoskeletal Disorders

It focuses on musculoskeletal disorders that are caused or made worse by work, as well as the conditions in which the work is done. Musculoskeletal disorders like these are thought to be caused or made worse by work, but other things like housework or sports may also be to blame. Irritation at the point where the muscles and tendons join the bone is yet another typical ailment. There is also a possibility of harm to the muscles and tendons.[8] The total burden imposed on the apparatus. The entirety of the mechanical load affects the musculoskeletal systems.

1.2. Problem Statement

It was noticed in the literature and also confirmed during the preliminary survey that many of the professionals in our study area are suffering from musculoskeletal symptoms such as pain in the body mainly in the lower limb and upper limb of body parts due to the several risk factors such as socio-demographic, occupational, biomechanical and psychosocial, etc. that may also have deleterious effects on quality of Physical working life and efficiency of employees in the organizations.

In light of above mentioned sustainable goal the aim of our study is to analyze the prevalence of musculoskeletal symptoms associated with risk factors". The purpose of this study is to identify risk factors for work-related musculoskeletal disorders. To analyze the prevalence of musculoskeletal symptoms in professionals. And To investigate the association of risk factors & develop a regression model.

1.3. Scope of Study

The prevalence of musculoskeletal symptoms among workers/ officials /professionals is a significant issue in all service/manufacturing sectors worldwide. Many research studies are reported on this issue but unfortunately, very few of them are from our country. Nowadays most of the researchers in our country have turned their attention to this issue and have carried out research studies by using different research approaches but the population focused in our study and the consideration of risk factors regarding this issue has not remained their subject of studies. Thus our study addresses this gap in the literature and contributes to discoveries on this topic and area for improving the quality of life and environment at the work.

This study has four main limitations; This research is consisting of limited number of participants. Sample size is limited i.e. couldn't achieved. Some of the results of this study are significant while others are not. The study is descriptive and analytical.

2. Literature Review

2.1. Background of Ergonomics

Ergonomics may be a key part of getting and keeping workers at high levels of productivity. Workers in different sectors such as the textile industry have to twist their knees, neck, back, and shoulder joints to do their jobs[9,10]. This is because the ergonomic design makes it easier for workers to do their jobs. Muscle pain can be caused by specific actions or activities and can be affected by ergonomic risk factors.

Muscles in the shoulders, upper back, lower back, hands, wrists, thighs, and knees are all affected. Muscles that have been hurt for a long time can cause both illnesses and injuries that affect the bones, joints, and muscles.[11]

Concrete workers should be asked to report any injuries or problems with their muscles and joints, as well as how much pain they are in[12].

2.2. Evaluation of MSDS Research

It was found that the chances of having neck/shoulder pain with pressure sensitivity went up when all of the basic physical risk factors were present, as well as when they were present together with repetitiveness[13]. Biomechanical stress is caused by things at work called ergonomic risk factors. Musculoskeletal problems can be caused or made worse by one or more risk factors in the workplace[14]. Some of the most dangerous factors include working in very cold or very hot temperatures or doing the same thing over and over again without giving your muscles a chance to rest.[15]

MSD is caused not only by the fact that risk factors are present but also by how bad they are. In the same way, when an MSD is linked to a risk factor, it is usually a combination of several risk factors, not just one, that cause or contribute to the MSD[16]. In the last few decades, many ergonomic risk assessment methods have been created to measure exposure to WMSD risk factors. Because of this, QEC and REBA are recommended for assessing risk factors for musculoskeletal diseases at work in similar industries[17].

Schneider says that strains and sprains are caused by work that is hard on the body[18], positions that are uncomfortable or stay the same, vibration, the harsh weather outside, and other related risk factors.[19]

2.3. Research Approaches Related to MSDs

Methods have been developed for assessing exposure to risk factors for MSDs, most for assessment of the upper regions of the body such as the back, neck, shoulder, arms, and wrists. Any attempt to quantify exposure should therefore include all the three dimensions for a worker being assessed. Data should also be recorded for the other important exposure factors, such as postural variation, rate of movement, and vibration, as well as the measurement of psychosocial and organizational factors that may be present in the workplace concerned.

2.4. Exposure Assessment Techniques

A wide range of methods has been identified and categorized under the three headings that have conventionally been used by earlier reviewers and they are listed below in order of increasing precision of the data gathered from and invasiveness to the worker(s) being assessed: Self-reports, Observational methods, and direct measurements.

2.5. Factors that leads to MSDS

a) Repetition

Repetition is using the same muscles over and over again without giving them a chance to rest or heal. This is good for both big and little muscles. When you hit something hard, your muscles and tendons tend to get overworked.

b) Vibration

Vibrations happen when an object moves quickly back and forth around a fixed point, like a pendulum swinging back and forth. Vibration is also a simple way to explain any movement of a body concerning a fixed point. It has been found that tools that vibrate between 20 and 80 Hz are an etiological factor in the workplace.

c) Awkward Posture

Posture is how the different parts of your body are set up. When you are in an unnatural position, your muscles, tendons, and ligaments have to work harder and may become stressed. When a joint bends or twists too much, beyond its normal range of motion, this is called an awkward posture.

d) Contact Stress

When pressed against the sharp edge, the muscles and tendons are crushed. When the hand is used as a hammer to close a lid tightly, mechanical forces are created, especially if the lid has raised surfaces or sharp edges. When a hard or sharp object comes into contact with the skin, this is called local contact stress. The pressure hurts the nerves, which hurts the tissues under the skin.

e) Extreme Temperatures

Cold temperatures, which are sometimes called «coffee temperatures, »slow people down and make it easier to see signs of nerve-end damage. When the body is exposed to cold, it may go through cold stress, which lowers the deep core temperature. A worker who is exposed to cold may shiver, have trouble thinking, feel pain in their limbs, have dilated pupils, and have an irregular heartbeat, among other systemic symptoms.

f) Permanent Loading

Musculoskeletal diseases caused by work have become a major cause of illness among workers in both developed and developing countries. Compared to other types of workers, construction workers have the second-highest risk of getting musculoskeletal illnesses at work. Especially for construction workers, these conditions will cause both short-term and long-term harm. Musculoskeletal injuries are a very big risk for all types of construction workers[20].

It depends on what the construction workers are doing since each task needs a different range of body movements. A lot of the work that construction workers do is repetitive and hard on their bodies.[21] Body posture is an important part of how the work process and workplace are set up because it affects how easily and well workers can reach, grip, and use equipment. Muscle pain makes it hard for development workers to do their jobs regularly, and they can only stay in good shape for a very short time.

3. Research Methodology

3.1. Methodology Adopted in the Research

Objectives of this study analyzed by this methodology, frame-work, correlation and ANOVA test. This methodology is showing that how this study has been done, from where data has been collected, from which sources literature has been combines, how data has been analyzed, etc. from conceptual frame-work the objectives will be identified that what are those risk factors which effects on human body, how musculoskeletal disorders (MSDs) occurs in body, how MSDs impacts on biomechanically, physical, psychologically and mental ability of human. Correlation and Test analyzed that what is the relation between given factors psychological, occupation, biomechanical and socio-demographic; that whether it is strong or weak and positive or negative. ANOVA test also identify the impact factor that how much MSDs effect on body, shows the results significant or not and whether the null hypothesis should be rejected or not.

Fig.1. shows Over there for research, there has been used multiple types of questioners have different sections which are already explained in the research methodology section. After making questionnaires, adding literature reviews from different sources such as books, research papers, conference papers, etc., and then studying that theory, these are included in the exploration of the study there is a research design in this portion that used sapling strategy through using different research methods. In the research execution portion, there is pivot testing which means a small scale-study conducted before conducting an actual experiment; designed to test and refine the procedure. So our study is based on pivot testing after that there has been collecting data through questionnaires and then analyze and finally submitted a report.

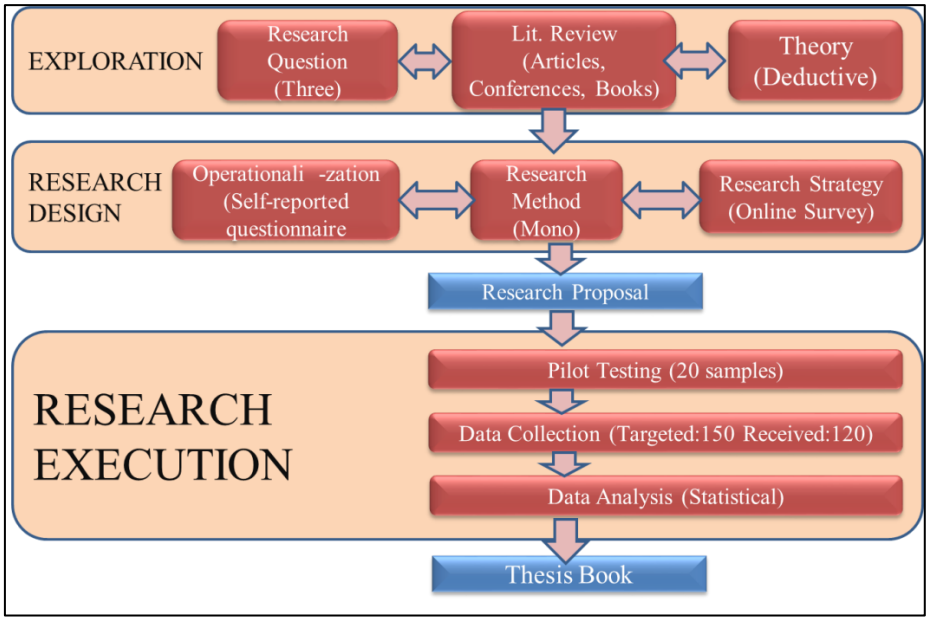

Fig. 1. Adopted Research methodology

4. Data Collection and Analysis

4.1. Conceptual framework

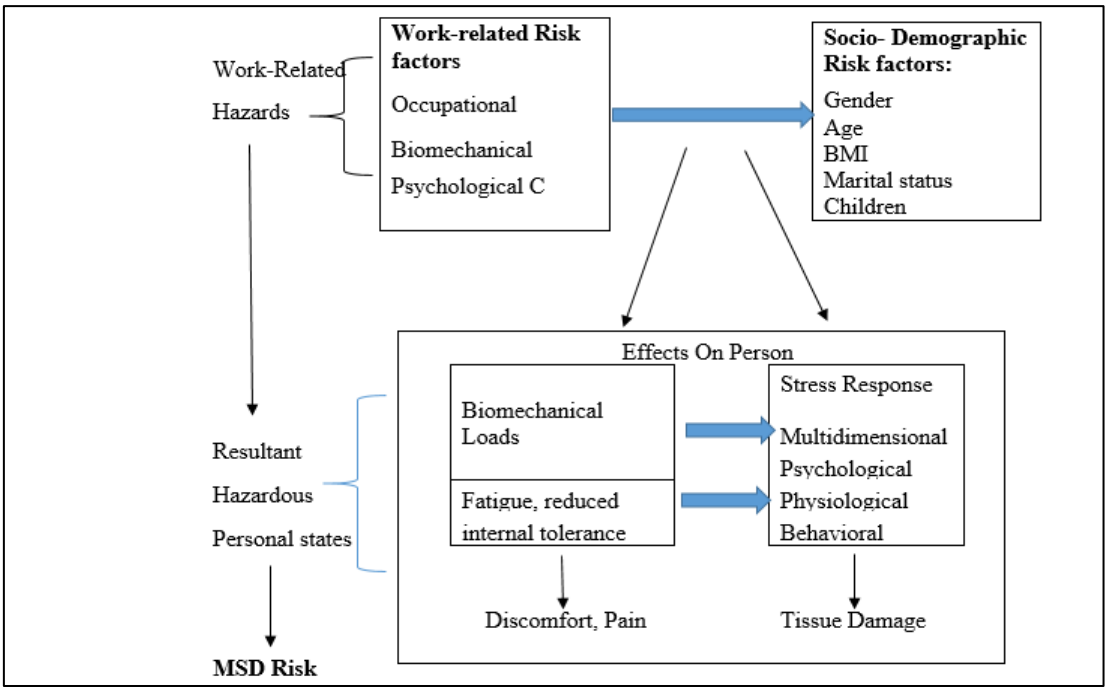

Fig. 2. Revised Model of Risk factors for work-related MSDs [22]

Fig.2. shows conceptual frame-work of MSDs risk factors that what are those risk factors which effects on human body, how musculoskeletal disorders (MSDs) occurs in body, how MSDs impacts on biomechanically, physical, psychologically and mental ability of human.

4.2. Risk Factors

Several risk factors that lead MSDs such as Socio-demographic factors such as:

1. Socio-demographic
2. Biomechanical
3. Psychosocial, and
4. Occupational factors.

Socio-demographic factors included sex, age, BMI, education, marital status, and the presence of children. **Occupational/organizational factors** included the following variables: professional category, work environment, duration of service in the company, working hours per week, the interval between work breaks, and engagement in other employments. **Psychosocial factors** such as the perceived meaning of work, commitment to the workplace, job satisfaction, and work-family conflict were evaluated using items from the Copenhagen Psychosocial Questionnaire II by Pejtersen et al.; psychological demands, job control, job insecurity, supervisor support, and support from co-workers were assessed using items from the JCQ. And reward and over-commitment were assessed using items from the ERI. However, it is unclear whether these factors contribute to specific regional MSP or multisite pain.

Several studies have reported many male-female differences in the prevalence of certain symptoms of work-related musculoskeletal disorders. Work-related risk factors may also differ according to gender.

The study concentrated on the business, education, industry, and healthcare sectors in Hyderabad, Kotri, and Jamshoro. These areas have been chosen because there are so many Workers working and we can study easily. The study was divided into four Stages: (I) site selection, (ii) sampling (iii) design questionnaire (IV) statistical analysis.

4.3. Site Selection for the Study

The first stage of the investigation attempted to map and outline the locations where the research was conducted by the four selected skilled sectors. Three cities were chosen: Kotri, Jamshoro, and Hyderabad. Despite having demographics and populations that are broadly comparable to those of other cities in the region, each designated city is the largest in its respective area. The accessible situation choices for each skilled sector were approached by various businesses/institutions from the public and private Sectors. Companies, clinics, and universities were all classified as part of the Education sector in Jamshoro Town, while other business establishments were classified as part of the commerce sector. Hyderabad has a textile industry as well. Kotri was home to a variety of public and private companies, hospitals, and healthcare institutions, as well as the railway.

4.4. Sampling of Targeted Population

The targeted population of University teachers, retail salespeople, manufacturing industry workers, nurses, doctors, nursing assistants, and other health professionals comprised the sample group. The sampling of the targeted population is given hereunder.

$$n = \frac{N*Z_{\alpha}^{2}*p*q}{Z_{\alpha}^{2}*p*q+d^{2}*(N-1)} \quad (1)$$

Where:
N=Population Size=1500
p=Expected frequency=50%=0.5
q=1-p==50%=0.5
d=acceptable error = 5.55% = 0.055
α=confidence level = 95%
n=150(approx.)

4.5. Data Collection Tool: Online Questionnaire

The data collection tool was designed to collect data on both dependent and independent elements. The dependent variables were pain complaints in the lower limbs from the previous days (thighs, knees, legs, ankles, and feet). To quantify pain, the modified Nordic Questionnaire was utilized, which was supported by (Yes &No). Four groups were formed from the socio-demographic, biomechanical, psychological, and occupational characteristics. Socio-demographic characteristics included gender, age, BMI, education, legal status, and thus the presence of children. BMI was classified into three categories by the World Health Organization: normal weight (BMI 18.5-24.9 kg/m2), overweight (BMI 25-29.9 kg/m2), and low weight (BMI 18.5 kg/m2). Among the organizational and Occupational factors were the professional category, work environment, period of Employment with the company, several hours worked per week, the time between work Breaks, and participation in other jobs. This study, like Widanarko et al. The study evaluated biomechanical parameters by taking into account the number of Hours spent each day performing or holding the following tasks or positions: (1) Standing, (2) sitting, (3) squatting, (4) holding the upper limbs in Awkward positions, (5) holding the lower limbs in awkward positions, (6) having A curved trunk, (7) having a twisted trunk, (8) using hands and fingers, and (9) lifting loads Weighing up to six kg, (10) Lifting loads weighing between 6 and 15 kg, (11) lifting loads Weighing over 15 kg, (12) performing repetitive movements, and (13) the utilization of hand tools. The variables were grouped using the frequency Categories shown below: infrequently (6 h per day). Pejtersen et al. (Pejtersen et al., 2010) employed items from the Copenhagen Psychosocial Questionnaire II (COPSOQ II) to examine psychosocial aspects such as the perceived significance of Work, dedication to the workplace, job satisfaction, and work-family conflict. The JCQ (Karasek et al., 1998) items were used to assess psychological demands, Computer programming, job insecurity, supervisor support, and colleague support (Siegrist, 1996).

4.6. Prevalence of Musculoskeletal Symptoms and their Relationship with Risk Factors

Table 2. Prevalence of WMSDs and their Relationship with Socio demographic factors

Sex		**Percent**
Male	94	78%
Female	26	22%
Age		
18-35	118	98%
more than 35	2	2%
BMI		
Low weight	19	16%
Normal Weight	94	78%
Over Weight	7	6%
Education		
Incomplete Elementary Education	2	2%
Complete Elementary Education	3	3%
Incomplete High School	1	1%
Complete High School	34	28%
Other	80	67%
Marital Status		
Single	99	83%
Married	21	18%
Presence Of Children		
Yes	19	16%
No	101	84%

Table 2. shows the socio-demographics data of populations, through this table it can be analyzed that age, sex, body mass index, education, marital status and availability of children to the married population. 78% respondents were male and 22% were female, most of population were between 18-35 years' age, 78% population have normal weight, 16% have low weight and only 6% were overweight, only 6% of the participant were done less than high school education, 28% of respondents done high school and 67% populations done other educations means College and universities. 83% were single due that 84% have no any children.

Table 3. Prevalence of WMSDs and their Relationship with Occupational factors

Professional category		
Railway	8	7%
University	89	74%
Dentist clinic	10	8%
Hospital	13	11%
Work Environment		
Private	41	34%
Public	79	66%
Duration of services in the company(year)		
No	45	38%
Less than one	31	26%
1_5	26	22%
16-30	8	7%
Other	0	0%
Working hours per week		
Less than 15	54	45%
16-40	50	42%
41-60	15	13%
60	1	1%
Interval between work break(in month)		
Less than 6	85	71%
6_11	28	23%
11	7	6%
Engaging in other employments		
yes	44	37%
no	76	63%

Table 2 shows occupation factors, means those factors which come during working or at working place. This table has been arranged as per questioners those are professional category means what is the profession of that individual respondents, what is the work environment where they are working, how much duration of services he or she is giving, means all others just like that.

Table 4. Prevalence of WMSDs and their Relationship with Biomechanical factors

Work Standing up?		
< 1	51	43%
1-6	60	50%
> 6	9	8%
Work Sitting down?		
< 1	42	35%
1-6	55	46%
> 6	23	19%
Work Squatting?		
< 1	56	47%
1-6	48	40%
> 6	16	13%
Upper Limbs in uncomfortable position?		
< 1	55	46%
1-6	51	43%
> 6	14	12%
Lower Limbs in uncomfortable position?		
< 1	59	49%
1-6	45	38%

> 6	16	13%
Curved Trunk?		
< 1	58	48%
1-6	45	38%
> 6	17	14%
Twisted Trunk?		
< 1	69	58%
1-6	35	29%
> 6	16	13%
Lifting Load up to 6Kg?		
< 1	69	58%
1-6	33	28%
> 6	18	15%
Lifting loads between 6 and 15 Kg?		
< 1	69	58%
1-6	35	29%
> 6	16	13%
Lifting loads over 15 Kg?		
< 1	73	61%
1-6	25	21%
> 6	22	18%
Recitative Movements?		
< 1	42	35%
1-6	50	42%
> 6	28	23%
Use of Hands and Fingers?		
< 1	34	28%
1-6	53	44%
> 6	33	28%
Use of hand tools?		
< 1	44	37%
1-6	47	39%
> 6	29	24%
Efforts?		
Low	38	32%
High	82	68%
Physical Demands?		
Low	38	32%
High	82	68%

Table 4 shows biomechanical factors that risk factors influence on the body of human and it is basis on research questioners those are standing, sitting, knees, fingers, hand tool usage, efforts, demands, lifting, repetitive task etc.

Table 5. Prevalence of WMSDs and their Relationship with Psychological factors

Meaning of work		
Low Significance	29	24%
High Significance	91	76%
Commitment to the Work place		
Low	28	23%
High	92	77%
Psychological Demand		
Low	35	29%
High	85	71%
Job Control		
Low	35	29%
High	85	71%
Motivation		
Low	31	26%
High	89	74%
Job Satisfaction		
Low	36	30%
High	84	70%
Job Insecurity		
Low	60	50%
High	60	50%
Supervisor Support		
Low	46	38%
High	74	62%
Support From Co-Worker		
Low	47	39%
High	73	61%
Reward		

Low	50	42%
High	70	58%
Over Commitment		
Low	71	59%
High	49	41%
Work Family Conflict		
Low	83	69%
High	37	31%

Table 5 show psychological factors that means how factors are effecting on psychological behavior and how much those. The different percentage is given above in table according research survey that how much these are effecting.

4.7. Correlation Between Risk Factors & Regression Model

Table 6. ANNOVA Test

ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**Fcrit**
Between Groups	7692.457	3	2564.152	3.586744	0.016474	2.697423
Within Groups	70059.9	98	714.8969			
Total	77752.35	101				

Table 6 shows ANOVA test that gives the F is greater than F critical and p value is less than 0.05 so null hypothesis cannot reject.

Table 7. Male and Female having health issues

		Male	**Female**	**Total**
Neck	Yes	45	21	**66**
	No	49	5	**54**
Shoulder	Yes	47	22	**69**
	No	47	4	**51**
elbows	Yes	40	13	**53**
	No	54	13	**67**
Wrists/Hands	Yes	51	16	**67**
	No	43	10	**53**
Upper Back	Yes	48	17	**65**
	No	46	9	**55**
Lower back	Yes	48	17	**65**
	No	46	9	**55**
hips/thighs/buttocks	Yes	43	11	**54**
	No	51	15	**66**
knees	Yes	44	13	**57**
	No	50	13	**63**
ankles/feet	Yes	40	11	**51**
	No	54	15	**69**
	Total	**846**	**234**	**1080**

Table 7 shows the effect of risk factors on different part of human body, that is basis on Nordic section questions and from this table it can be analyzed that how much male and female having problems of neck, shoulder, elbows, wrists, back, hips, thigh, knees and feet.

Table 8. Co-relation between socio demographic, psychological, occupational and biomechanical factors

Co-Relation				
	Socio demographic Factors	Psychological Factors	Occupational Factor	Biomechanical Factors
Socio demographic Factors	1			
Psychological Factors	-0.424645553	1		
Occupational Factor	-0.372807776	0.405303441	1	
Biomechanical Factors	-0.33797446	0.022525078	0.239634133	1

Table 8 shows correlations between four risk factors, the relation between socio-demographic and psychological, occupational and biomechanical is negative that is moderate negative. The relation between psychological and occupational is positive and its moderate. Relation between biomechanical and psychological is positive weak and relation between biomechanical and occupational factors is weak positive.

5. Statistical Analysis

A concise descriptive Statistic was developed to represent the samples' socio-demographic, occupational, Biomechanical, and psychosocial risk exposure. The symptoms of pain in the Lower limbs were described similarly. By the ANOVA test value, we got that is F = 3.58 and Fcrit = 2.69. The value of F is greater than F critical value so we cannot reject the null hypothesis. The generalized variance inflation factor was used to investigate numerous risk factor correlations. Ordinal supplying regression Models with Bonferroni correction were used to (1) identify the Socio-demographic, occupational, biomechanical, and psychosocial risk variables for WMSDS; and (2) categorize the likelihood of obtaining WMSDS in the presence of several risk factors.

6. Results

Table 2 shows socio-demographic information and its Association with the risk of WMSD symptoms in the lower limbs the sample was discovered to be predominantly made up of unmarried men and women between the ages of 18 And 45. The majority of the participants had normal BMIS, with 14.04% having extra body fat. The majority of them had completed High school and attended college. Table 3 depicts the associations between Activity factors and WMSD symptoms in the lower limbs. The majority of the participants were private employees with one to fifteen years of experience in teaching or caring. The majority of people (60%) reported working at least 16 hours per week, with average employment breaks lasting less than 6 months. Table 4 depicts the relationship between WMSD symptoms in the lower limbs and Biomechanical measures. The participants indicated that they spent one to Six hours working while standing and abusing their hands and fingers. The Majority of those doing work sitting for more than six hours, carrying objects weighing less than 50% takes sixteen kilograms with their lower limbs. Unnatural positions and Trunks bowed. Table 6 shows the ANOVA test score of all respondents over four factors that test gives the value of F is 3.386 and F critical is 2.697, from this analysis we can imagine that value of f is greater than F critical so the null hypothesis will be rejected. And the value of p is also less than 0.05 so we can reject the null hypothesis. Table 7 shows how many males and females have a problem with the neck, shoulder, wrist, ankle, knee, etc. This table directly show percentages of male and female having problems in different parts of body. By using table 7 and with expected got chi test that is table 8. From the Chi test, we got the value of P separately male and female and together as well. The Chi test gave an overall value of p 0.1387 and the individual value of p of a male is 0.997 and a female is 0.371. So finally these all values are more than 0.05 so it is not statistically significant and indicates strong evidence for the null hypothesis. This means we retain the null hypothesis and reject the alternative hypothesis. Table 5 depicts the link between psychosocial factors and the Likelihood of WMSD symptoms in the lower limbs. Employees exhibited low Perceptions of most of the researched criteria, except Supervisor support and work satisfaction, which showed a comparable percentage. The final word model, as well as all risk classes (Table 4), indicated that Biomechanical variables had a significant impact on reported symptoms. High Motivation was discovered to be the most influential factor (74.2%). Furthermore, practically all psychosocial factors were found to reduce the chance of developing WMD symptoms. Male sex, age, BMI, and vacation time all Enhanced the exaggerated risk of symptoms, while participation in another job reduced that risk. As a result, the final regression model included socio-demographic factors such as gender, age, BMI, and the presence of Children (Table 2): organizational and occupational factors such as working hours per week, the time between work breaks, and participation in alternative Employment (Table 3); and biomechanical factors such as holding lower limbs in uncomfortable positions, performing repetitive motions, using hands and Fingers, using manual tools, and exerting physical effort (Table 4). Table 6 gives an analysis of the variance of all respondents over four factors. Table 8 gives a correlation between these four factors Socio-demographic, psychological, occupational, and biomedical. And that shows the relationship is not good because all values are less than 0.5 in positive and negative both. So between these also not good relations. Displays the odds ratios for the association between the identified risk Factors and the occurrence of WMSD symptoms in the lower limbs Biomechanical Variables have been shown to influence lower limb WMSD symptoms. Numerous psychosocial Factors have been discovered to indirectly contribute to the avoidance of lower Limb WMSD symptoms. Employees with positive perceptions of the means of labor had a 15%-25% OR= [0.75; 0.85]) decreased risk of WMSD symptoms in the Thighs, ankles, and feet. Individual and activity characteristics may influence WMSD Symptoms in the lower limbs. All over the collinearity of the Variables in the logistical regression models was minimal.

7. Discussion

This study is the first to think about the influence of risk factors of various natures on WMSDs within the lower limb regions of workers in remote areas of Hyderabad, Kotri, and Jamshoro Sindh, Pakistan. This study is significant because it demonstrates how musculoskeletal disorders and risk factors are related in many locations. As each area was individually evaluated, an important level of accuracy was reached in evaluating the correlations between these risk variables and the reported symptoms. A variety of factors, including socio-demographic factors occupational factors,

biomechanical factors, and psychosocial factors, were discovered to have an impact on how employees experienced their WMSD symptoms.

These findings are consistent with prior research that has found risk factors for musculoskeletal in members of the general public, healthcare workers, educators, vine workers, and mining workers' lower Limbs. A weak relationship has been analyzed between psychosocial and occupational factors and individuals with lower limb musculoskeletal issues, according to Systematic analyses. The issue of «lower Limbs in uncomfortable positions» was substantially associated with thigh Pain symptoms, showing that certain components of particular job obligations May lead employees' limbs to be positioned unpleasantly. Many Characteristics, such as operating with the back in a very bent or twisted Posture and thus the kneeling position, leg posture, and seating type, operating In standing and bending positions, machine style, and ergonomics stress, are tested to contribute to the perception of pain symptoms among the thighs.

Who discovered that a lack of labor control and a lack of coworker support increased the risk of feeling symptoms of thigh pain by 17% and 23%, respectively? Pain has been linked to posture, ergonomic stress, machine design, and type and squatting, which may result in unnatural positions and worsen WMSD symptoms. The use of manual instruments, painful lower limb positions, and the usage of hands and fingers were all significant risk factors in Biomechanics. Completing repetitive tasks did not cause symptoms in the three inner cities because they required more physical effort and strength than speed and repetition.

Effort and improper working postures, rather than repetitive motion, were the main risk factors for lower limb WMSDS. Only in the foot region did this study find a link between work effort and symptoms. WMSD foot symptoms were similarly correlated with BMI. In our investigation, five lower limb regions were examined to see whether working with the lower limbs in unpleasant positions was connected to WMSD symptoms.

In terms of occupational factors, our study revealed that not having several jobs had a good impact on leg pain. The study is the first to identify factors that influence the occurrence of WMSD in different employees 'lower limbs, and it confirms previous research on the relationship between psychosocial factors and WMSDS. Our data were collected transversally; longitudinal studies may be able to reach more valid findings on the risk factors for WMSDS. Most risk factors evaluated supported the perception of the workers and in the limited area, there may be another issue if we cover a lot of areas for data and many responses. The phenomenon cannot be fully comprehended by focusing on lower limb MSDS, particularly considering the links to psychological disorders that may influence upper neck/back pain and lower back pain, among other symptoms.

8. Conclusion

The present study was carried out to evaluate the ergonomics examines ways in which working conditions and requirements of job may be tailors to abilities of the individual worker. The study concentrated on the business, education, industry, and healthcare sectors in Hyderabad, Kotri, and Jamshoro. The ergonomics is the study of how to operate in a way that minimizes physical and mental strain. There are two methods were applied for analyzed the data, one is primary data in which data was collected directly by interviews, surveys and experiments. Other is secondary data which is already collected from primary sources and also reported by many researchers. The data was analyzed by qualitative and quantitative methodology. Participants in present study had to be at least 18 years old, those are temporary employment, those who had lost their jobs due to WMSDS or workplace accidents, and those who were hypertensive, pregnant, or had other health difficulties were all excluded from this study. University teachers, retail salespeople, manufacturing industry workers, nurses, doctors, nursing assistants, and other health professionals comprised the sample group. The questionnaires were fully completed by 50% of the respondents, resulting in a sample of 116 workers. 81% was calculated for this sample size.

The socio-demographic information and its association with the risk of WMSD symptoms in the lower limbs the sample was discovered to be predominantly made up of unmarried men and women between the ages of 18 and 45. The majority of the participants had normal BMIS, with 14. The majority of them had completed high school and attended college. The majority of the participants were private employees with one to fifteen years of experience in teaching or caring. The ANOVA test score of all respondents over four factors that test gives the value of f is 3. And value of p is also less than 0.5. Moreover, practically all psychosocial factors were found to reduce the chance of developing WMDS symptoms. Male sex, age, BMI, and vacation time all enhanced the exaggerated risk of symptoms, while participation in another job reduced that risk 15-25%, decreased risk of WMDS symptoms in the thighs, ankles, and feet.

9. Recommendations

The user's workstation should be set up differently to allow the user to continue working while leaning back against the chair.

To access the second and third molars in the upper jaw, the upper jaw plane needs to be tilted at an angle of 25 degrees concerning the vertical. Lower the chin of the patient until the maxillary plane for the patient's mandibular front teeth is 8 degrees ahead of the vertical.

The dentist ought to be stationary in the area surrounding the operating table and should move their hands, arms, and body as little as is practicable.

The helper needs to be near the tools and equipment.

10. Future Direction

To make models of occupational MSDs that are more realistic and accurate, it is important to first understand the MSD research that has already been done and then find the research gaps. This work by a group of researchers will help improve the design of workplaces, the parameters of exposure, the diagnosis of injuries, and the assessment of workers' ability to return to work. This will lead to fewer risks, lower medical costs, and healthier workers.

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Authors' Profiles

Atam Kumar is a fresh graduated student in the Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Jamshoro, Pakistan. His research interest in Ergonomics, Lean Manufacturing and Six Sigma, Engineering Management and Quality Control.

Hafiz Karim Bux Indher is currently working as an Assistant Professor in the Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Jamshoro, Pakistan. His research interest in Ergonomics, Lean Manufacturing and Six Sigma, Statistic, Operation Research and Management

Ali Gul is a fresh graduated student in the Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Jamshoro, Pakistan. His research interest in Ergonomics, Lean Manufacturing and Six Sigma, and Quality Control

Rab Nawaz is a fresh graduated student in the Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Jamshoro, Pakistan. His research interest in Ergonomics, Lean Manufacturing, Projects Management and Quality Control

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Productivity Improvement of Assembly Line-by-Line Balancing Technique: Case Study Textile Manufacturing Company Karachi Pakistan

Atam Kumar [a++*] and Ramesh Kumar [b++]

[a] Department of Engineering Management, Università Della Calabria, Rende, Cosenza-87036, Italy.
[b] Department of Engineering for Natural Risk Management, Università Degli Studi di Genova, Italy.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The study on assembly line balancing theory and concept, focusing on the textile sector in Karachi, Pakistan, specifically the stitching department of a company, aimed to enhance efficiency through meticulous analysis and optimization. By employing time and motion analysis techniques, the research sought to identify and eliminate redundant activities, ensuring a seamless workflow with minimal idle time. The methodology employed involved a comprehensive observation of the entire production process, starting from stitching through to packing. This involved using a stopwatch to meticulously analyze each step of the process, thus gaining insight into the current operational dynamics of the assembly line. Line balancing was ensured by calculating Standard Allowed

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[++] *Master's Student;*
**Corresponding author: Email: atamkumar2018@gmail.com;*

Minutes (SAM), assessing capacity, and determining the required manpower and machine resources. To further refine the efficiency of the stitching line, data collection was conducted using stopwatch techniques, to devise an improved layout. By reducing processing time and minimizing unproductive intervals, the study aimed to establish a foundation for enhanced productivity and streamlined work orders. Various tools were utilized to scrutinize the procedures involved in the production process, encompassing activities, operator proficiency, equipment efficiency, and material usage. This comprehensive approach aimed to optimize the workflow, making it more ergonomic and conducive to efficient operations while ensuring worker satisfaction. The study's analysis specifically targeted the stitching operations related to sheet sets, with a focus on minimizing the number of machines and achieving optimal line capacity. Significant reductions in machine requirements were achieved, with the number of machines for both sheet sets and fitted sheets being reduced substantially. Capacity calculations based on SAM and machine numbers demonstrated the achievement of production targets. Moreover, manpower requirements were reassessed and optimized, resulting in a reduction in the number of workers required for packing operations, thereby further enhancing efficiency.

Keywords: Line balancing; time and motion study; work-study; SAM; assembly line.

1. INTRODUCTION

Henry Ford introduced the manufacturing assembly line in the early 1900s as a highly efficient and productive method for manufacturing a specific product. The basic assembly line consists of linearly arranged workstations connected by material handling devices [1]. The assembly line balancing (ALB) process involves assigning tasks to workstations to ensure all workstations have equal work. Priority relations should not be violated during task assignments, and numerous heuristics have been reported for ALB. This process is commonly used for mass production [2]. The installation of an assembly line is a long-term, capital-intensive decision that requires careful design and balance to ensure efficiency. The system must be re-balanced periodically or after the production process or program changes. Balancing decisions should be carefully chosen considering the strategic goals of the enterprise, as the long-term impact of these decisions is significant [3].

The assembly line is a popular method in manufacturing industries like electronics, textiles, and furniture, but it often leads to bottlenecks due to difficulties in balancing, resulting in wastes like waiting time, work in process (WIP), and overproduction. A lean line balancing could support smooth WIP flow with minimal buffers [4].

Lean manufacturing, also known as Toyota Production System (TPS), is a set of principles, tools, and techniques adopted by industrial organizations to enhance production efficiency and customer value while eliminating waste [5]. Line balancing, a mechanism of cellular manufacturing, involves work-study and lean manufacturing techniques. Time study and stopwatch time study are used to calculate work progression and time spent on specific processes. Lean manufacturing is increasingly adopted in the textile sector to improve product quality and reduce non-value-added activities [6].

Lean manufacturing is the name under which the Toyota production system (TPS) became widely known and later adopted by many companies worldwide. Lean, also denoted as lean Management, Manufacturing (LM), and Lean Principle (LP), is a set of principles, tools, and techniques that many industrial organizations and companies' option to implement, to enhance the efficiency of production and overall customer value while at the same time eliminating waste [7].

Line balancing is a crucial aspect of assembly line efficiency, distributing workload evenly among tasks within a cell or value stream. It is essential for optimizing performance in the garment manufacturing sector, where sewing machines are strategically distributed to meet individual garment style and design requirements. Improving productivity and quality in apparel assembly requires identifying and mitigating factors affecting workers, leading to enhanced production and quality [8].

A time study is a method used to calculate work progress by breaking down operations into smaller, manageable components. It involves

selecting average cooperative operators to analyze a specific process by skilled workers to determine the most effective time spent. This technique measures the time needed for a work process to be completed efficiently. Stopwatches are used for this study due to their ease of data recording and ability to record exact data without subtractions. The study helps detect operators and record the time taken for each element over a specific cycle. cycles.

A textile company is a cloth manufacturing company where different processes are carried out and change the raw material (cotton) by applying different processes like spinning, weaving, dying, printing, and stitching to form a finished product. These 3 processes are the complete formation of the finished product (cloth) but some of the small and medium textile companies just do some of the processes like spinning, and weaving, although the textile sector is very complex and focuses on quality improvement and waste reduction therefore the lean manufacturing being adopting widely in textile sector.

The concept of lean manufacturing is now widely used in textile companies, because of the demand for the production and quality of products therefore textile sector now greatly using lean manufacturing tools to eliminate the non-value-added activities from the production process and make the worth of the product different tools used in textile company whereas line balancing greatly used in assembly purpose mostly in stitching line 5s greatly used because to improve the management between the low and middle management and the flow of process remain undisturbed.

1.1 Problem Statement

To improve assembly lines, several steps can be taken. First, analyze the assembly process to identify redundant or unnecessary workers and reorganize positions. Implement a lean manufacturing approach to optimize labor utilization and efficiency. Second, standardize cycle time by implementing standard operating procedures, time studies, training programs, and automation solutions. Third, identify non-value-adding activities and prioritize improvement based on labor costs and efficiency. Implement lean manufacturing principles like 5S to eliminate waste and improve workflow. Continuously monitor and measure key performance indicators to track progress. Fourth, balance assembly lines by analyzing workload and process flow, using techniques like line balancing, cross-training programs, and investing in equipment or technology solutions. Finally, foster a culture of continuous improvement through employee engagement, encouraging active participation in problem-solving and idea-generation initiatives. Implement a structured Kaizen program to identify and address inefficiencies in the assembly process. Regular review meetings and performance feedback mechanisms will help sustain improvements over time.

The study aims to enhance the efficiency of the assembly line. The objectives of the study are to streamline the assembly line process by minimizing excess manpower and machinery, thereby enhancing the efficiency of the sheet set assembly line. Additionally, to suggest or advocate for an optimized layout design following thorough line balancing.

2. LITERATURE

Line balancing assembly involves allocating tasks and activities among operators in a balanced manner to minimize waiting time and ensure equal intensity. This process can increase productivity, reduce costs, and improve product quality in the manufacturing industry by balancing the time it takes to complete different tasks [9]. Assembly line planning involves optimizing process time and productivity through logical and physical operations. Line balancing categorizes work equally for all workstations to minimize resources and maintain productivity. Designing and balancing an assembly line for industrial products is crucial as it eliminates trial-and-error activities and costs associated with large-scale production [10]. Bottlenecks in the sewing assembly line cause longer cycle times and slow processes, reducing production line efficiency. Line balancing is a technique for balancing production lines. Traditional production systems need to be replaced with assembly lines for greater product variability and shorter cycle times [11].

Line balancing operates under two constraints: precedence requirement, represented by a precedence diagram, and cycle time restriction. The precedence diagram shows the sequence of tasks, with work elements represented by nodes. Cycle time is the maximum time a product can spend at each workstation, ensuring that tasks are completed before any other tasks [12].

Lean also denoted as lean Management, Manufacturing (LM), and Lean Principle (LP), is a set of principles, tools, and techniques that many industrial organizations and companies' option to implement, to enhance the efficiency of production and overall customer value while at the same time Eliminating waste[13]. Lean manufacturing practices such as line balancing, frequent time & motion study, periodic time, TPM programs, and OEE have been suggested for improving productivity, profitability, and quality in various industries. A case study on a pharmaceutical assembly line identified defective waste, motion waste, waiting waste, and over-processing waste as the deadliest waste. In the textile stitching unit, line balancing, and time & motion study were applied to improve productivity [14].

Time and motion studies are a systematic and critical approach to analyzing the efficiency and economic efficiency of tasks. They involve breaking down complex jobs into simple steps, observing the sequence of movements to detect wasteful motion, and measuring the time taken for each correct movement. This information is used to calculate production and delivery times, prices, and incentive schemes. Time and motion studies were first proposed by Frederick Winslow Taylor and developed by Frank Gilbreth and Dr. Lillian Gilbreth [15].

The main objectives of time study include determining the standard time for various operations, estimating product costs, predicting work durations, determining the number of machines an operator can run, determining the optimal number of men and machines, providing information for planning and scheduling, balancing work of all workers in a group, and comparing work efficiency of different workers/operators. Techniques for time study include time study using stopwatches, predetermined motion time systems (PMTS), work sampling, and analytical estimating [15].

Waste can be identified in seven forms: defaults, overproduction, waiting, conveyance, processing, inventory, and motion. Each form has its causes and solutions and eliminating them can lead to multiple benefits [16]. Lean manufacturing focuses on reducing waste in the manufacturing process, which includes procedures that customers do not pay for. Waste can be caused by delays, processes, costs, and errors, and can be categorized into seven forms: defects, waiting, overproduction, conveyance, processing, inventory, and motion. Eliminating these wastes can provide multiple benefits, such as increased productivity. Eight Lean manufacturing wastes include over-processing, waiting, unnecessary (motion, transportation, and inventory), over-processing, unused skills, and defects. Implementing these tools can enhance the productivity of the Ethiopian garment industry [17].

Textile companies are responsible for manufacturing cloth by applying various processes like spinning, weaving, dying, printing, and stitching to transform raw materials like cotton into a finished product. While some companies focus on spinning and weaving, the textile sector is complex and focuses on quality improvement and waste reduction. Lean manufacturing is increasingly being adopted in the textile sector to eliminate non-value-added activities and improve product value. Tools like line balancing are used in assembly, particularly in stitching, to improve management between low and middle management and maintain the flow of the process. This approach is crucial for the success of textile companies in the complex and demanding industry.

3. METHODOLOGY

3.1 Line Balancing

Line balancing is the process of leveling workload across all operations in a line to remove bottlenecks and excess capacity. It is essential in mass production where garments are produced in lines or sets of machines, with production per hour varying based on work content, manpower allocation, operator skill level, and machine capacity. Bottleneck operations determine output, and increasing production from these operations is crucial. Line supervisors and work-study officers implement ways to increase production from bottleneck operations to level work across operations. However, some factories use the term "line balancing" instead of "machine balancing" [18,19].

The Simple Assembly Line Balancing Problem (SALBP) is a crucial optimization challenge in production and manufacturing, like the Traveling Salesman Problem (TSP). It focuses on the optimal allocation of tasks in an assembly line environment, aiming to minimize performance metrics like total cycle time, production cost, and resource utilization while respecting constraints. SALBP optimizes the assembly line

configuration, maximizing efficiency, minimizing cycle time, balancing workloads, reducing costs, and enhancing flexibility and adaptability. By ensuring each station operates at its maximum capacity, SALBP ensures efficient resource utilization, reduces cycle time, and promotes a smooth workflow [20].

The flow chart Fig. 1 shows the methodology steps that have followed in this study first of all have identified the company, as the interest area was in textile sector so this study conducted in the textile mill limited Karachi Pakistan and observe the whole process of company that how the production take place and how product flow through different processes as this study was focused in the stitching department of company and did time and motion study of whole assembly process from stitching to packing by stopwatch and analyze the current situation of the line that how much time the whole process is taken to complete the product assembly so author takes the before reading and which assure that line is unbalance by calculation of SAM, capacity and man, machine requirement then change some scenarios of whole assemble line like(remove the dumping of the material through which WIP reduced Start Select the company to implement line balancing Make a little research on the company Collect the data using stopwatch; Numbers of worker involves, total time of sheet set completion , sheet set operations time , activities during sheet set change over time. Analyze the current situation of the line Time and Motion study to create a good layout for the line end and reduce the bottleneck again take the final reading of the whole assembly line and find the improvement then accordingly author creates or recommends a better layout for stitching line.

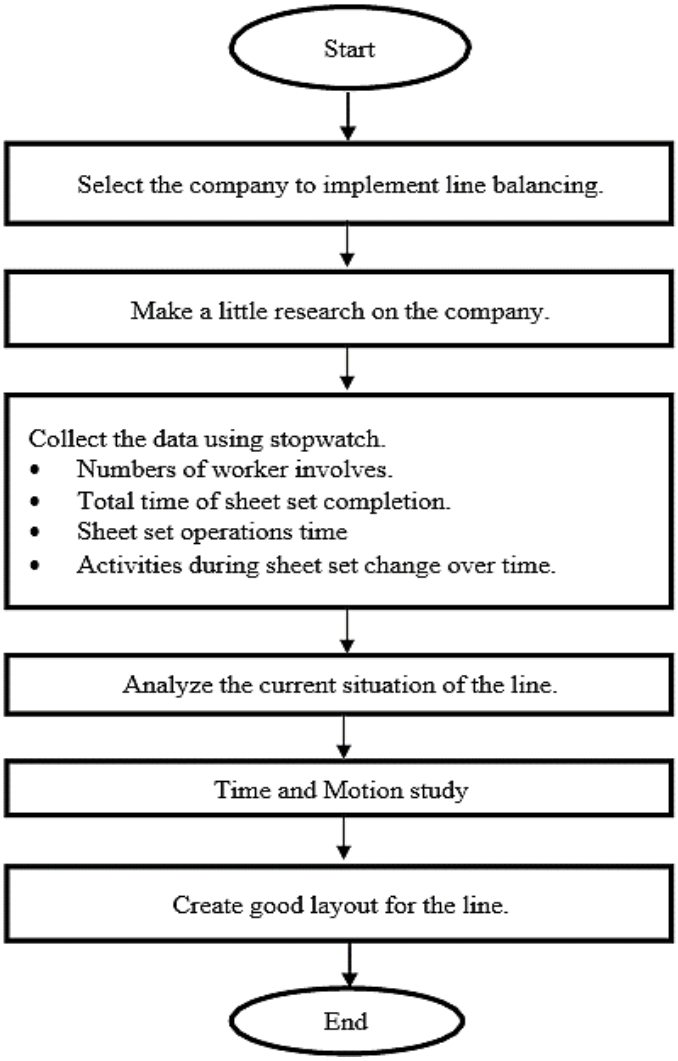

Fig. 1. Flow chart of methodology

Line balancing involves analyzing the current situation of a line and providing the best solution for it. Methods study focuses on decreasing work satisfaction in a job or operation, while the work dimension is concerned with unsuccessful time related to the process and following the formation of time values for the operation. Tools for observing procedures judgmentally are provided, covering activities achieved, complex operators, equipment and tools used, and materials treated or moved.

3.2 Methods of Line Balancing

Analyze the current situation of the line and give the best solution for line balancing.

3.2.1 Analysis of work content using method study

The method study process is primarily concerned with improving efficiency by reducing unnecessary work and time wastage in job operations. It involves critically examining various aspects of the process to identify areas for improvement. The core areas covered in the method study include activities performed, involvement of operators, equipment and tools utilized, and materials managed or transported.

During the study, job data is carefully observed and scrutinized for practicality and necessity. This includes examining factors such as determination, location, arrangement, and method of performing tasks. By evaluating the manufacturing potential and allocation of resources, it becomes evident that many activities within the process contribute little to no value, leading to an increase in processing time. Therefore, the primary objective of the study is to decrease processing time by minimizing non-value-added activities.

To achieve this objective, alternative methods are devised to establish a foundation for new work orders. The perspective of operators is crucial, as their input helps in identifying challenges and allowances in real-world scenarios. Through documentation and engagement with operators, they become significant stakeholders in the process, making it more worker-friendly and suitable. Additionally, workers are provided with training and exercises on the new work orders under the guidance of an industrial engineer, ensuring smooth implementation and adoption of the improved methods.

3.3 Time Motion Study

Time study is a method of analyzing work cycles, involving the use of specific control mechanisms to minimize timing errors. Electronic devices are increasingly used for timing, sometimes converting observed times into basic times. The number of cycles needed depends on the work's variability and the required accuracy level. Time study is a sampling technique, which estimates the time required for a job based on observed times. Statistical techniques can be used to estimate the number of observations required under specific conditions, considering a range of variable conditions and workers [21].

A time study is a method used to calculate work progression by breaking down an operation into specific elements, ensuring a balanced representation of the task. Skilled operators are chosen to perform these elements, and their performance is measured using stopwatch time study techniques. The primary objective is to identify the most efficient time utilization methods for a given process. Stopwatch time measurement is preferred due to its simplicity and accuracy in data recording. Operators are observed and the time taken for each element is recorded over multiple cycles to accurately capture the time required to complete each action. Budgets are allocated for necessary but non-productive actions. The study also focuses on controlling work standards to eliminate idle actions and establish new average times for analysis. Continuous monitoring and adjustment of work values are used to optimize productivity and efficiency in the workplace. In summary, the time study methodology involves meticulous observation and measurement of work processes to enhance productivity and reduce time wastage.

Time motion study calculates work in progression by breaking down operations into smaller, less time-consuming elements and selecting an average cooperative operator(s). A Stopwatch time study is used to examine a specific process by skilled workers to find the maximum effective customs in terms of time. This technique is easier and earlier in data recording, allowing element times to be entered directly on the time study sheet without the need for subtractions.

The time study of fitted sheet sets is used for three articles of sheet set. The stopwatch method calculates the cycle time of each operation of

each article, calculates the SAM, and calculates the capacity and machine requirement of the line.

The goal of this study is to decrease processing time through falling unsuccessful times and form the basis for new work orders. Operator views are measured based on allowances and difficulties faced in real situations, making the procedure friendlier and suitable for workers.

4. DATA COLLECTION AND ANALYSIS

4.1 Scope of the Study

The study concentrates on understanding the theory and concept of Assembly line balancing. The data collected from the industry was analyzed using a time and motion study of Line Balancing. The study shall be concerned with line balancing effectiveness by eliminating unnecessary Activities from the Assembly line and providing sequential work activities in the Assembly line with minimum idle time. The main target is to explore the companies suitable for this project, learn and collect necessary data from the existing system, and propose the optimum system based on parameters, for example, cycle time, line efficiency, and balance delay. The project is concerned with the Assembly line balancing of the Sheet set a product of Textile Company in Pakistan that consists of one fitted sheet, one flat sheet, and two pillows.

4.2 Analysis

The analysis of this assembly line results in a set of standardized production in stitching, checking, and packaging operations. The next step was to organize these tasks/activities optimally to achieve the required targets. Line balancing is the major decision problem that arises when constructing or re-configuring an assembly line. Line balancing consists of distributing the total workload uniformly among all the workers present along the stitching, checking, and packing. The overall performance of the system was affected by this distribution of work.

A line balancing problem was associated with the design of a process flow line, which, generally consists of several processes that were joined together by some type of material handling system, for example, the transport of finished products to the warehouse, after ten to fifteen minutes a worker brings a packet of packing box and other accessories materials before the start of new batch, etc. For a given product, the entire assembly line processes are broken down into several work elements or tasks. Each task is performed by workers assigned to the line. The product assembly line was completed by sequential completion of all the tasks.

Every product goes through the same sequence of assembly line tasks in the same order. However, the operations for the completion of the article may be changed due to the change of customer.

4.3 Software Used in the Study

The study conducted for line balancing is primarily based on time and motion analysis, utilizing stopwatches to collect data on various activities. Initially, the data collected is analyzed using Microsoft Excel and Visio software. However, in the final report, only Excel is utilized for analysis purposes. Excel is chosen as the primary tool for analysis due to its versatility, ease of use, and wide acceptance in the industry for data manipulation and visualization. It offers a range of functions and tools that are well-suited for processing time and motion data, such as sorting, filtering, pivot tables, and charting capabilities.

By using Excel, the collected data can be organized efficiently, allowing for the identification of bottlenecks, optimization opportunities, and the balancing of tasks across the production line. Additionally, Excel's spreadsheet format enables easy sharing and collaboration among team members involved in the study. Furthermore, Excel provides the flexibility to customize analysis based on specific requirements or criteria of the study. This includes the ability to create custom formulas, macros, and visualizations tailored to the needs of the line-balancing analysis.

4.4 Current Situation of the Company

The study aims to control the fluctuating SAM (Standard Allowed Minutes) by ensuring timely provision of product accessories and maintaining worker efficiency. Workers are often unaware of potential product loss due to delivery delays, leading to defective products. The first reading revealed widespread product dumping, resulting in Work in Progress (WIP) due to the unavailability of packing materials or management's failure to order from the warehouse. The stitching and checking line

forwarded the product to the packing line after completing their task, causing dumping. This shift in working efficiency will result in a change in the SAM (Standard Allowed Minutes) of packing line workers, as they lose their working spirit, affecting their overall efficiency. The study suggests that the timely provision of product accessories and maintaining worker efficiency can help maintain a consistent SAM throughout the operation.

5. RESULTS AND DISCUSSION

This study made a standard by the negotiation with the stitching, checking, and packing line supervisor. To start the assembly line, work the packing line supervisor confirms the availability of all the packing accessories first and then orders to stitching line supervisor to start their work result to avoid dumping of product and run the whole assembly line undisturbed, this study also minimizes the machines, manpower of stitching, checking, and packing line respectively. The target was achieved concerning the capacity of a whole assembly line. The data is shown in the Table 1.

Table 1 shows the before data of sheet set stitching operations machine (M/C) requirement of sheet set flat, fitted, and pillow for the sheet set flat machine requirement that calculated for the operation 10 cm hem (1 side) and 1 cm hem (3 sides) plus 1 label attach is 5 and 10 respectively. A total of 15 machines were required in sheet set flat stitching line.

For sheet set fitted machines requirement that we calculate for the operation 4 corners stitch (4 sides) and elastic attach (4 sides) is 6 and 11, respectively. A total of 17 machines were required in sheet set fitted stitching line. For the sheet set pillow the machine requirement that calculates for the operation 10 cm hem (2 sides), safety (2 sides) plus 1 label attach, and tacking (1 side) is 5, 5, and 1 respectively total in stitching line of sheet set pillow was 11 machines.

Table 2 sheet set data of stitching operations shows the result in before and after format. Here the author has minimized the number of machines as the target of the line was reached concerning line capacity in a sheet set flat, the study has reduced the machines from 15 to 10 machines. In the sheet set fitted we have reduced the machine from 17 to 16 and in a sheet set pillow the machine remains the same because the required target was achieved on these 11 machines according to the line capacity.

Table 3 sheet set data of stitching operations shows the result of capacity in before and after format. Here calculated the capacity with the help of SAM and the number of machines and conclude that the given target has been achieved. In the sheet set flat before data shows that the target in 1cm hem (3sides) +1 label attach not achieved and no of the machine was 8, but after the target has achieved in all of two operations of the sheet set flat. Similarly, the sheet set fitted before data shows that in elastic attach (4 sides)) operation the given target wasn't achieved but after data, it was achieved, and the total number of machines was reduced from 18 to 16. In the last sheet set pillow before data shows that in the starting of two operations the given target wasn't achieved but after data, all three operations achieved the given target.

The Table 4 shows the data set of checking before the line balancing and Table 5 sets the data of checking operations to show the result. Here minimizes the amount of manpower as the target of the line was achieved concerning line capacity in sheet set flat reduced the manpower from 8 to 5. Similarly, the sheet set fitted reduced the manpower from 8 to 5, and in the sheet set pillow, the machine remained the same because the required target was achieved on the 3 pairs of manpower according to the line capacity.

The sheet set data of checking operations shows the result of capacity in before and after format. Here in the sheet set flat both format before and after, the target has been achieved but now this time we gave the preference number of manpower, so the result has shown in the above data sheet, before data the manpower was 8 has achieved the target but in after reading the given target was achieved in 5 manpower. Similarly in the sheet set fitted in both formats target was achieved but reduced the manpower from 8 to 5 and in the sheet set pillow there are several manpower reductions because the target can achieve at least 3 manpower.

The Table 7 shows the Manpower requirement of the sheet set packing operations, before the date the operations were done manually by the workers each worker had a time of 450 minutes in a day and each had a target of 3500 according

Table 1. Machine requirements for sheet set stitching operations before data analysis

Machine (M/C) requirement						
Sheet Set (Flat)						
Stitching Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
10 cm hem (1sides)	SNL	450	3500	0.5	4.58	*5*
1cm hem (3 sides) + 1lbl	SNL	450	3500	1	9.15	10
TOTAL				**1.50**	**13.73**	**15**
Sheet Set (Fitted)						
Stitching Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
4 corners stitch (4 sides)	SNL	450	3SOO	0.6	5.49	6
Elastic Attach (4 sides)	SNL	450	3500	1.2	10.98	11
TOTAL				**1.80**	**16**	**17**
Sheet set (Pillow)						
Stitching Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
10cm hem (2 sides)	SNL	450	7000	0.25	4.58	5
Safety (2 sides) + 1lbl	SF	450	7000	0.26	4.76	5
Tacking (1 side)	SNL	450	7000	0.05	0.92	1
TOTAL				**0.56**	**10.25**	**11.00**

NB: M/C (Machines), SNL (Single needle lock stitch), and SAM (Standard Allowed Minutes)

Table 2. After analyzing data from sheet set stitching operations: Machine requirements

Machine requirement						
Sheet Set (Flat)						
Stitching Operations	**Efficiency**		**8S%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
10 cm hem (1 sides)	SNL	450	3500	0.41	3.73	4
1cm hem (3 sides) + 1lbl	SNL	450	3500	0.62	5.65	6
TOTAL				**1.03**	**9.39**	**10**
Sheet Set (Fitted)						
Stitching Operations	**Efficiency**		**1**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
4 corners stitch (4 sides)	SNL	450	3500	0.44	4.01	5
Elastic Attach (4 sides)	SNL	450	3500	1.14	10.46	11
TOTAL				**1.58**	**14**	**16**
Sheet Set (Pillow)						
Stitching Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
10 cm hem (2 sides)	SNL	450	7000	0.22	4.08	5
Safety (2 sides) + 1lbl	SF	450	7000	0.23	4.14	5
Tacking (1 side)	SNL	450	7000	0.05	0.92	1
TOTAL				**0.50**	**9.13**	**11.00**

NB: M/C (Machines), SNL (Single needle lock stitch), and SAM (Standard Allowed Minutes)

Table 3. Data of sheet set stitching operations capacity

Before						**After**					
Capacity						**Capacity**					
Sheet Set (Flat)						**Sheet Set (Flat)**					
Stitching Operations	**Efficiency**		**85%**		**capacity**	**Stitching Operations**	**Efficiency**		**85%**		**capacity**
	M/C Type	**Working Minutes**	**No of m/c**	**SAM**			**M/C Type**	**Working Minutes**	**No of m/c**	**SAM**	
10 cm hem (1sides)	SNL	450	8	0.5	6120 3060	l0cm hem (sides)	SNL	450	4	0.41	3750
1cm hem (3 sides) +1lbl	SNL	450	8	1		1cm hem (3sides) + 1lbl	SNL	450	6	0.62	3714
TOTAL		**450**	**16**	**1.50**	**4080**	**TOTAL**		**450**	**10**	**1.03**	**3728**
	Sheet Set (Fitted)						**Sheet Set (Fitted)**				
Stitching Operations	**Efficiency**		**85%**		**capacity**	**Stitching Operations**	**Efficiency**		**85%**		**capacity**
	M/C Type	**Working Minutes**	**No of m/c m/c**	**SAM**			**M/C Type**	**Working Minutes**	**No of m/c**	**SAM**	
4 corners stitch (4sides)	SNL	450	9	0.6	5738	4 corners stitch (4 sides)	SNL	450	5	0.44	4347
Elastic Attach (4sides)	SNL	450	9	1.2	2869	Elastic Attach (4 sides)	SNL	450	II	1.14	3691
TOTAL		**450**	**18**	**1.80**	**3825**	**TOTAL**		**450**	**16**	**1.58**	**3873**
	Sheet set (Pillow)						**Sheet set (Pillow)**				
Stitching Operations	**Efficiency**		**85%**		**capacity**	**Stitching Operations**	**Efficiency**		**85%**		**capacity**
	M/C Type	**Working Minutes**	**No of m/c m/c**	**SAM**			**M/C Type**	**Working Minutes**	**No of m/c**	**SAM**	
10 cm hem (2 sides)	SNL	450	2	0.25	3060	10cm hem (2 sides)	SNL	450	5	0.22	8693
Safety (2 sides)	SF	450	4	0.26	5885	Safety (2 sides)	SF	450	5	0.23	8315
Tacking (1side)	SNL	450	2	0.05	15300	Tacking (1 side)	SNL	450	1	0.05	7650
TOTAL		**450**	**8**	**0.56**	**5464**	**TOTAL**		**450**	**11**	**0.5**	**8415**

NB: M/C (Machines), SNL (Single needle lock stitch), and SAM (Standard Allowed Minutes)

Table 4. Manpower requirement for sheet set checking operations before data analysis

Manpower requirement						
Sheet Set (Flat)						
Checking Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
Cropping+ Stacking	Manual	450	3500	0.8	7.32	8
Bundle Making	Manual	450	3500	0	0.00	0
TOTAL				**0.80**	**7.32**	**8.00**
Sheet Set (Fitted)						
Checking Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
Cropping +Stacking	Manual	450	3500	0.8	7.32	8
Bundle Making	Manua l	450	3500	0	0.00	0
TOTAL				**0.80**	**7**	**8.00**
Sheet Set (Pillow)						
Checking Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
Cropping+ Stacking	Manual	450	7000	0.1	1.83	2
Turning	Manua l	450	7000	0.03	0.55	1
TOTAL				**0.13**	**2**	**3**

Table 5. After data of sheet set checking operations manpower requirement

Manpower requirement						
Sheet Set (Flat)						
Checking Operations	**Efficiency**			**85%**	**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
Cropping + Stacking	Manual	450	3500	0.48	4.39	5
Bundle Making	Manual	450	3500	0	0.00	0
TOTAL				**0.48**	**4.39**	**5.00**
Sheet Set (Fitted)						
Checking Operations	**Efficiency**			**85%**	**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
Cropping+ Stacking	Manual	450	3500	0.47	4.27	5
Bundle Making	Manual	450	3500	0	0.00	0
TOTAL				**0.47**	**4**	**5.00**
Sheet Set (Pillow)						
Checking Operations	**Efficiency**			**85%**	**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	Working Minutes	Daily Target	SAM		
Cropping + Stacking	Manual	450	7000	0.10	1.83	2
Turning	Manual	450	7000	0.03	0.51	1
TOTAL				**0.13**	**2**	**3**

Table 6. Data of sheet set stitching operations capacity

Before						**After**					
Capacity						**Capacity**					
Sheet Set (Flat)						**Sheet Set (Flat)**					
Checking Operation	**Efficiency**		**85%**		**capacity**	**Checking operation**	**Efficiency**		**85%**		**capacity**
	M/C Type	**Working Minutes**	**No of m/c**	**SAM**			**M/C Type**	**Working Minutes**	**No of m/c**	**SAM**	
Cropping + stacking	Manual	450	8	0.8	3825	Cropping + stacking	Manual	450	5	0.48	3984.375
Bundle Making	Manual	450	0	0	0	Bundle Making	Manual	450	0	0	0
TOTAL		**450**	**8**	**0.8**	**3825**	**TOTAL**		**450**	**5**	**0.48**	**3984.375**
	Sheet Set (Fitted)						**Sheet Set (Fitted)**				
Checking Operation	**Efficiency**		**85%**		**capacity**	**Checking Operation**	**Efficiency**		**85%**		**capacity**
	M/C Type	**Working Minutes**	**No of m/c**	**SAM**			**M/C Type**	**Working Minutes**	**No of m/c**	**SAM**	
Cropping + stacking	Manual	450	8	0.8	3825	Cropping+ Stacking	Manual	450	5	0.47	4069.1489
Bundle Making	Manual	450	0	0	0	Bundle Making	Manual	450	0	0	0
TOTAL		**450**	**8**	**0.8**	**3825**	**TOTAL**		**450**	**5**	**0.47**	**4069**
	Sheet Set (Pillow)						**Sheet Set (Pillow)**				
Checking Operation	**Efficiency**		**85%**		**capacity**	**Checking Operation**	**Efficiency**				**capacity**
	M/C Type	**Working Minutes**	**No of m/c**	**SAM**			**M/C Type**	**Working Minutes**	**No of M/c**	**SAM**	
Cropping + stacking	Manual	450	2	0.1	7650	Cropping+ Stacking	Manual	450	2	0.10	7650.0000
Turning	Manual	450	1	0.03	12750	Turning	Manual	450	1	0.03	12750
TOTAL		**450**	**3**	**0.13**	**8826.923**	**TOTAL**		**450**	**3**	**0.13**	**8826.923**

Table 7. Before data of sheet set packing operations manpower requirement

Manpower requirement						
Sheet Set						
Packing Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
2 inlay card insertions in polybag	Manual	450	3500	0.2	1.83	2
Fitted Folding	Manual	450	3500	0.13	1.19	2
Flat Folding with stiffener	Manual	450	3500	0.25	2.29	3
Pillow Pairing	Manual	450	3500	0.29	2.65	3
Fitted + Pillow Pairing	Manual	450	3500	0.16	1.46	2
Set Pairing (Fitted. Flat· Pillow)	Manual	450	3500	0.13	1.19	2
Set insertion in a polybag	Manual	450	3500	0.12	1.10	2
Zip closing	Manual	450	3500	0.37	3.39	4
2 Stickers attach	Manual	450	3500	0.44	4.03	5
Insertion in carton	Manual	450	3500	0.12	1.10	2
carton sealing	Manual	450	3500	0.2	1.83	2
TOTAL				**2.41**	**22.05**	**29.00**

Table 8. After data of sheet set packing operations manpower requirement

MANPOWER requirement						
			Sheet Set			
Packing Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
2 inlay card insertions in polybag	Manual	450	3500	0.2	1.83	2
Fitted Folding	Manual	450	3500	0.12	1.10	2
Flat Folding with stiffener	Manual	450	3500	0.19	1.74	2
Pillow Pairing	Manual	450	3500	0.22	2.01	3
Fitted + Pillow Pairing	Manual	450	3500	0.14	1.28	2
Set Pairing (Fitted-Flat-Pillow)	Manual	450	3500	0.13	1.19	2
Set insertion in a polybag	Manual	450	3500	0.12	1.10	2
Zip closing	Manual	450	3500	0.33	3.02	4
2 Stickers attach	Manual	450	3500	0.36	3.29	4
Insertion in Carton	Manual	450	3500	0.12	1.10	2
Carton sealing	Manual	450	3500	0.2	1.83	2
TOTAL				**2.13**	**19.49**	**27.00**

Table 9. Data of sheet set packing operations capacity

Before						**After**					
Capacity						**Capacity**					
Sheet Set						**Sheet Set**					
Packing Operations	**Efficiency**		**85%**		**capacity**	**Packing Operations**	**Efficiency**		**85%**		**capacity**
	M/C Type	**Working Minutes**	**No of m/c**	**SAM**			**M/C Type**	**Working Minutes**	**No of m/c**	**SAM**	
2 inlay card insertion in polybag	Manual	450	2	0.2	3825	2 inlay card insertions in polybag	Manual	450	2	0.2	3825
Fitted folding	Manual	450	2	0.13	5884.6154	Fitted Folding	Manual	450	2	0.12	6375
Flat Folding with stiffener	Manual	450	3	0.25	4590	Flat Folding with stiffener	Manual	450	2	0.19	4026.3158
Pillow Pairing	Manual	450	3	0.29	3956.8966	Pillow Pairing	Manual	450	3	0.22	5215.9091
Fitted + Pillow Pairing	Manual	450	2	0.16	4781.25	Fitted + Pillow Pairing	Manual	450	2	0.14	5464.2857
Set Pairing (fitted-Flat· Pillow)	Manual	450	2	0.13	5884.6154	Set Pairing (Fitted-Flat· Pillow)	Manual	450	2	0.13	5884.6154
Set insertion in polybag	Manual	450	2	0.12	6375	Set insertion in poly bag	Manual	450	2	0.12	6375
Zip closing	Manual	450	4	0.37	4135.135	Zip dosing	Manual	450	4	0.33	4636.3636
2Stickers attach	Manual	450	5	0.44	4346.5909	2Stickers attach	Manual	450	4	0.36	4250
Insertion in Carton	Manual	450	2	0.12	6375	Insertion in Carton	Manual	450	2	0.12	6375
Carton sealing	Manua l	450	2	0.2	3825	Carton sealing	Manual	450	2	0.2	3825
TOTAL		**450**	**29**	**2.41**	**2.6971**	**TOTAL**		**450**	**27**	**2.13**	**4848.5915**

to their calculated SAM the Manpower requirement of operation 2 inlay card insertion in polybag, Fitted Folding, Flat Folding with stiffener, Pillow Pairing, Fitted + Pillow Pairing, Set Pairing (Fitted flat Pillow), Set insertion in polybag, Zip closing 2 Stickers attach, Insertion in carton, carton sealing is 2, 2, 3, 3, 2, 2, 2, 4, 5, 2, and 2 respectively.

Table 8 shows the set data of Packing operations shows the result. Here the study minimized the amount of manpower from 29 to 27 as the target of the line was achieved concerning line capacity.

Operations show the result of capacity in before and after format. Here is the combined result of Flat, Fitted, and pillow. After performing all the operations of stitching and checking to Flat, Fitted, and pillow they combine into a sheet set and assemble in a packing room the above sheet shows the whole sheet set capacity.

6. CONCLUSION

The study aimed to improve the productivity of an assembly line for manufacturing sheet sets, focusing on the stitching process to the final packing stage. Key objectives included reducing cycle times, optimizing workforce allocation, and augmenting production capacity. A comprehensive approach was employed, utilizing time and motion analysis techniques and Microsoft Excel to analyze data.

Results showed a strategic reduction in machine requirements for Flat and Fitted Stitching Operations and an increase in machinery allocation for Pillow Operations. This realignment of resources led to a more balanced production capacity across various stages of sheet set assembly. Additionally, the study led to a refinement in manpower allocation, resulting in reduced workforce requirements for Flat and Fitted Sheet Checking and Pillow Checking processes. The packing stage also saw improvements, with a reduction in required manpower from 29 to 27 individuals while increasing packing capacity. This optimization of packing resources contributed to overall efficiency gains in the assembly line.

A key aspect of the study's success was the design and implementation of a balanced line layout, which ensured a smooth and efficient flow from stitching to packaging stages. This process involves analyzing several factors such as workflow, production rates, worker skills, and machinery capabilities to ensure smooth operations.

Line balancing is a common method used in this type of study, where tasks along the production line are analyzed and adjusted to ensure optimal operation at each station. Implementing these optimizations can lead to cost savings, improved productivity, and enhanced market competitiveness. It also allows for better resource utilization, contributing to sustainability efforts by reducing waste and energy consumption.

7. RECOMMENDATIONS

The discussion revolves around the importance of timely accessory availability in balancing production lines. The Time Study emphasizes the need for an Integrated Management System (ERP) to streamline operations and reduce Work in Progress (WIP). The company should also provide comprehensive training to supervisors and floor in-charges on the ERP system to minimize unnecessary movement, reduce waiting times, and enhance lead times in the production process. This strategic move aims to reduce unnecessary movement and improve overall efficiency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Design Modification and Fabrication of An Active Solar Dryer

Danesh Kumar Meghwar*
Department Mechanical Engineering, MUET, Jamshoro, Sindh Pakistan
Instructor Mechanical at Department of Mechanical Technology at Government Polytechnic Institute, Mithi Tharparkar, Pakistan
Email: kumardanesh012@gmail.com
ORCID iD: https://orcid.org/0009-0000-4149-0307
*Corresponding Author

Atam Kumar
Department of Engineering Management, University of Calabria, Rende, Cosenza, Italy
Department Industrial Engineering and Management, MUET, Jamshoro, Sindh Pakistan
Email: atamkumar2018@gmail.com
ORCID iD: https://orcid.org/0000-0002-0197-8532

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Abstract: This study presents the design modification and performance evaluation of an active solar dryer. The Modified Active Solar Dryer (MASD) is equipped with a non-concentrating flat plate thermal collector and drying chamber to dry various agricultural products. The drying chamber contains trays inside it. These are used to completely circulate airflow inside it. The drying Chamber has a cross-section Area of 0.30m × 0.45m and a height of 0.45m. The Flat plate collector has 0.91 m length, 0.45 m width, 0.12 m depth, and 0.049 m^3 volume. This study performed experimental work and evaluated performance by drying the chili in a Simplified Active Solar Dryer and Modified Active Solar dryer from 8 am to5 pm with average solar irradiance of 883.25W/m^2. The temperature has been recorded at six different points. The difference in temperatures between the dryer input and the surrounding air has been observed continuously. Temperatures at the Thermal Collector and Drying Chamber are the main prime mover of solar drying, so our main concern was on these two temperatures. The temperature achieved by SASD in the thermal collector is in the range of 55 ~ 60˚C meanwhile in the MASD temperature range is 65 ~ 70˚C. In SASD chili was dried in five days meanwhile in Modified Active Solar Dryer it took four days. The moisture content of the chili was reduced to 10% and it took 45hour for SASD and 34 hours for MASD. It is concluded that Modified Active Solar Dryer took 34% less time than the Simplified Active Solar Dryer.

Index Terms: Modified Active Solar Dryer (MASD), Fabrications, Solar Dryer, Temperature, Thermal Collector

1. Introduction

1.1. Background

Drying is an essential process for the preservation of agricultural products. Food products, especially fruits and vegetables require hot air in the temperature range of 45~ 70˚C for safe drying. Agricultural food products can dry quickly to a safe moisture content and assure superior quality of products by solar drying under controlled temperature and humidity.

For thousands of years, people have dried fruits and vegetables in the open sun by spreading out the product in a suitable area and allowing it to dry. It is a highly economical method of drying. While the product is soaked, a person must keep chasing away animals and remove it when the weather turns too windy, dusty, or rainy.

In most South Asian countries, agriculture represents the biggest part of the economy. Agriculture contributes 24% of the GDP of Pakistan [1]. In Pakistan, 35% to 40%people work in agriculture. Despite these significant numbers, the population's needs are not being met by the food supply system. I.e tomatoes are imported from neighboring countries to fulfill needs. One of the main reasons for this shortfall is that a substantial number of crops are spoiled in the post-harvest period.

As science brings new technologies, population growth increases day by day, and demands for nutritious food, affordable natural food has led to the development of the Modified Solar Dryer. Solar drying requires technology and costs to dry fruits and vegetables. To dry the food properly in a solar dryer, a great amount of dry air circulates through the thermal collector to the drying chamber. Modified Active Solar Dryer allows products to dry overnight and in heavy rain. Dried food has enough nutrients, minerals, fibers, and vitamins. Modified Active Solar Dryer improves the position of farmers because farmers sell their agricultural products at very low cost during the harvest seasons as they can't preserve or store their products in large quantities [2].

This study intends to solve these issues by designing and fabricating the model of MASD using Solid Works. [3] Also analyses and compares the performance of Simplified Active Solar Dryer and Modified Active Solar Dryer.

1.2. Solar Energy Potential in Pakistan

Energy is an essential input for the economic growth of any country (Agriculture and industries). Pakistan is blessed with rich solar resources. Pakistan is the luckiest country since it has an average sunlight 12 hours every day. Pakistan receives the mean value of sunlight 19MJ/m2 per day over 95% of the country's total areas. [4]

1.3. Solar Thermal Collector

The primary component of a solar heating system is a Thermal collector, which captures solar energy converts it into heat energy, and transfers it to fluid passing through it. Solar collectors extract heat energy from radiation using radiation and convection processes. The components of a solar thermal collector are a metal plate called an absorber, a transparent cover, and insulation materials. Types of Solar Thermal collectors are:

Non-concentrating or Flat plate type solar thermal collector (Collector Area = absorber area). Concentrating or Focusing type STC. Concentrating Collectors have an area greater than the absorber area and higher temperature can be obtained. It focuses the sun's beams on the pipe through which the fluid is passing. Compared to non-concentrating thermal collectors concentrating thermal collectors have higher efficiency.

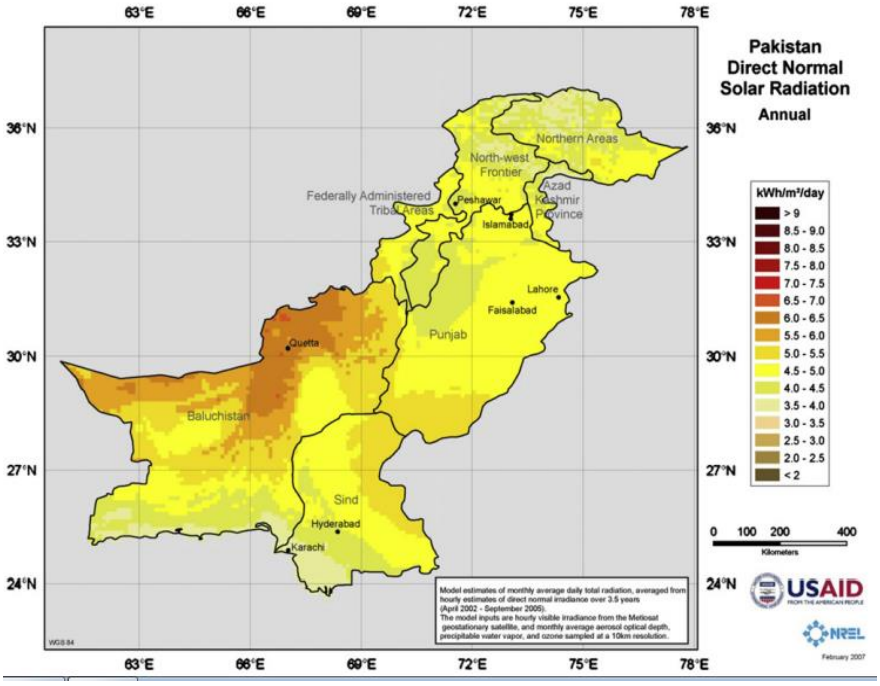


Fig. 1. Solar energy map of Pakistan with direct normal solar radiation [5]

1.3.1. Flat plate solar thermal Collector

The earliest generation of home hot water heating collectors used flat-plate collectors. A flat plate collector (FPC) comprises an insulated, weatherproof box with a glass and absorber plate with pipes to convey the heat transfer circulating fluid. When solar energy strikes a blackened absorber surface, after passing through a transparent cover. A large portion of this energy is absorbed by the plate and then transferred to the transport medium in the fluid tubes.

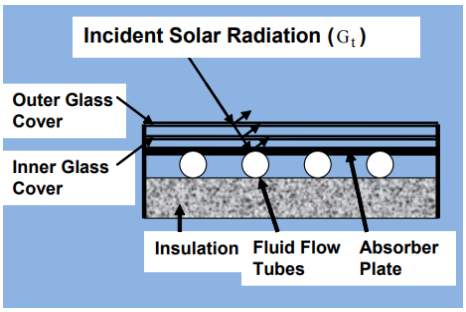


Fig. 2. Flat plate thermal collector [6]

1.3.2. Evacuated tube Solar Thermal Collector

Evacuated tube collectors (ETC) are composed of parallel rows of clear glass tubes, each housing an absorber tube. Although evacuated tubes are sensitive to breakage, they have several important benefits. Even in low temperatures and cloudy environments, efficiency is maintained at a high level. Because of its circular shape, it absorbs solar radiation the whole day.

1.3.3. Parabolic trough Concentrator

The parabolic trough (PTC) is a type of concentrating solar thermal collector. It focuses the sun's beams on the pipe through which the fluid is passing. It has a set of concave mirrors that focus sunlight on it. It can produce a temperature of 150 to 200˚C and is used to produce steam and for space heating.

1.3.4. Parabolic Dish Concentrator

Parabolic dish solar concentrators (PDC) are two-axis solar tracking devices that focus the sun's rays on a heat engine in the dish's center or concentrate them on a thermal

The receiver is at the dish collector's focal point as the dish is swiveled to follow the sun.

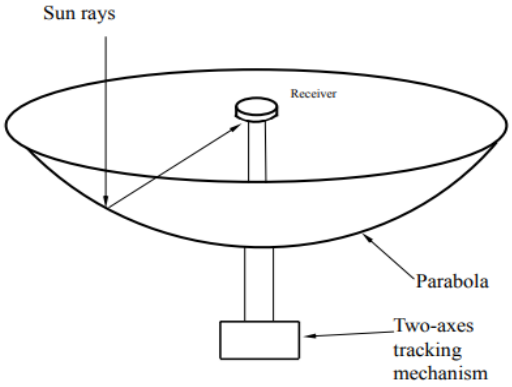


Fig. 3. Parabolic dish solar concentrators [6]

Table 1. Comparison of solar collectors

Motion	Type of collector	Concentration ratio	The temperature	Temperature in (℃)
Stationary	Flat plate collector (FPC)	1	Flat	33-80
	Evacuated tube collector (ETC)	1	Flat	50-210
	Compound parabolic collector (CPC)	1-5	Tubular	60-250
Tracking on a single-axis	Parabolic trough collector (PTC)	10-40	Tabular	50-300
	Parabolic dish reflector (PDR)	100-100	Point	100-510
Tracking along two axes	Heliostat field collector (HFC)	100-1500	Point	200-2000

1.4. Solar Dryer

Solar dryers are used to remove moisture from agricultural products including fruits, vegetables, and crops.

The basic principle of the solar dryer is that air is heated in the thermal collector through solar radiation and passed over to the agricultural products that must be dried.

The heating process could include:

- by directly subjecting the item to sunlight radiation
- the air being heated and passing through the product.

In MASD can dry fruits, vegetables, spices, food items, green leaves, seawater foods, etc. Solar dryers can be classified into two types based on their heating modes.

1.4.1. Passive solar dryer

The Passive solar dryer is also known as a natural circulation system or natural ventilation solar dryer. In this dryer there is no external source to push the air in the dryer, meanwhile, it is naturally circulated to the absorber and then to the dryer chamber.

1.4.2. Active solar dryer

An active solar dryer is also known as a forced convection dryer.

In this dryer, the air is pushed into the thermal collector with the help of blowers and fans. Active solar dryer temperatures are in a wide range and do not depend on weather conditions. Compared to natural circulation type, Active solar dryers are more efficient.

1.5. Problem statement

Various factors such as temperature, humidity, and moisture content affect open sun drying. Further problems affiliated with open sun drying are varying sunlight, rainy season, unhygienic conditions, and non-homogenous drying of products. There are numerous flaws and faults in open sun drying and dryer without control of temperature.

No uniform heat distribution inside the drying chamber due to improper subcomponent arrangements and lack of solar radiation absorption throughout the whole day. Due to the low temperature in the simple solar dryer, the product takes a lot of time to dry. Modifications in the thermal collector can alter the overall results of the dryer and can improve the quality of agricultural products, and the efficiency of the dryer.

*1.6. Aim and **Objectives***

This study aims to design modification and fabricate the active solar drier by providing the product with more heat than is naturally accessible, raising the moisture vapor pressure, and lowering the relative humidity. This project is to introduce a low-cost, temperature-controlled solar dryer to raise the temperature and dry agriculture products. The objectives of this study are:

To design a modified active solar dryer. To fabricate the modified active solar dryer. To evaluate the performance of the modified active solar dryer and compare it with the SASD.

2. Literature Review

This chapter consists of a review of previous studies made on agriculture drying-based solar energy to enhance the performance and effects of different factors. The literature provides the different methods of drying and gives the important equations used to find out the required factors for the performance.

2.1. Scanlin D [7] has reviewed that food drying was a great technique to keep the food fresh, and solar food dryers were suitable for food preservation technology. Authors concluded that every year, millions of dollars worth of gross were lost through spoilage. Because there is no preservation of agricultural products rural farmers sell their harvested products at low rates.

2.2. C L Hii et al [8] have shown that sun drying is economical but the product through it is poor quality. Because of the involvement of dust, insects, birds, and rain. Also, there is a loss of vitamins and unacceptable color changes due to the direct strike of ultraviolet sun rays. They show that solar dyer is the best device to protect foods from these.

2.3. Abro A [9] has developed an Active dryer in the laboratory EE Department SAU, Tandojam. Evaluated the performance of Active Home Use Dryer and dried commonly available vegetables such as bitter guard spinach, also suggested that Active Home Use Dryer can also be used commercially.

2.4. Mohanraj M and Chandrasekhar [10] concluded that the action drying system i.e. forced convection drying is highly efficient than natural convection solar dryers and drying faster than forced convection dryers and it has a better quality.

2.5. Hedge V N [11] developed a top-flow and bottom-flow solar dryer, in a drying chamber using skewers and conventional trays. Vinay evaluated the performance of the banana. The drying rate is increased by using skewers instead of conventional trays.

2.6. Kumar R et al [12] developed two different dryers namely a Cabinet dryer and a Hot air oven drying to dry the chili. They show that it took about one hour less time at 70˚C as compared to 50, and 60˚C to dry the sample completely. They also concluded that Hot air oven drying took more time to dry the sample as compared to tray drying, which means that more moisture transfer took place in the case of tray drying than hot air oven drying.

2.7. The EI Paso Solar Energy Association [13] claims that the necessity for solar drying is driven by the fact that in some areas of the world, during the summer season, fruits are in great amounts or abundance. But there is no easy or cost-effective way to store them, most of it is spoiled. And during the winter season, there is no agricultural cultivation, causing hunger. They concluded that solar food drying may be employed in most locations where the food chain is influenced by a variety of factors, particularly the amount of sunlight and relative humidity. Additionally, they offer some instructions for drying food.

2.8. Bhandari et al [14] explained the comparative performance analysis of three different types of FPTC, FPTC with single glazing. FPTC with double glazing, Double-glazing solar air heating.

A MATLAB code was generated to analyze by considering the effect of mass flow rates, inlet temperature, and intensity of solar radiation.

2.9. For all three types of FPTC, it was concluded that for the same mass flow rate. Double-pass finned FPTSC has the highest thermal performance in terms of efficiency factor F as compared to double-glazing FPTSC and single-glazed FPTSC

2.10. Wissam et al [15] evaluated exegetic performance and the experimental evaluation of energy efficiency and exergy loss of several absorber plates. They compare the exergy performance of conventional solar dryers i.e. flat plate collectors with three different absorber plates equipped with different fins arrangements with variable mass flow rates. They conclude that the largest exergy loss is at solar noon of the traditional type of absorber is a flat plate. This is due to the exergy calculations for this kind only using a small portion of the solar energy collected by the absorber plate. And exergy efficiency of the incline staggered tabulator is higher around 77% than in-line and staggered tabulators.

2.11. Said M et al [16] performed the 4E analysis of solar PV panels and PV thermal collectors. The study analyzed that solar thermal dryers are equipped with PV panels to enhance energy efficiency, and profitability, and determine viability and cost-effectiveness on a big scale using economic, and environmental. It was concluded that the drying time of infrared and heat pump solar dryers is short while construction and energy costs are relatively high. Compared to non-concentrating solar dryers, concentrating solar dryers have high energy efficiency and short drying times. Discussed that drying is the best way to preserve food and that solar dryers are a suitable food preservation technique for sustainable development.

2.12. Kumar L et al [17] analyzed and compared the real-time performance of flat plate collectors with photovoltaic thermal in series and photovoltaic thermal with heat pipe evacuated tube collector. Cascade Solar assessed process heating can relatively improve the performance of the Process heating system by up to 85.59%. It was concluded that these technologies can be assessed in process heating in different industries.

After a detailed literature review, it has been found that a modified active solar dryer is the most suitable or finest type of drying system, which can be designed and fabricated for the conventional dryer to improve its overall efficiency and performance. Although enough research work has been done on this technology, it requires massive attention and research to improve previous work.

According to this literature review, which is mentioned above, we have concluded that most agricultural commodities can be dried using a modified version of the conventional sun drying approach. In comparison to open drying, solar dryer maintains solar dryers retain greater air temperatures and much lower relative humidity, which enables them to achieve improved drying rates.

3. Design and Fabrication of MASD

3.1 Introduction

This chapter presents the methodology for design modification and fabrication of an active solar dryer. Five steps have been used to complete the design and fabrication. In the first step, review of the literature to clear the concept of the solar dryer and their evolution from already existing work to the present. The problem statement and set of objectives have been achieved and defined. As a part of the second step, the dryer has been designed using CAD models for each component in SolidWorks, whose dimensions were taken from the information found in earlier related studies. In the third step purchase the required parts and fabricate using the designed model the simplified active solar dryer and modified active solar dryer at the Mechanical workshop MUET Jamshoro. In the fourth step analyzed the performance of the Simplified active solar dryer and modified active solar dryer and compared the results of each dryer to check the performance and efficiency.

A project report with a set of Conclusions, Recommendations, and future work has been written in the final step as a concluding document.

3.2 Design of Modified Active Solar Dryer

The objective of the thesis is to design MASD using SolidWorks software 2017. Each component of the solar dryer is designed and given below.

3.2.1 Design model of the drying chamber

The drying chamber is a rectangular type of structure closed box consisting of horizontal trays heating the air present in the thermal collector passed into the drying chamber and drying the agriculture products is shown in Fig 4. The 3-D design of the drying chamber is shown in Fig 5.

The dimensions of the drying chamber are:
Length of drying chamber = 45 centimeters
Width of drying chamber = 30 centimeters
Height of drying chamber = 45 centimeters

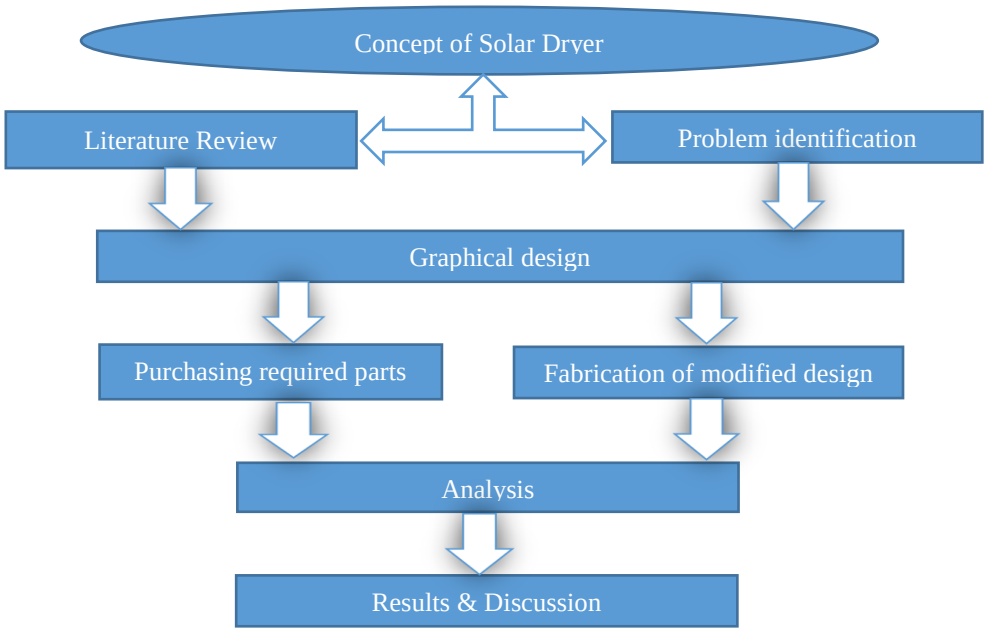


Fig. 4. Flow diagram of the methodology

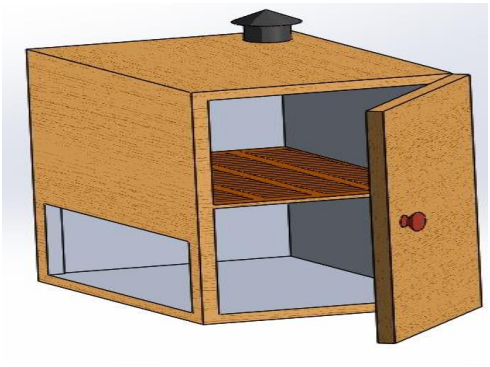


Fig. 5. 3-D Design model of the drying chamber

3.2.2 Design model of Flat plate thermal collector

The thermal collector is a heat exchanger device that converts solar energy into heat energy. Fins are attached to the absorber plate to increase the contact area. To maintain the consistency of heat use insulation. When solar radiation strikes an absorber attached to the fins is heated. The airflow along the fins is heated, and the heated air is used for drying. The 3-D dimensioned model of the thermal collector is designed on solid work and is shown in Fig 6.

The dimensions of the thermal collector are:

Length of Thermal collector = 91.44 centimeters

Width of Thermal collector = 45.72 centimeters

Height of Thermal collector = 12.7 centimeters

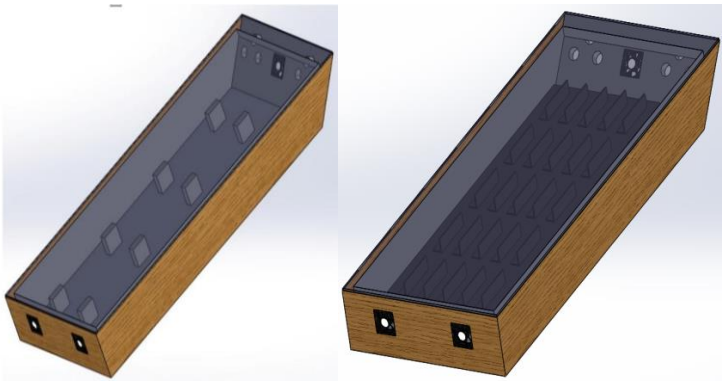


Fig. 6. 3-D design model of thermal collector

3.2.3 Design model of the Absorber plate

The basic function of the absorber plate is to collect the heat energy from solar radiation. On the surface of the absorber plate extended L-type fins are mounted to increase the rate of heat transfer to the air. The three-dimensional model of the Absorber plate and L-type fins designed in solid works is shown in Fig 7.

Dimensions of the Absorber plate are:

Area of Fins = 4 x 6 square inches

Area of Absorber plate = 30 x 15 square inches

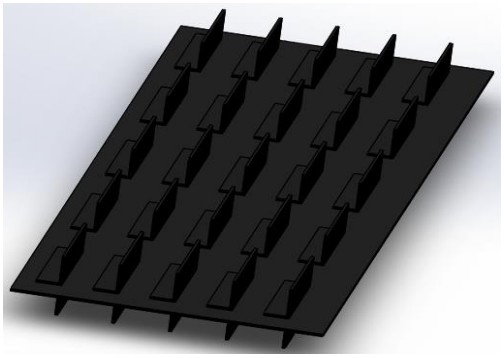


Fig. 7. 3-D design model of Absorber plate

3.2.4 Design model of DC fan

The DC fans of 12 Volt consist of an electric motor having 12V voltage and 0.12A current. DC fans are used to push the air in the thermal collector. The dimensions designed model of the DC fan is shown in Fig 8.

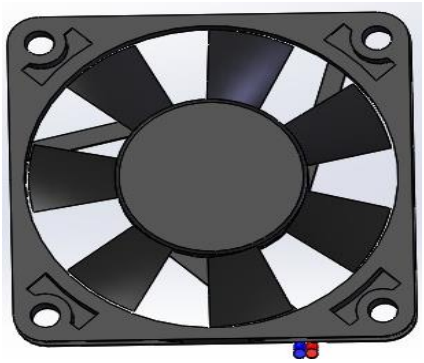


Fig. 8. 3-D design model of DC fan

3.2.5 Design model of solar dryer stand

The Solar dryer stand, or foundation is welded by arc welding that supports other components. The 3-D dimensioned model of solar dryer stand is designed on SolidWorks as shown in Fig 9.

The dimensions of the solar dryer are:
Length of frame = 47 centimeter
Width of frame = 32 centimeters
Height of frame = 40 centimeters

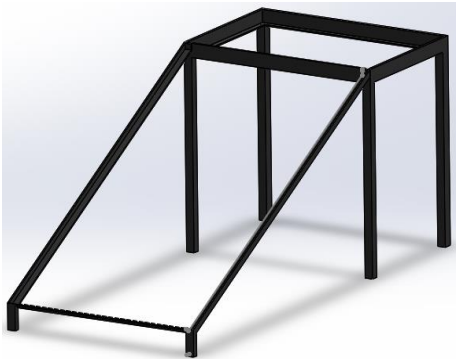


Fig. 9. 3-D design model of solar dryer stand

3.3 Fabrication of Modified Active Solar Dryer

The raw material is transferred into the finished product in this project. The fabrications of each part are fabricated first by referring to their respective design and then assembled into a single final body. During project fabrication, the following procedure is followed.

- Material Selection
- Fabrication

3.3.1 Fabrication of drying chamber

The solar dryer chamber is the main part of the dryer and is a box-type construction, where the products are placed and get dried. It consists of two trays having tiny holes for the passage of the rising warm air from the thermal collector. The fabricated drying chamber is shown in Figure 10.

Fig. 10. Fabricated drying chamber

3.3.2 Fabrication of Thermal Collector

The thermal collector is fabricated to warm out the air circulating toward the drying chamber. The thermal collector is made of wood and an L-type aluminum fins sheet is inserted in the modified active solar dryer. The fabricated flat plate thermal collector is shown in Figure 11.

Fig. 11. Fabricated Flat plate thermal collector

3.3.3 Transparent Glass

Transparent material glass is placed inclined on the thermal collector such that proper transfer of solar radiation. Glass is composed of sand, soda, ash, and limestone.

Transparent glass is shown in Figure 12. Dimensions of transparent Glass are:

Width of Glass = 12 inches

Length of Glass = 36 inches

Thickness of Glass = 0.4 inch

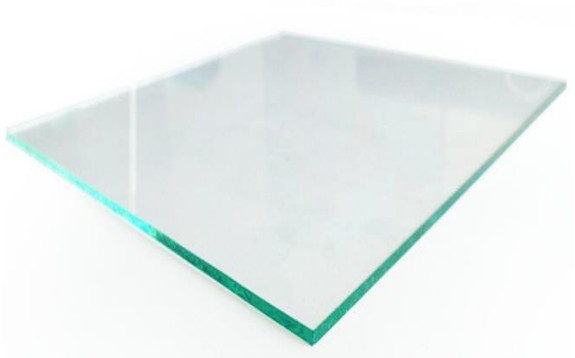


Fig. 12. Normal Glass

A list of different types of Glass is given below.

Table 2. Different types of Glasses.

S.NO	Name
1	Tempered glass
2	Acrylic glass
3	Float Glass
4	Toughened Glass
5	Mirrored Glass.
6	Laminated glass

3.3.4 Absorber plate

Absorber plates are fabricated to collect the heat energy of solar radiation into the air through the method of the convention. We attach the five L-type aluminum fins to the absorber plate by the arrangement of rows and columns as shown in Figure 13.

Fig. 13. Fabricated Absorber plate

3.3.5 Solar dryer stand

The solar dryer stand holds the drying chamber and inclines the thermal collector at an angle of 25 The solar dryer stand is made of mild steel with six legs on which all other components are mounted, and it is fabricated to support the thermal collector and drying chamber during the drying the agriculture products.

The fabricated solar dryer stands as shown in Fig 14.

Fig. 14. Fabricated Solar dryer stand

3.4 Experimental procedure and Energy analysis of Modified active solar dryer

3.4.1 Experimental procedure of Modified active solar dryer

In the Modified Active Solar dryer daily tests have been done every day from 8:00 am to 5:00 pm. A thermocouple is used during the experiment to detect the air temperature at the input and output of the solar thermal collector and the drying chamber.

Solar irradiation on the surface of the collector is obtained by a pyrometer. The pyrometer and all the thermocouples are connected to a data logger to save data at regular times. In the MSD two DC fans are used to push air inside the thermal collector. The air is heated by the action of convection heat transfer between the fins. This heated air is then directed to the drying chamber.

3.4.2 Energy analysis of the Modified active solar dryer

Heat and mass transfer are combined in the modified active solar dryer method to get rid of any moisture that might be in the product. As a heat exchanger, the solar thermal collector converts solar energy into heat energy and then transmits that heat to the working fluid air.

Energy analysis is performed to quantify the energy required to dry chili in the designed solar drying chamber.

Energy analysis is performed to calculate the energy needed to dry the chili in the constructed solar drier using solar energy Based on the mass balance for hot air in a steady state that is present in Equation 1

$$\boldsymbol{the}\ \sum \dot{\mathbf{m}}_{\mathbf{ai}} = \sum \dot{\mathbf{m}}_{\mathbf{ao}} \tag{1}$$

Moisture content while drying in 2.

$$\sum\left(\dot{\mathbf{m}}_{\mathbf{wi}} + \mathbf{m}_{\mathbf{mp}}\right) = \dot{\mathbf{m}}_{\mathbf{wo}} \tag{2}$$

For energy conversion in 3.

$$\dot{\mathbf{Q}} - \dot{\mathbf{E}}\mathbf{u} = \sum \dot{\mathbf{m}}_{\mathbf{ao}}\left(\mathbf{h}_{\mathbf{ao}} + \frac{\mathbf{v}_{\mathbf{ao}}{}^{2}}{2}\right) - \sum \dot{\mathbf{m}}_{\mathbf{ai}}\left(\mathbf{h}_{\mathbf{ai}} + \frac{\mathbf{v}_{\mathbf{ai}}{}^{2}}{2}\right) \tag{3}$$

The useful heat energy in STC in 4

$$\dot{\mathbf{Q}}_{\mathbf{u}} = \mathbf{m}_{\mathbf{ai}}\mathbf{C}\mathbf{p}_{\mathbf{ai}}(\dot{\mathbf{T}}_{\mathbf{ai}} - \mathbf{T}_{\mathbf{amb}}) \tag{4}$$

The heat use in the Chamber in 5

$$\dot{\mathbf{Q}}_{\mathbf{d}} = \mathbf{m}_{\mathbf{ai}}(\mathbf{h}_{\mathbf{hi}} - \mathbf{h}_{\mathbf{do}}) \tag{5}$$

Moisture Ratio in Dryer

The moisture ratio in the drying chamber is calculated as in Equation 6

$$\mathbf{MR} = \frac{\mathbf{M} - \mathbf{M}_{\mathbf{d}}}{\mathbf{M}_{\mathbf{d}}} \tag{6}$$

The efficiency of flat plate collector

Collector efficiency defined in Eq. 7

$$\boldsymbol{\eta}_{\mathbf{collector}} = \frac{\dot{\mathbf{m}} \cdot \mathbf{C}_{\mathbf{p}} \cdot (\mathbf{T}_{\mathbf{out\ collector}} - \mathbf{T}_{\mathbf{in\ collector}})}{\mathbf{A}_{\mathbf{collector}} \cdot \mathbf{G}_{\mathbf{T}}} \tag{7}$$

4. Results and Discussion

4.1. Final Assembly of Simple Active Solar Dryer

The three-dimensional model of Simplified Active Solar Dryer using SolidWorks 2017 software is designed as shown in Fig 15 (a).

A simplified active solar dryer consists of the following components, which are assembled to form the complete design.

Thermal collector, drying chamber, DC fans, solar dryer stand, Normal Glass of 4mm thickness. Simple Active Solar Dryer is without aluminum fins sheet. The drying chamber and thermal collector are insulated with aluminum foil. The fabricated final assembly of the Simple active solar dryer is shown in Figure 15 (b).

(a) (b)

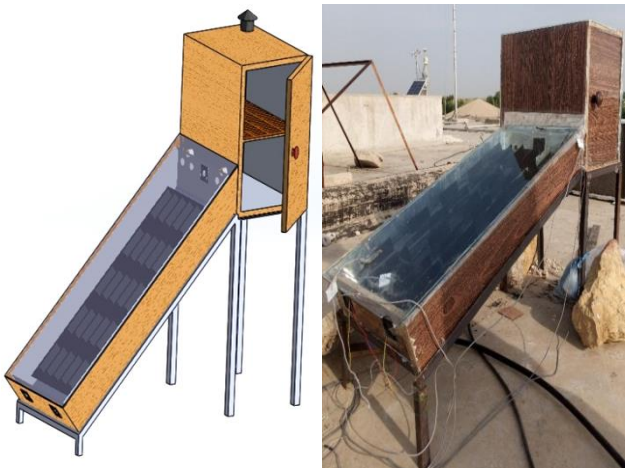
Fig 15. (a) 3-D Design model of Simplified Active Solar Dryer (b) Fabricated Simplified Active solar dryer

4.2. Final assembly of Modified Active Solar Dryer

The three-dimensional model of the Modified Active Solar Dryer using SolidWorks 2017 software is designed as shown in Fig 16 (a).

The modification is done by adding L-type Fins in a thermal collector painted with black color, due to its great absorption property. The thermal collector is provided with two DC fans at the inlet fitted in holes 3x3cm for fresh air and one at the exit to push the hot air toward the drying chamber. The thermal collector and drying chamber are made up of wood sheets. And insulate it with aluminum foil. The drying chamber is connected with a thermal collector tilted at 25˚ at the ground to utilize or capture maximum sun irradiance. The drying chamber has two trays between the top and bottom surfaces on which the chili has dried.

The final fabricated assembly of the Modified active solar dryer is shown in Fig 16 (b).



(a) (b)

Fig. 16. (a) 3-D Design model of Modified Active Solar Dryer (b) Fabricated Modified Active solar dryer

4.3. Performance evaluation of SASD & MASD

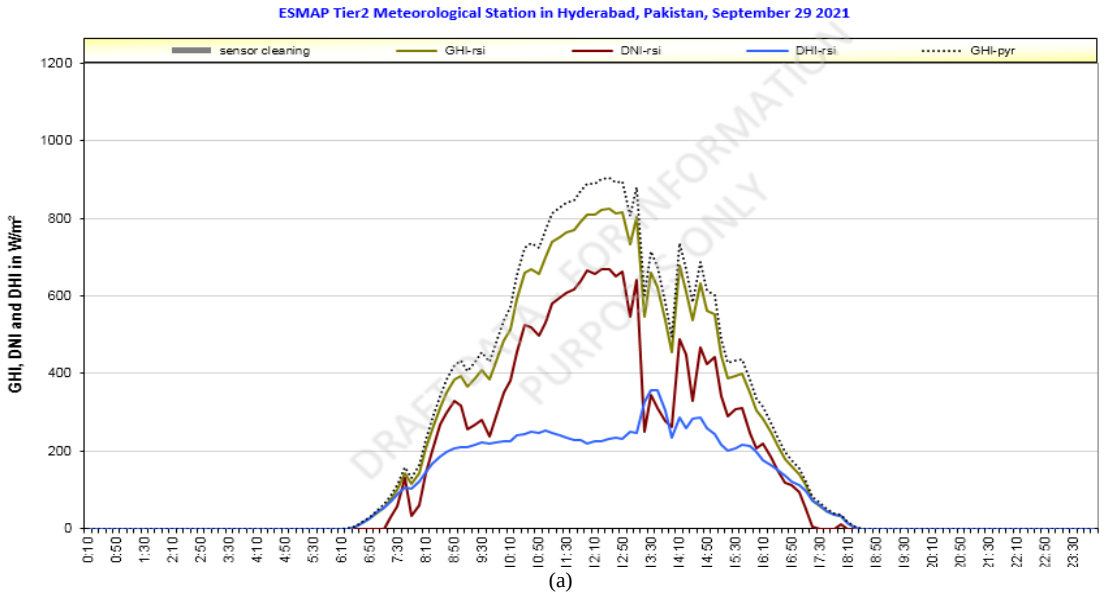
4.3.1 Solar Irradiance on Dryer

It is shown in the figures that meteorological reports give us global solar irradiance on the earth starts from 6 am and increases to 889W/m2 at 12:50 pm on average and then decreases continuously as the sun sets.

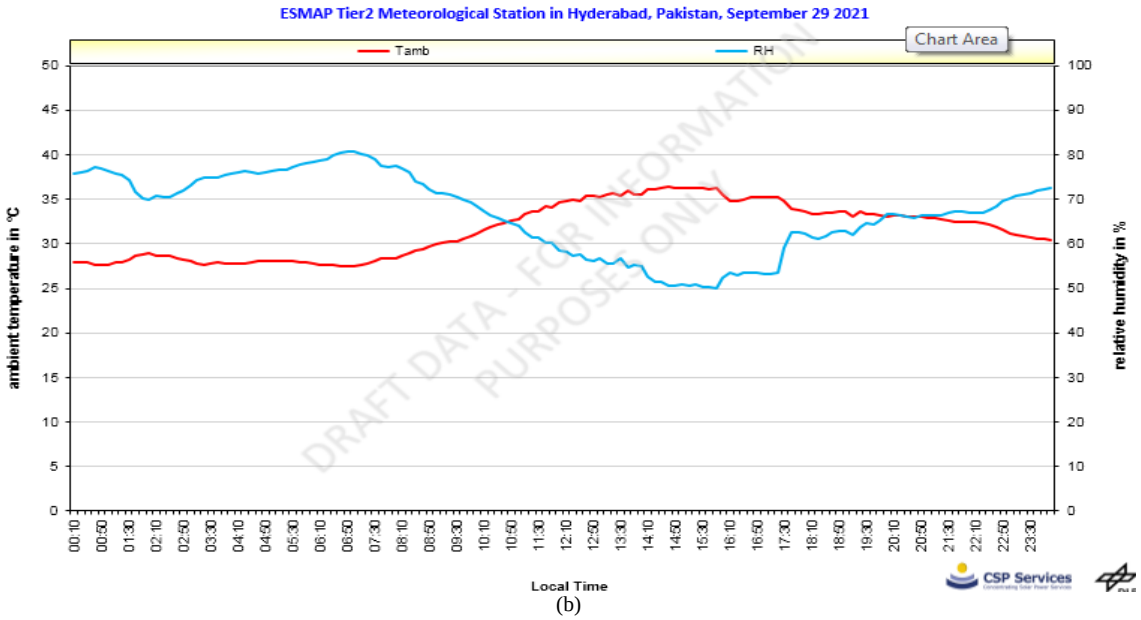
Indirect global solar irradiance is in the range of 800~900 W/m2 (black dotted line) shown in the figure 17. Direct Solar Irradiance is shown in the blue line. It is very low as the Sun radiation is reflected and diffused by hindrances.

4.3.2 Temperature and relative humidity

The graph shows the relationship between temperature and humidity. With the increase in temperature, humidity decreases. In the morning's temperature is low and the humidity is relatively high. These coincide at the times of 10 a.m. and 8 p.m. Here meteorological reports of Hyderabad show that humidity is 40% at midnight and 26% at noon.



(a)



(b)

Fig. 17. (a): Solar Irradiance on Dryer, (b): Temperature and Relative humidity

4.3.3 1st day of drying

The first day of our analysis started on the 11th of September 2022 by drying chili in SASD and MASD Dryers.

500g Chilies have been kept in a drying chamber. On that day highest ambient temperature was 54.83˚C and the highest Drying temperature was 59˚C in SASD and 69 ˚C in MASD. Hourly reading has been collected which is shown in Table 4. The results of the 1nd day are shown in figure 18.

Table 3. Results of Simplified and Modified Active Solar Dryer - 1st day

Time	SASD		MASD	
	T1	T3	T1	T3
8:00	37.31	48	37.31	44.44
9:00	38.67	52	38.67	44.29
10:00	47.45	57	47.45	54.58
11:00	51.99	51.2	51.99	61.76
12:00	53.08	55.25	53.08	68.34
13:00	54	58.9	54	69
14:00	54.83	59	54.83	65.8
15:00	49.9	57.98	49.9	62.5
16:00	43.35	56.82	43.35	60.83
17:00	41.5	50.95	41.5	59
18:00	40.1	43	40.1	58

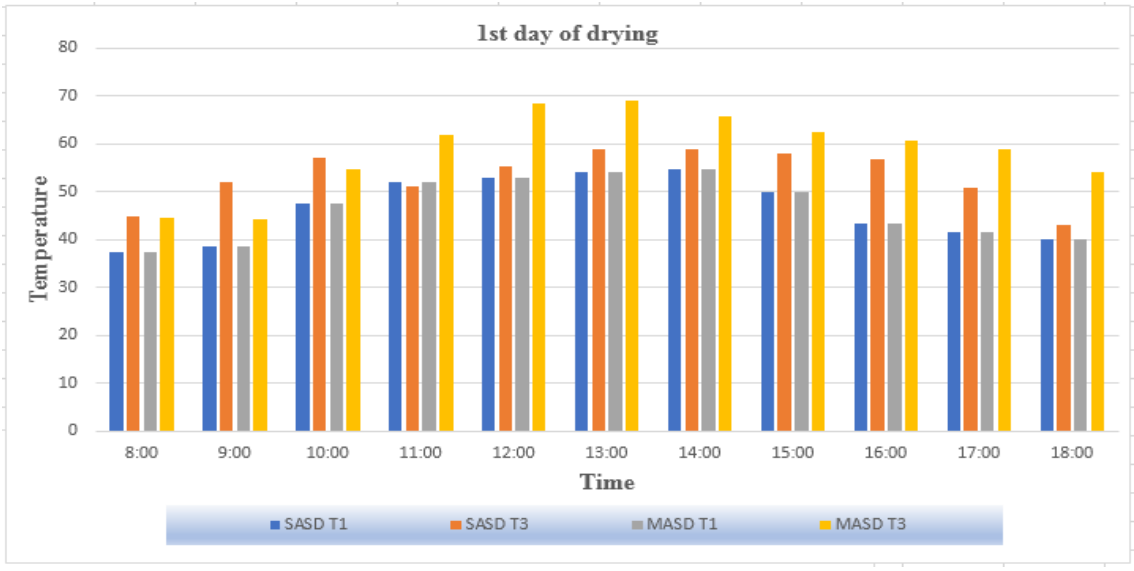


Fig. 18. Results of Simplified and Modified Active Solar Dryer - 1st day

4.3.4 2nd day of drying

The results of the SASD and the MASD are tabulated in Table 4. It is observed in the graph that SASD has a maximum temperature of 59˚C and MASD has achieved a maximum temperature of 69 ˚C. Both have a maximum temperature of 1:20 pm. This was the last day of drying for MASD. The chili has achieved a minimum (10%) moisture content in MASD meanwhile the SASD product had a 42% moisture content

The results of the 2nd day are shown in figure 19.

Table 4. Results of Simplified and Modified Active Solar Dryer – 2nd day

Time	SASD		MASD	
	T1	T3	T1	T3
8:00	37	48	37	50
9:00	40	52	40	60
10:00	41	57	41	62
11:00	41.5	58	41.5	66
12:00	43	59	43	68
13:00	44	59	44	69
14:00	43	59	43	69
15:00	42.5	59	42.5	68
16:00	41	58	41	67
17:00	39.5	56	39.5	65
18:00	37.5	50	37.5	62

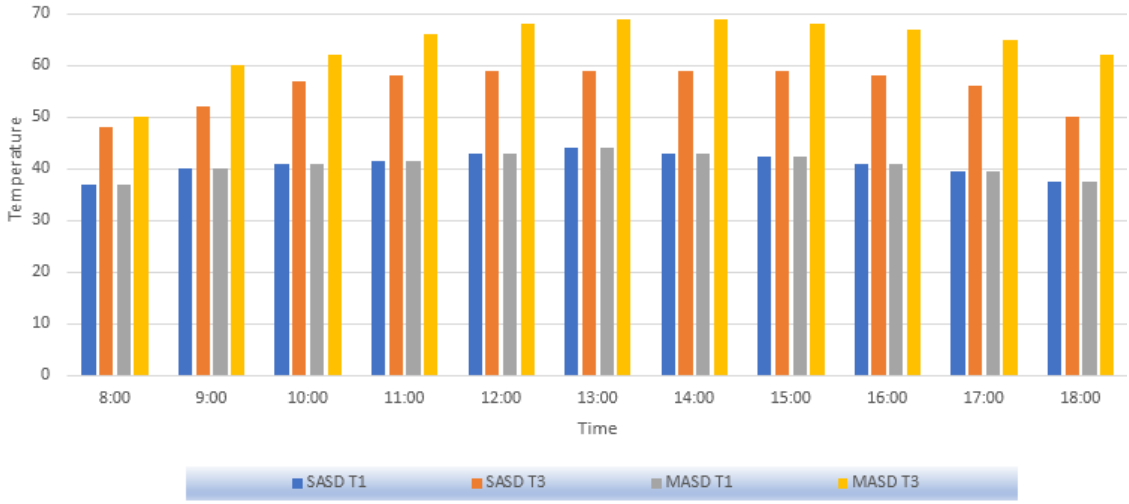


Fig. 19. Results of Simplified and Modified Active Solar Dryer – 2nd day

4.3.5 3rd day of drying

It was the last day for drying chili in SASD. Chilies were dried from 9 September 2022 to 15 September 2022 and on the 5th day of drying in SASD chili was completely dried. It took a total of 45 hours to dry to the minimum moisture ratio of 10%. The highest ambient temperature on the fifth day was T1 = 51.03˚C and the highest collector temperature recorded was 58.23˚C. Hourly reading which has been collected is shown in Fig 20.

Table 5. Results of Simplified Active Solar Dryer – 3rd day

Time	T1	T3
8:00	37	41
9:00	40.83	44.02
10:00	46.37	48
11:00	47.35	53.31
12:00	51.03	54.88
13:00	49	56.43
14:00	48.11	57.75
15:00	47.56	58.23
16:00	43.4	54.82
17:00	41.36	47.95
18:00	37.98	40.51

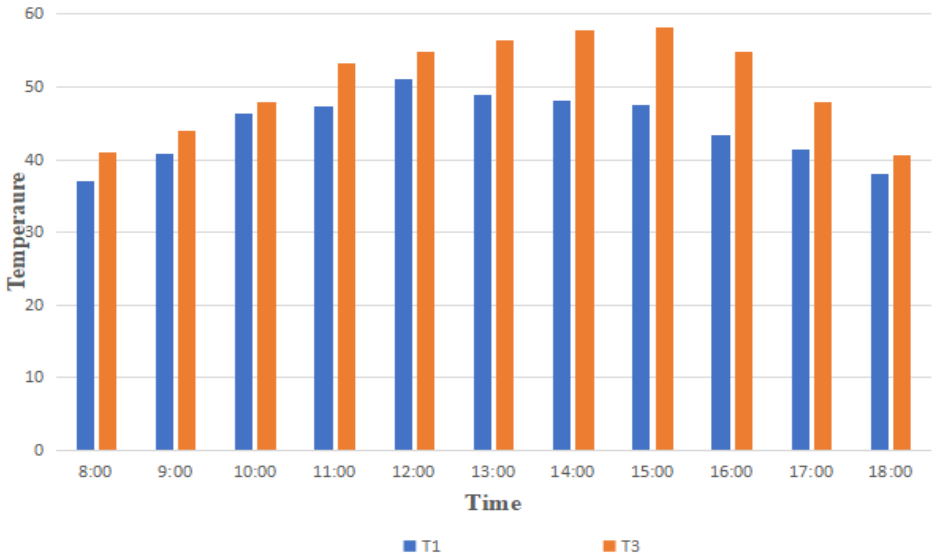


Fig. 20. Results of SASD – 3rd day

4.4 Bill of quantities

The cost of Modified Active Solar Dryer to fabricate is Rs.12000 PKR as shown in Table 6. It shows that locally available material can be used to fabricate the Modified active Solar Dryer at a reasonable cost.

Table 6. Material needed for fabrication of MASD

S.NO	Name	Quantity	Unit rate	Budget (Rs) PKR
1.	Wood sheet (4 x 8 inches)	1	2500	2500
2	Black Spray 0.5letter	1	250	500
3.	Inlet DC Fan	2	250	500
4.	Outlet DC Fan	1	250	250
5.	Aluminum foil (2x4 cm)	3	400	1200
6.	Aluminum sheet (4 feet)	2	300	600
7.	Hygrometer Humidity meter	1	500	500
8.	Temperature sensor	6	50	300
9.	Voltage Regulator	2	250	500
10.	Stitch solution	1	80	80
12.	Angle for stand (Mild steel)	1	3000	3000
13.	PV panel 80 watt	1	720	720
14.	Glue	2	50	100
15.	Wood Screw (Stainless Steel)	100	3	300
16.	Normal Glass (1.5x3 feet)	1	900	900
17	Nails (kg)	1	50	50
	Total			12000

5. Conclusion

In this study, the solar dryers have been designed, fabricated and performance of Modified Active Solar Dryer has been compared with Simplified Active Solar Dryer. Both equipped with Flat plate thermal collector. In Simplified Active Solar Dryer we dried the chili completely in five days at a lower temperature. Meanwhile, in the Modified Active Solar Dryer more temperature is obtained, and drying time was reduced.

The conclusion of the MASD is:

The SASD dried the chilies under the temperature of 60˚C for three days. The MASD dried the chili within 2 days at a temperature of 69˚C.MASD products have been dried well and food can be stored for a longer time. The moisture in chili is completely removed after 34 hour in MASD. By increasing the inlet temperature of the drying chamber humidity in the chili was removed quickly, and the results show an effective drying and better quality.

Observation from the experiments indicated that MASD is an effective method for drying agriculture products because it has a higher Drying temperature and takes less time to dry products.

The performance of MASD equipped with a flat plate collector is more if there is sufficient solar energy supplied. Also, MASD took less time to dry the vegetables.

6. Declaration

6.1 Recommendations

The following recommendations are made based on this experiment:

The temperature of the Modified Active Solar Dryer can be increased by changing the size of the thermal collector and drying chamber according to need. In thermal collector instead of L-shape fins use diamond shape extended fins for more effective heat transfer. For getting better heat ratios in thermal collector tempered glass may be used instead of normal glass. Solar drying shall be experienced in all months of the calendar of the year including cloudy days to understand the time versus drying ratio. Many crops were ruined by the recent flood in Sindh province; if farmers had access to this dryer, they could harvest their crops, dry them, and store them for a longer period. It recommended to the Sindh government that MASD can be distributed to the formers directly or through NGOs. MASD can be utilized by farmers because of very convenient and cost-effective. It's also recommended that other species of chilies should be tested and observe the behavior of different varieties of chilies in Sindh province.

6.2 Future work

Future work in any running scientific project is always needed, as the population grows it feels the deficiency for its foods. The suggestions for future work are shown below. This lab-scale experimental research work can be extended for projects on a scale-up level. It will be advantageous for the Modified Active Solar dryer to have an energy storage system so that the product continues to dry even when there is no sunlight

Photovoltaic panels with a dryer system will increase electrical and thermal efficiency. A proper solar dryer mechanism can be designed and built to dry and store the agricultural products cultivated by farmers for a long time. The government should subsidies NGOs and commercial institutions so they can move forward with creative initiatives to promote the MASD to formers.

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Authors' Profiles

Danesh Kumar Meghwar is currently working as Instructor in Department of Mechanical Technology, Faculty of Engineering, Government Polytechnic Institute Mithi at Tharparkar, Pakistan. He received BE in Mechanical Engineering from Mehran University of engineering and technology Jamshoro in 2022, His research interests are in Renewable Energies, Object Recognition, and design analysis using Solid works and Ansys Applications.

Atam Kumar is currently studying in a master's degree in the Department of Engineering Management at University of Calabria, Rende (CS), Italy. He has done BE in Industrial Engineering and Management from Mehran University of Engineering and Technology Jamshoro in 2022, His research interests are in Supply Chain Management, Operation management, Ergonomics, Quality Control, Automation, Project Management.

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Reduction of Lean Wastes by Using Value Stream Mapping: A Case Study of Textile Company in Pakistan

Atam Kumar[1], Ramesh Kumar[2] and Ali Gul[3]

[1]Master student in the Department of Engineering Management at the Università Della Calabria, Rende, Cosenza, 87036, Italy

[2]Master's Student, Department of Engineering for Natural Risk Management, Università degli Studi di Genova, Italy

[3]Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Pakistan.

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Abstract

Purpose: Lean manufacturing, originating from the Toyota Production System (TPS), aims to reduce waste and optimize resources. Developed countries must adopt Lean practices for performance improvements while developing countries often use just-in-case approaches. Value Stream Mapping (VSM) is a crucial tool for diagnosing, implementing, and maintaining Lean Manufacturing, helping identify improvement opportunities and eliminating waste. The research at the company aims to eliminate Lean wastes and line unbalancing issues to improve lead time and the value-added ratio (VAR), enhancing production efficiency. The research aligns with Sustainable Development Goal 12 (Responsible Production & Consumption) by focusing on waste reduction.

Methodology: The research uses time study, Edaw max, and Visio software to analyze tasks, create VSMs of current and future states, and control charts to examine data variations over time. Data collection involves cycle time, batch size, packet size, and the number of workers required for each activity.

Findings: The research objectives include studying the existing scenario of production units via VSM, identifying, and eliminating Lean wastes, and comparing proposed and existing scenarios for improvement opportunities. The literature review highlights the importance of Lean manufacturing in eliminating unnecessary processes, reducing lead time, and fostering positive stakeholder relationships.

Unique Contribution to Theory, Practice and Policy: This study suggests the better way to reduce the lean wastages and balance the line by using VSM technique. The future state VSM is created to conceptualize potential improvements and gather feedback, focusing on reducing non-value-adding tasks, work-in-process inventory, workforce, and overall process time.

Keywords: *Lean Manufacturing, Lean Wastes, Value Stream Mapping, Textile Industry, Stitching Department, Time Study*

INTRODUCTION

Toyota Production System (TPS) introduced lean manufacturing; a concept adopted by developed countries for performance improvements. However, developing countries still use just-in-case approaches, leading to poor performance. Implementation of lean manufacturing, piloted by Toyota in the 1970s, reduced waste and inventory[1]. Lean manufacturing reduces waste by focusing on value-added and non-value-added activities. Tools like value stream mapping reduce lead time, cycle, and takt time, and improve production. Hybrid production control strategies enhance results and reduce inventory[2]. Lean manufacturing (LM) is a crucial evolution in various sectors, involving all organizational levels. VSM, a technique for diagnosing, implementing, and maintaining LM, helps identify improvement opportunities and waste elimination, providing a standardized approach[3].

Value Stream Mapping (VSM) is a qualitative process that maps the manufacturing plant state, identifies waste, and eliminates it, aiding small-scale industries in understanding Lean Manufacturing's power by reducing cycle times, lead times, and inventory[4]. It is a lean manufacturing method that enhances inventory and information flow, identifies waste, and implements lean principles. It outlines customer requirements, process steps, metrics, inventory, supplier material flows, total lead time, and Takt time [5]. Value stream mapping is a lean tool for analyzing a company's current scenario and information flow, identifying problems and opportunities for improvement. It covers all processes from customer orders to product delivery, ensuring efficient data collection and planning[6].

Value stream mapping is a tool for enterprise improvement that visualizes production processes, including material and information flow, and documents relationships between manufacturing processes and management controls[7]. It is a crucial tool in lean manufacturing (LM) that helps identify waste in value streams and find appropriate routes for its removal. It involves visually mapping the flow of information and material, including resources and communications. LM focuses on delivering high-quality products on time and at the lowest cost, eliminating waste by all members of the organization. VSM has been successfully implemented in small and medium enterprises (SMEs) to improve their competitiveness and produce high-quality products[8].

Organizations are increasingly competitive due to increased customer demand, leading to a need for improved production processes [9]. To reduce waste, value stream mapping (VSM) tools are used to analyze material and information flow, identify losses, and reduce the time between order placement and product delivery. VSM can be analyzed statically or through simulation, adding time dynamics and aiding decision-making regarding production process changes[10].

Problem Statement

Currently, textile company is facing an increased Lead time issue related to the supply, production & transportation. It is observed in the literature that increased lead time issues occurring in production may also lead the poor production efficiency which is also caused by lean wastes & line unbalancing issues. Hence the focus of this study is to eliminate lean wastes & line unbalancing issues of production to improve the lead time and value-added ratio (VAR) for enhancing the efficiency of production.

Research Aims

Considering the above problem statement & following the sustainable development goal. The aim

to improve the flow of production lines through the elimination of lean waste.

Sustainable Goal

The SDG followed in this research is SDG12 which is **Responsible Production & Consumption which means the** preservation of resources during production and Consumption through waste reduction.

Research Objectives

To study the existing scenario of production units via VSM. To identify & eliminate Lean Wastes of production units. To compare proposed & existing scenarios via VSM for improvement opportunities.

LITERATURE REVIEW

Lean manufacturing eliminates unnecessary processes, reducing lead time and waste. It's a method that fosters positive relationships between customers, producers, and suppliers. Despite initial challenges, successful implementation can lead to increased customer satisfaction and reduced inventory [8]. Lean methodology is a flexible solution for various production or service creation industries, with five basic tools for implementation. It focuses on inventory reduction, efficient manpower utilization, order lead time improvement, customer satisfaction, and statistical process control. Value stream mapping (VSM) maps an organization's entire process, identifying value-adding and non-value-adding processes[1].

The Lean Production System (LPS) is a systematic approach to identifying and eliminating wastages in manufacturing processes to improve customer satisfaction and reduce costs. It consists of tools like VSM, 5S, SMED, and standardized work, which focus on specific aspects of a manufacturing process to eliminate waste and improve quality while reducing production time and cost. VSM has been applied in various industries, such as bread manufacturing in Zimbabwe, semi-automated factories in Texas, and crankshaft manufacturing in India[11].

Toyota pioneered value stream mapping (VSM) techniques to implement Lean concepts, minimizing waste and ensuring a continuous flow of products and information throughout a value stream through visualization[12]. In today's global market, companies are implementing lean manufacturing strategies like the Toyota Production System (TPS) to improve efficiency and competitiveness. Lean thinking involves defining value from customer perspectives, determining value streams, achieving flow, scheduling production, and seeking perfection through continuous improvement. Lean accounting and thinking provide reliable decision-making information[13].

Value stream mapping (VSM) is a visual tool that captures the input/output of various processes, based on five lean management principles: defining value, developing value streams, eliminating wastes, and allowing uninterrupted flow. Toyota's average value-added time is over 50%, and wastes in the Product Development Process should be identified and eliminated[14].

Lean manufacturing is a strategy adopted by major manufacturing plants in Asia, particularly in Malaysia, to remain competitive in the global market. It focuses on cost reduction by eliminating non-value-adding activities and waste from each step in the production chain. Lean manufacturing tools and techniques, such as just-in-time (JIT), cellular manufacturing, total productive maintenance, and production smoothing, have been extensively used since the birth of the Toyota Production System. The Toyota Production System (TPS) is a systematic

approach to identify and eliminate waste activities through continuous improvement[15].

Lean management, developed by Toyota in the 1940s, focuses on reducing non-value-added activities like waste. Value Stream Mapping (VSM) is a crucial tool for lean thinkers, aiding in waste elimination. Lean has contributed to organizational objectives like profitability, efficiency, and customer satisfaction. However, the integration of lean with green initiatives is a recent research stream, aiming to improve environmental performance[16]. Toyota's executive Taiichi Ohno developed TPS, focusing on quality and diversity in the automotive industry. Lean manufacturing aims to maximize value by eliminating production waste. Ohno identified seven common wastes, which negatively impact production costs and productivity. Lean management methods have been successful in various industries[17].

The integration of Lean and Green principles in industries has led to the development of tools like Green VSM and Sustainable VSM. These focus on energy and cost savings, while green manufacturing includes environmentally friendly materials and processes. IoT technology offers a digital twin enabled VSM solution[18].

The use of Value Stream Mapping (VSM) in Zimbabwe's bread manufacturing industry, highlights its effectiveness in reducing waste. The case study demonstrates that the VSM tool reduced defects by 20%, unnecessary inventory by 18%, and motion by 37%. The study emphasizes the importance of waste relationship ranking and management commitment to waste reduction, highlighting the potential of VSM in enhancing manufacturing efficiency[19].

A value stream mapping study in Fars province, Iran, reveals significant data gaps in wheat and bread loss and waste. The study identifies hotspots in farms, food service, and households, highlighting the need for transparency and further research. The study suggests that researchers can use this holistic approach to investigate loss and waste in other food items across different geographical contexts, enhancing the scope of lifecycle assessment and circular economy studies[20].

The Value Stream Mapping (VSM) method was used in Southern Africa's iron and steel industry to identify and evaluate industrial waste. The method involved collecting and verifying waste generation data, mapping waste generation and fractions, and compiling state maps. The first year saw a 28% reduction in waste and a 45% reduction in waste removal costs, exceeding the initial 5% reduction target[21].

One project demonstrates the importance of Value stream mapping (VSM) in enhancing productivity and business strategy in the power generation industry. By identifying and redesigning a layout, a new layout was developed, demonstrating the practicality of VSM in generating effective genset manufacturing assembly[22].

VSM is a lean manufacturing technique that helps organizations identify and eliminate waste in their processes. It bridges the gap between current and future state, reducing variation, inventory levels, and system flexibility. Studies have shown that VSM can reduce system waste, minimize resources, and optimize performance. It is a proactive approach that helps choose the best technological approach at the beginning of a project[23].

What is Value Stream Analysis?

Planning tool to optimize results of eliminating waste.

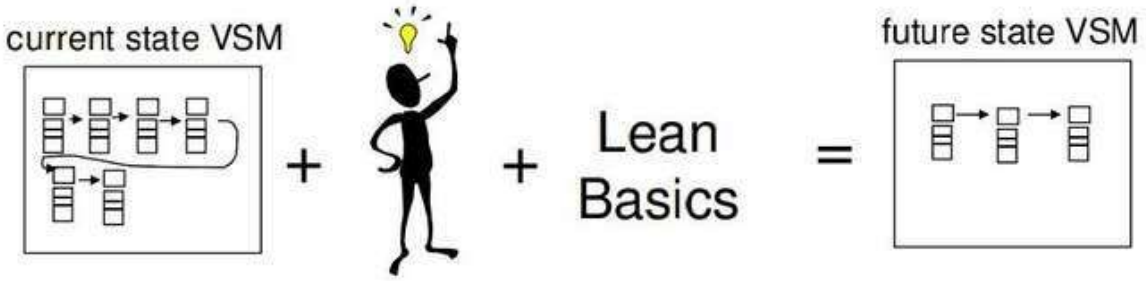

Figure 1: Value Stream Analysis. [24]

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METHODOLOGY

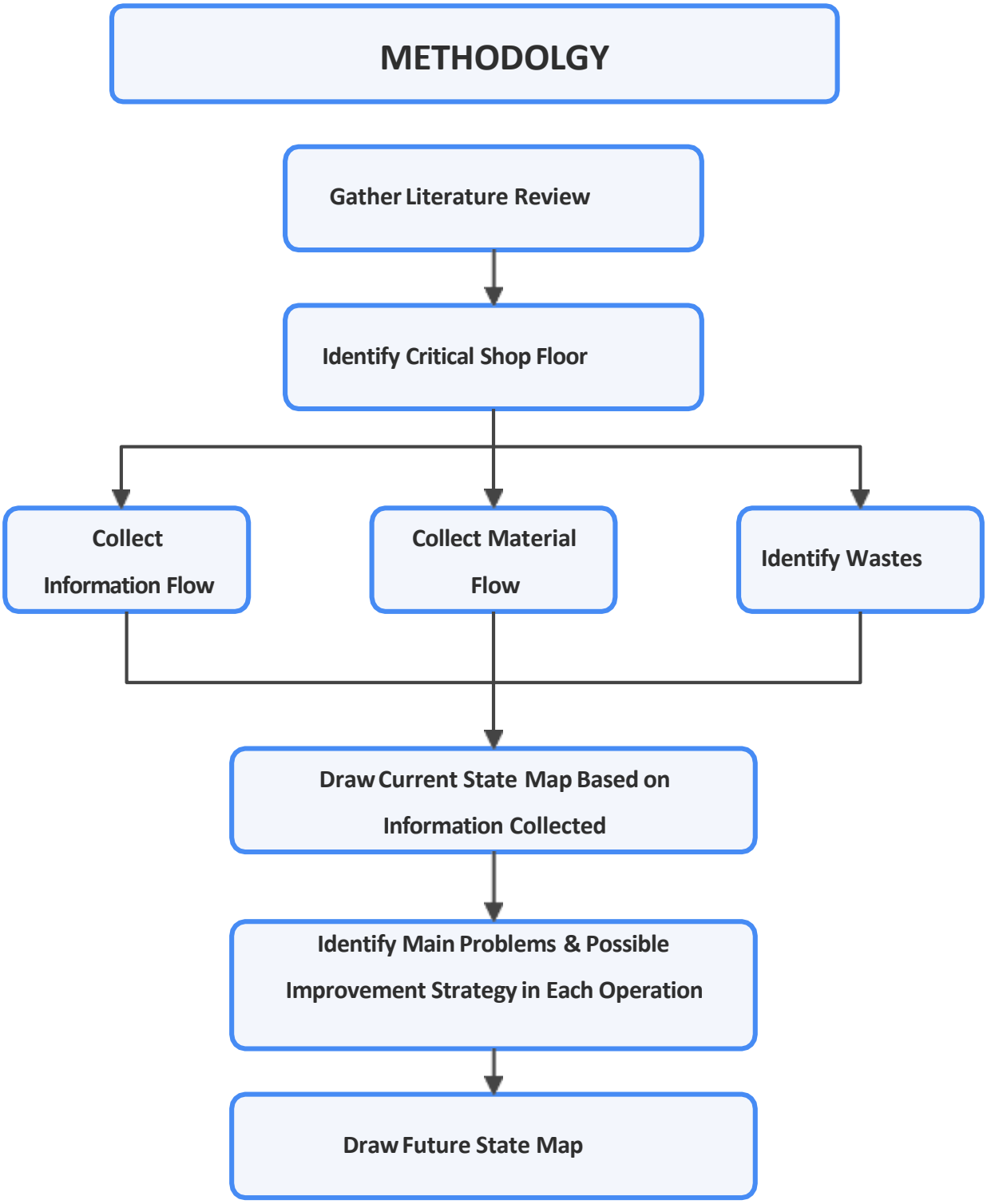

Figure 2: Research Methodology

Time Study

"Frederick Winslow Taylor" created the "Time Study" method to establish benchmark times for various tasks or projects. Time studies are typically conducted in environments with repeating work cycles that range in length from short to long and where there are many different types of work. This is because time studies require participants to observe an activity directly and continuously while also using a timekeeping device to track how long it takes to complete a task[25].

An examination of how time is used can lead to the creation of standards for directing or controlling performance as well as a set of standards for directing efforts to improve current circumstances. In the absence of basic time study data, it is impossible to assess whether a task or piece of work has improved over time or whether there are variations in how well it is completed within a unit. As a result, through time study, we carefully analyze the task or activity to minimize or eliminate any unnecessary aspects of the work involved and then approach the task or activity in the best way possible[26].

Stopwatch and time study forms or sheets make up the time study equipment used in this study.

A reliable clock with a second-hand clock and a calculator should also be present in the study. The time study forms or sheets are used to record the observations made during the time study and the stopwatch is used to calculate or measure how long it takes to complete the specific activity. As a result, all the crucial information about the time study is recorded on the time study methods or sheets of material[27].

Software Used in the Study

In this research, used Edaw max and Visio software to make Value Stream Mapping of Current and Future state and Production Flow.

Control Charts

A particular type of chart used to examine how the data varies over time is the control chart. In Excel, it is also referred to as a behavioral chart or Shewhart chart. It is used in business statistics to assist users or viewers in analyzing how any process changes. Its components are the control line, as well as the upper and lower control lines, and it is made with the aid of computations of the data's average and standard deviation.

Data Collection and Analysis

The data collection and analysis framework in research focused on Value Stream Mapping (VSM). VSM is a powerful lean management tool used to analyze and improve the flow of materials and information in a process or value stream. It helps identify waste, bottlenecks, and opportunities for improvement. Data collection and analysis play a crucial role in VSM research to gather relevant information, identify process inefficiencies, and make data-driven decisions for process improvement.

The following framework outlines the key steps involved in collecting and analyzing data for a research thesis on VSM.

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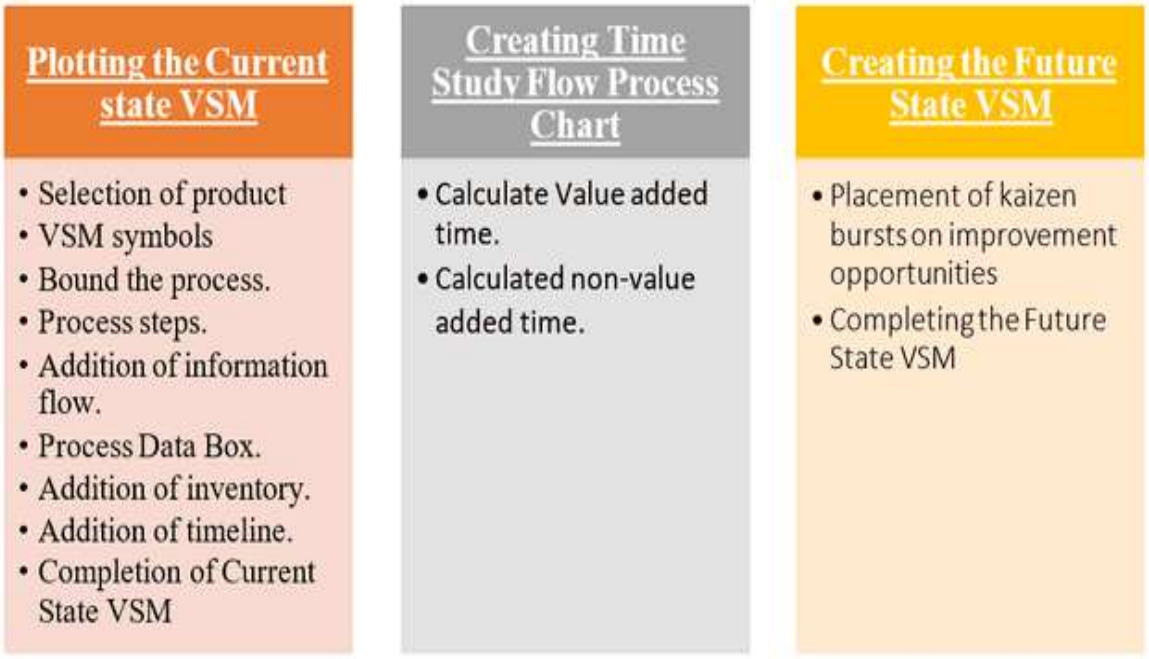

Figure 3: The Framework for VSM

On the Company Building's First floor (Pakistan), various products are being produced, out of which the Stitching department was selected for this study. It's needed to decide the limits of our map to bind the process. The study considers in stitching department on the Duvet object and to improve their process. But In Value Stream Mapping current and future Value Stream Mapping has been written all the processes from start to end.

In addition to information flow in this step how the customer places the order and how it is transported to the supplier. In the Manufacturing industry gives orders to the production department based on the weekly plan. Therefore, it was considered an electronic information flow hence the symbol was used accordingly. Inside the factory, Information flow starts by generating material requisition numbers from the production team, proceeds through confirmation at the store, and ends when a Material Receipt Note (MRN) is received at company unit 01 FWH (WAREHOUSE). A manual information flow icon was used to represent this flow because MRN is manually written, authorized, and handled throughout the flow.

Process the Data Box: recording actual data at the working area, we tried to avoid “historical” data where possible, noticing current information. For this research, the data required was cycle time, batch size, packet size, and number of workers required to perform the activity. This data was recorded in the “data boxes” placed below process boxes on our Value Stream Map, as shown in Figure 4.

Data Box
Cycle time
Frequency
Batch size
No: of workers
Total Production

Figure 4: Process Data Box

The addition of inventory during the processes, wherever it is seen, is the fourth step. Inventory was seen at four locations, which are divided into three categories: storage, work-in-progress, and finished goods inventory (not including the main warehouse, which we regarded as the supplier). The current state map has a timeline that can be used to determine both the lead time and the total cycle duration. Both the value-added and non-value-added times were shown on the timelines. The peaks on the timeline represent the times that added value, while the valleys on the timeline represent the times that did not.

The final step is to add more symbols to the current state map, such as quality checks, transport, push or pull arrows, and operator symbols, to represent activities besides processes and inventories. These symbols were added, and the result was a current state value stream map, as seen in the figure below.

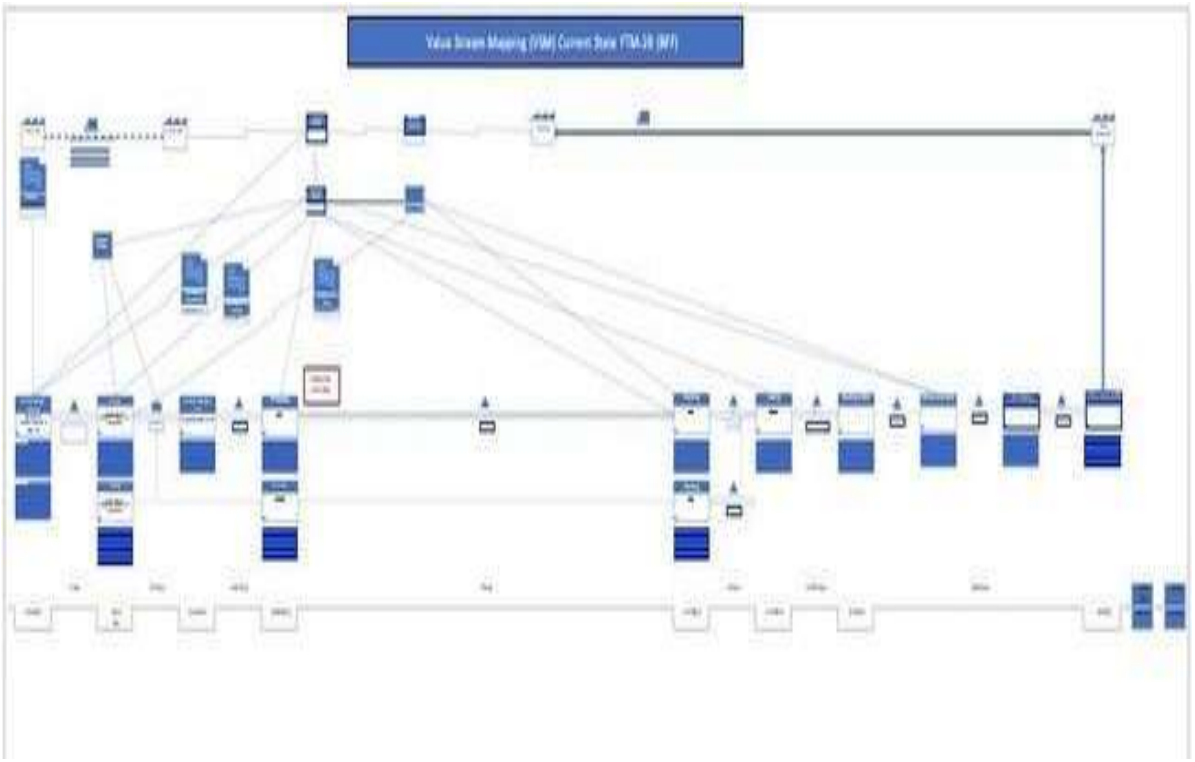

Figure 5: Current Value Stream Mapping of Company

Interpreting the Current State Value Stream Map

Current state VSM represents the flow of information and flow of material throughout the value stream. It assisted in identifying non-value-added activities. This research focused on some

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processes but main focus in Stitching i- e; Line Balancing and Cutting Stitching processes. Each process is explained in detail with a flow diagram and time for each activity involved in it.

Cutting Process Department

The following figure shows the process of cutting the department. Various steps are included in the department and those are followed by each article during the cutting process.

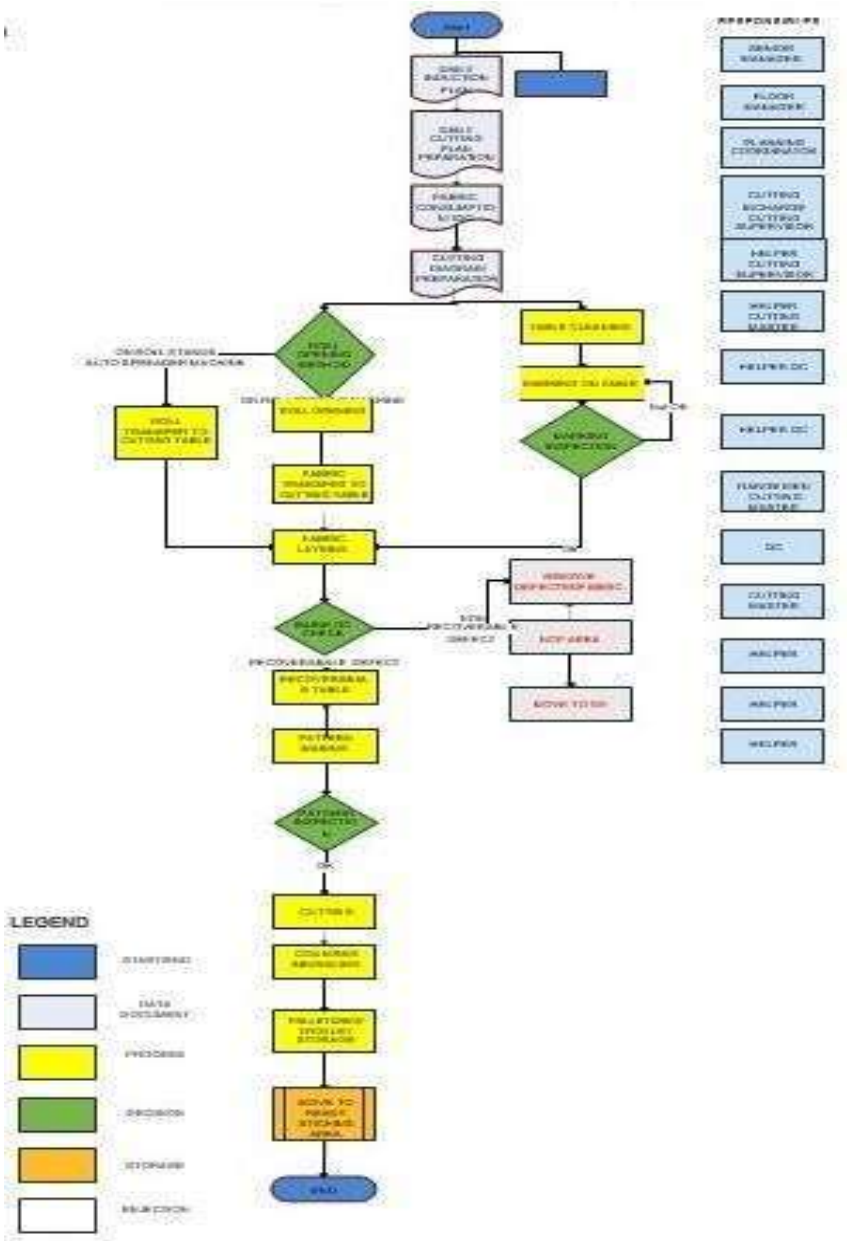

Figure 6: Cutting Process

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Cutting Data Formulas

- $\text{Total time of 1 range (min)} = \frac{\text{cycle time of layer (s)} * \text{No of layers in 6 inch}}{60}$
- $\text{Total production meters/CT} = \text{No of Layers in 6 inches} * \text{No of Meters}$
- $\text{Cycle time of 1 range in Hours} = (\text{Total time of 1 range} + \text{marking time} + \text{machine cutting time} + \text{bundling time})/60$
- $\text{Total ranges} = \frac{\text{Working Hours}}{\text{Cycle time of 1 Range}}$
- $\text{Total Production Meters} = \text{Total Ranges} * \text{Total Production Meters/CT}$
- $\text{Total Production Pcs} = \frac{\text{Total production Meters}}{\text{No of Meters}}$
- $\text{Efficiency} = \frac{\text{Actual Production}}{\text{Total Production/Day}}$

Table 1: Cutting Data

Operations	Table 1	Operations	Table 2
Article	Duvet Front	Article	Duvet Reverse
Manpower	4	Manpower	4
No Of Layers In 6 Inch Height	80	No Of Layers In 6 Inch Height	300
No Of Meters	3.5	No Of Meters	3.5
Cycle Time of Layer (Sec)	10	Cycle Time of Layer (Sec)	20
Total Time Of 1 Range (Min)	13	Total Time Of 1 Range (Min)	100
Marking Time (Min)	8	Marking Time	9
Relaxation Time (Min)	-	Relaxation Time (Min)	-
Machine Cutting Time (Min)	8	Machine Cutting Time (Min)	9
Bundling Time (Min)	20	Bundling Time	25
Total Production Meters/Ct	280	Total Production Meters/Ct	1050
Cycle Time Of 1 Range (Hrs.)	0.82	Cycle Time Of 1 Range (Hrs.)	2.38
Total Ranges	9.12	Total Ranges	3.15
Total Production Meters/Day	2554	Total Production Meters/Day	3304
Grand Total Production/Day	730	Grand Total Production/Day	944
Actual Production	700	Actual Production	850
Efficiency	96%	Efficiency	90%

The above table shows the cutting data of two different articles, in the table different operations

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are included.

Stitching Process Department

The following figure shows the process of stitching the department. Various steps are included in the department and those are followed by each article during the stitching process.

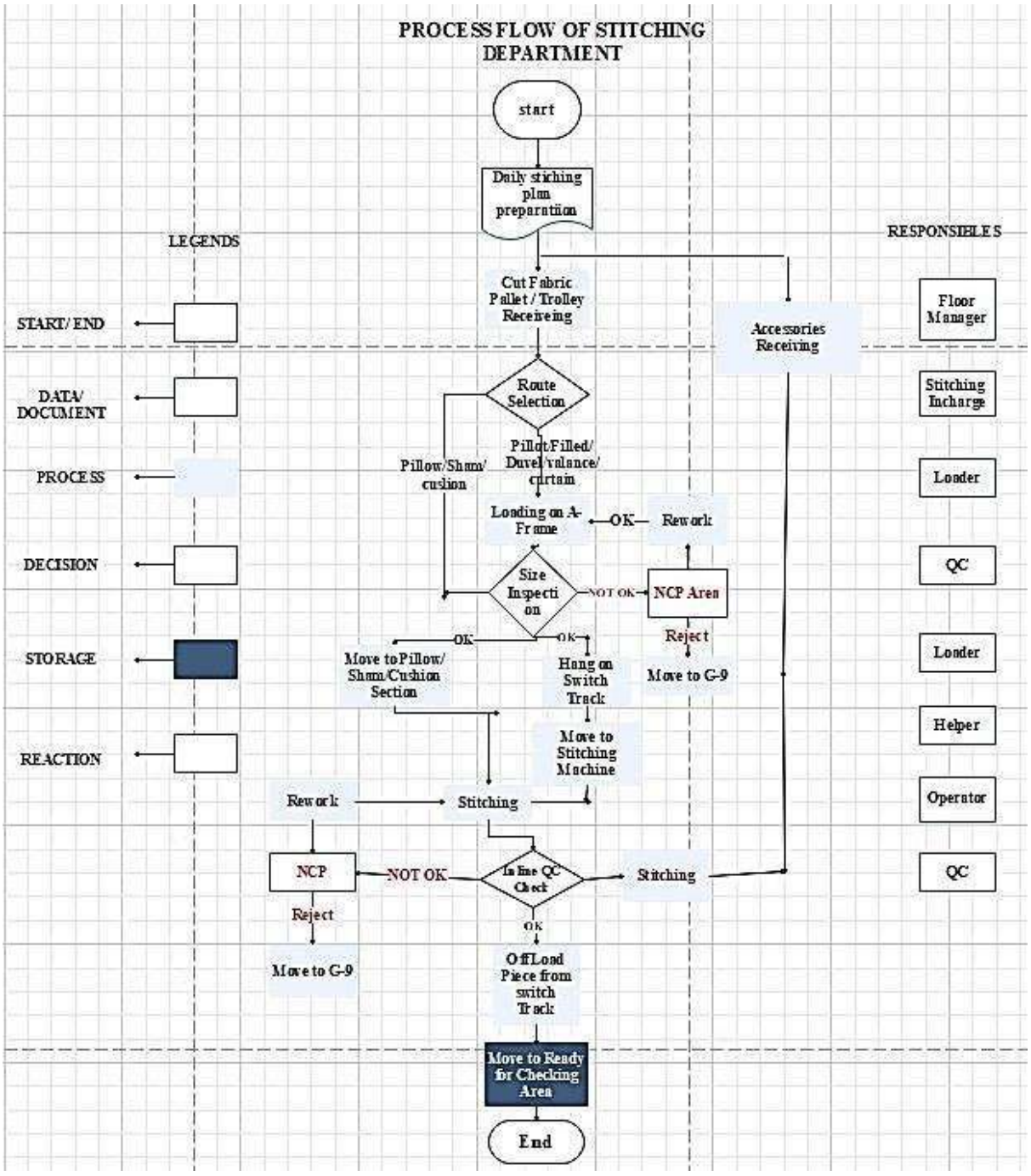

Figure 7: Stitching Process Department

Process of Flow of F Fabric Receiving, Issuance and Return

In this process, analyze the whole process of where are from the flow of fabric receiving,

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and issuance and then the return process.

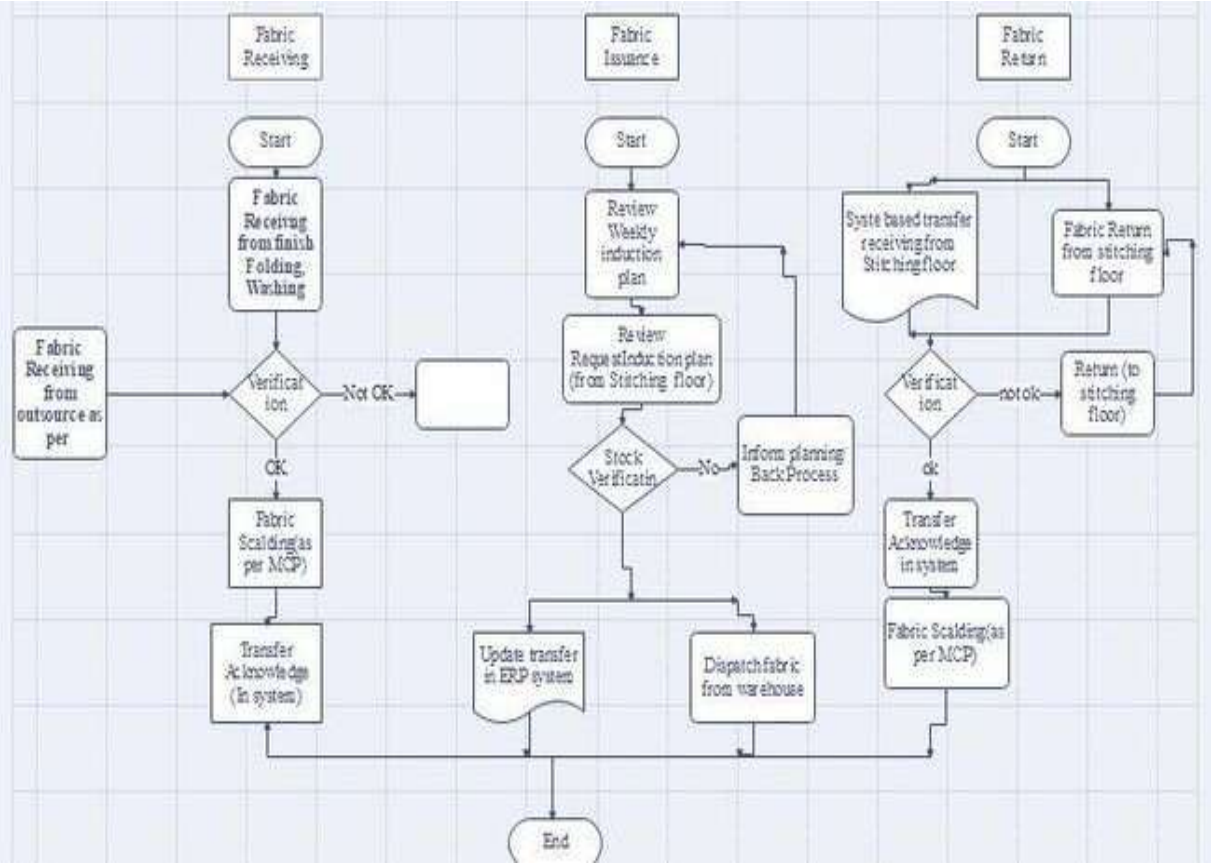

Figure 8: Process of Flow of F Fabric Receiving, Issuance and Return

Before Line Balancing of Stitching of Duvet:

The organization of machine capacity in a layout to ensure a reasonably uniform flow at capacity operation is known as line balancing.

In Before Line balancing, the total production is less, and takt time is more according to the production.

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Table 2: The results before Line Balancing of Stitching of Duvet

PIPING DUVET									
Operational Details	SPI	8	Efficiency	85%	Size	ALL		Cell Output	8
	Article	Operation Name	Machine	Avg SAM	Hourly Output/ Mc	Cell Output Per Day	Machine s req.	Total producti on/shift	Working hrs./shift
STITCHING	DUVET	PIPING ATTACHMENT 4 SIDE	SNLS	1.53	33	250	3	750	7.5
		PIPING TACKING	SNLS	0.25	204	1530	1	1530	7.5
		1 SIDE PATTA ATTACHMENT	SNLS	0.72	71	531	2	1063	7.5
		OVERLOCK 1 SIDE	3T O/L	0.42	121	911	2	1821	7.5
		HEM 2 SIDE	SNLS	0.35	146	1093	1	1093	7.5
		SHOULDER TACKING 2 SIDES	SNLS	0.58	88	659	1	659	7.5
		ASSEMBLE 4 SIDE	SNLS	2.62	19	146	5	730	7.5
		OVERLOCK 4 SIDE	3T O/L	1.01	50	379	1	379	7.5
		KAJ MAKING	Kaj	0.6	85	638	1	638	7.5
		BUTTON ATTACHMENT	Button	0.55	93	695	1	695	7.5
		CHECKING	Manual	2.2	23	174	4	695	7.5
		Total		10.83	19		22	379	

RESULTS

Table 3: Results of Piping Duvet-Glamour Oxford before line balancing

PIPING DUVET - GLAMOUR OXFORD	
SAM (min)	**10.83**
Number of machines	**18**
Total Production Capacity/Cell (Pcs)	**635**
Per Hour Pcs Per Cell (Pcs)Number of pieces per hour	**50**

The above table is of piping duvet glamour oxford before line balancing. In the table the SAM is 10.83 Min, 18 machines are used, the total production capacity per cell(pieces) is 635, and 50 pieces are per hour per cell.

Stitching Data Formulas

- $SAM = NORMAL\ TIME * PERFORMANCE\ RATING + ALLOWNCE\ (BH + PF)$
- $SAM = NORMAL\ TIME * 0.85 + NORMAL\ TIME * 0.85\ (17.5\%)$
- $SAM = NORMAL\ TIME * 0.85\ (1.175)$
- $PRODUCTION\ OR\ TARGET = \frac{WORKING\ MINTUES * 0.85 * NO\ OF\ MACHINES}{SAM}$
- $NO\ OF\ MACHINES = \frac{TARGET * SAM}{WORKING\ MINTUES * 0.85}$

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After Line Balancing Stitching of Duvet: In After Line Balancing, we precise and arrange the machine process sequences and increase the total production per pics in the required time.

Table 4: After Line Balancing of Stitching of Duvet

PIPING DUVET									
Operational Details	SPI	8	Efficiency	85%	Size	ALL		Cell Output Per Day	8
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Cell Output Per Day	Machines req.	Total production /shift	Working hrs./shift
STITCHING	DUVET	PIPING ATTACHMENT 4 SIDE	SNLS	1.53	33	250	3	750	7.5
		PIPING TACKING	SNLS	0.25	204	1530	1	1530	7.5
		1 SIDE PATTA ATTACHMENT	SNLS	0.72	71	531	2	1063	7.5
		OVERLOCK 1 SIDE	3T O/L	0.42	121	911	1	911	7.5
		HEM 2 SIDE	SNLS	0.35	146	1093	1	1093	7.5
		SHOULDER TACKING 2 SIDES	SNLS	0.58	88	659	1	659	7.5
		ASSEMBLE 4 SIDE	SNLS	2.62	19	146	5	730	7.5
		OVERLOCK 4 SIDE	3T O/L	1.01	50	379	2	757	7.5
		KAJ MAKING	Kaj	0.6	85	638	1	638	7.5
		BUTTON ATTACHMENT	Button	0.55	93	695	1	695	7.5
		CHECKING	Manual	2.2	23	174	4	695	7.5
		Total		10.83	19		22	638	

Table 5: Results after Line Balancing

PIPING DUVET - GLAMOUR OXFORD	
SAM (min)	**10.83**
Number Of machines	**18**
Total Production Capacity/Cell (Pcs)	**636**
Per Hour Pcs Per Cell (Pcs)	**85**

The above table is of piping duvet glamour oxford before line balancing. In the table the SAM is 10.83 Min, 18 machines are used, the total production capacity per cell(pieces) is 636, and 85 pieces are per hour per cell. Look now at the new production capacity is changed and pieces per hour are increased on the same machines and SAM. Here means considering the number of pieces is increasing at the same machines and SAM. The total production is increasing means first was less but after line balancing total production increased.

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Before Line Balancing of Stitching and Checking of SHAM

Table 6: Before Line Balancing of Stitching and Checking of SHAM

BEFORE LINE BALANCING								
Operational Details	SPI	8	Efficiency	85%	Size		Total Production Capacity/Cell	2125
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Machines req.	Total production/shift	Working hrs./shift
STITCHING & CHECKING	SHAM	2 SIDE HEM + LABLE	SNLS	0.15	340	1	2550	7.5
		ASSEMBLE 4 SIDE	SNLS	0.95	54	5	2013	7.5
		CUTTING 4 SIDE	S/F	0.20	255	1	1913	7.5
		TURNING	Manual	0.14	364	1	2732	7.5
		OVERLOCK 4 SIDE	SNLS	0.50	102	3	2295	7.5
		CHECKING	Manual	0.37	138	2	2068	7.5
	Total			1.80	54	10	1913	

WAFTLE SHAM	
SAM(min)	1.80
No. of machines	10
Total Production Capacity/Cell (Pcs)	2125
Per Hour Pcs Per Cell (Pcs)	283

The above table shows data on stitching and checking of SHAM before line balancing. In the table the SAM is 1.80 Min, 10 machines are used, the total production capacity per cell(pieces) is 2125, and 283 pieces per hour per cell.

After Line Balancing of Stitching and Checking of SHAM

Table 7: After Line Balancing of Stitching and Checking of SHAM

AFTER LINE BALANCING								
Operational Details	SPI	8	Efficiency	85%	Size		Total Production Capacity/Cell	1747
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Machines req.	Total production/shift	Working hrs./shift
STITCHING & CHECKING	SHAM	2 SIDE HEM + LABLE	SNLS	0.15	340	1	2550	7.5
		ASSEMBLE 4 SIDE	SNLS	0.95	54	4	1611	7.5
		OVERLOCK 4 SIDE	S/F	0.50	102	2	1530	7.5
		CHECKING	Manual	0.37	138	2	2068	7.5
	Total			1.97	54	9	1530	

GLAMOUR OXFORD	
SAM(min)	1.97
No. of machines	9
Total Production Capacity/Cell (Pcs)	1747
Per Hour Pcs Per Cell (Pcs)	233

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The above table shows data on stitching and checking of SHAM after line balancing. In the table the SAM is 1.97 Min, 9 machines are used, the total production capacity per cell(pieces) is 1747, and 233 pieces per hour per cell. Here the number of machines decreased, SAM increased, production capacity decreased, and per-hour pieces were also decreased. Due to the decrease in machines other operations are decreased. The total production is also increasing look at table.

Before Line Balancing of Packaging of Duvet Set

Table 8: Before Line Balancing of Packaging of Duvet Set

BEFORE LINE BALANCING								
Operational Details	SPI	8	Efficiency	85%	Size		Total Production Capacity/Cell	1536
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Manpower req.	Total production/ shift	Working hrs./shift
PACKING	DUVET SET	DUVET FOLDING WITH STIFFNER	Manual	0.30	170	1	1275	7.5
		PASSING THROUGH MDM	Manual	0.12	425	1	3188	7.5
		PILLOW PAIRING/FOLDING + SET MAKING	Manual	0.35	146	1	1093	7.5
		RIBBON ATTACH IN INLAY CARD + RFID STICKER PASTING	Manual	0.28	182	1	1366	7.5
		DUVET INSERTING IN RIBBON	Manual	0.17	300	1	2250	7.5
		BACK INLAY CARD ATTACH + RIBBON SETTING	Manual	0.91	56	1	420	7.5
		INSERTING IN POLYBAG & FLAP CLOSING	Manual	0.35	146	1	1093	7.5
		CARTON FILLING	Manual	0.11	464	1	3477	7.5
		CARTON SEALING	Manual	0.15	340	1	2550	7.5
	Total			2.74	56	9	420	

NORMAL DUVET PACKING	
SAM(min)	2.74
No. of persons	11
Total Production Capacity/Cell (Pcs)	1536
Per Hour Pcs Per Cell (Pcs)	205

The above table shows data on packing before line balancing. In the table the SAM is 2.74 Min,11 persons are working, the total production capacity per cell(pieces) is 1536, and 205 pieces per hour per cell.

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After Line Balancing of Packaging of Duvet Set

Table 9: After Line Balancing of Packaging of Duvet Set

AFTER LINE BALANCING								
Operational Details	SPI	6	Efficiency	85%	Size		Total Production Capacity/Cell	1536
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Menpower req.	Total production/shift	Working hrs./shift
PACKING	DUVET SET	DUVET FOLDING WITH STIFFNER	Manual	0.30	170	1	1275	7.5
		PASSING THROUGH MDM	Manual	0.12	425	1	3188	7.5
		PILLOW PAIRING/FOLDING + SET MAKING	Manual	0.35	146	1	1093	7.5
		RIBBON ATTACH IN INLAY CARD + RFID STICKER PASTING	Manual	0.28	182	1	1366	7.5
		DUVET INSERTING IN RIBBON	Manual	0.17	300	1	2250	7.5
		BACK INLAY CARD ATTACH + RIBBON SETTING	Manual	0.91	56	2	841	7.5
		INSERTING IN POLYBAG & FLAP CLOSING	Manual	0.35	146	1	1093	7.5
		CARTON FILLING	Manual	0.11	464	1	3477	7.5
		CARTON SEALING	Manual	0.15	340	1	2550	7.5
	Total			2.74	56	10	841	

NORMAL DUVET PACKING	
SAM(min)	2.74
No. of persons	11
Total Production Capacity/Cell (Pcs)	1536
Per Hour Pcs Per Cell (Pcs)	205

The above table shows data on packing after line balancing. In the table the SAM is 2.74 Min,11 persons are working, the total production capacity per cell(pieces) is 1536, and 205 pieces per hour per cell. But now look at the table on the same number of persons the production is increasing.

Overall Observations

To obtain precise data on industry cycle durations, performed time studies for this research. The study separated the procedures into various tasks and determined the duration of each task. The time studies in the stitching department provided us with the actual cycle times for every activity. The process of closely monitoring and documenting human labor to determine how long it takes to complete a task is known as a time study. Within the stitching department, conducted time studies and recorded thing cycle times for each operation using pre-made tables and a stopwatch, as seen above. The study utilized the crucial information these cycle times provided to us in our VSM. To determine which actions, bring value and which do not. The production per cell changes both before and after the balancing line, and the cycle duration increases because of the increased production and removal of certain non-value-added motions.

Creating the Future State Value Stream Mapping

Following some discussion, the present state of VSM was examined; very few possible outcomes were found. A future state VSM with a kaizen burst to show the amount of NVA time and the potential for improvement. The future state map is a conceptual representation of a possible future that was made to gather feedback. The Steam map offers the best value in terms

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of cost. The ongoing pursuit of improvement is the main goal of the future state map. Achieved this by reducing the time spent on non-value-adding tasks, the work-in-process inventory, the workforce, and the process.

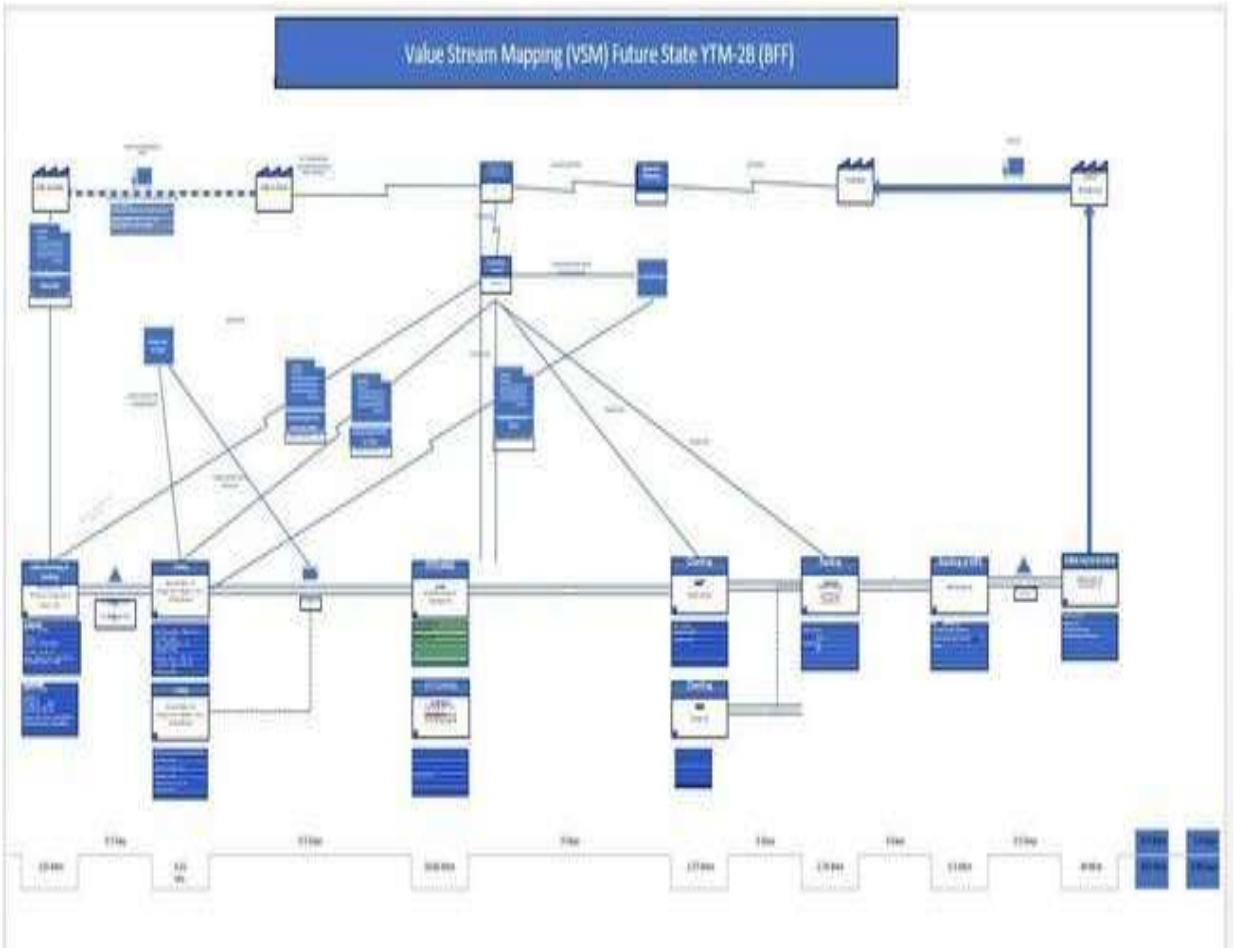

Figure 9: Creating Future VSM

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Results and Analysis of Current and Future Value Stream Mapping

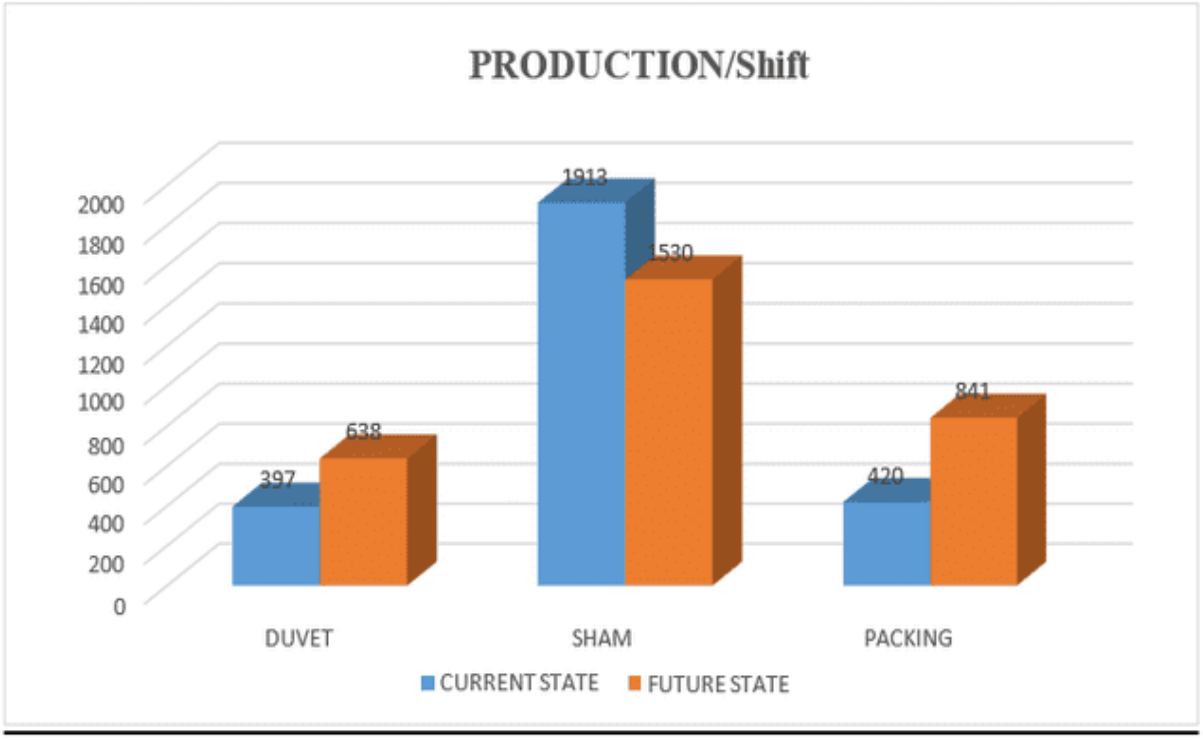

Figure 10: Compare Current and Future VSM in Production/Shift

The above graph suggests that VSM plays a crucial role in production, the figure shows in future the production can increase if the company implements the VMS technique.

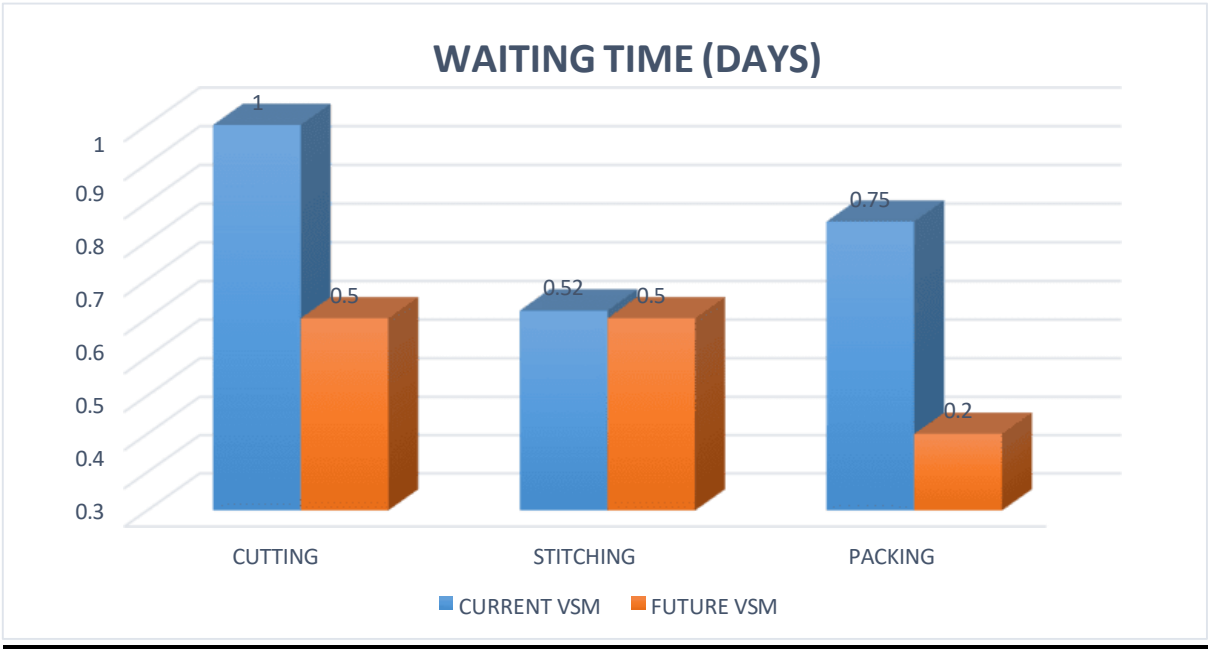

Figure 11: Compare Future and Current VSM Waiting Time (Days)

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The above figure shows current waiting time is high so in the future if the company implements the VMS technique, then the waiting time will decrease.

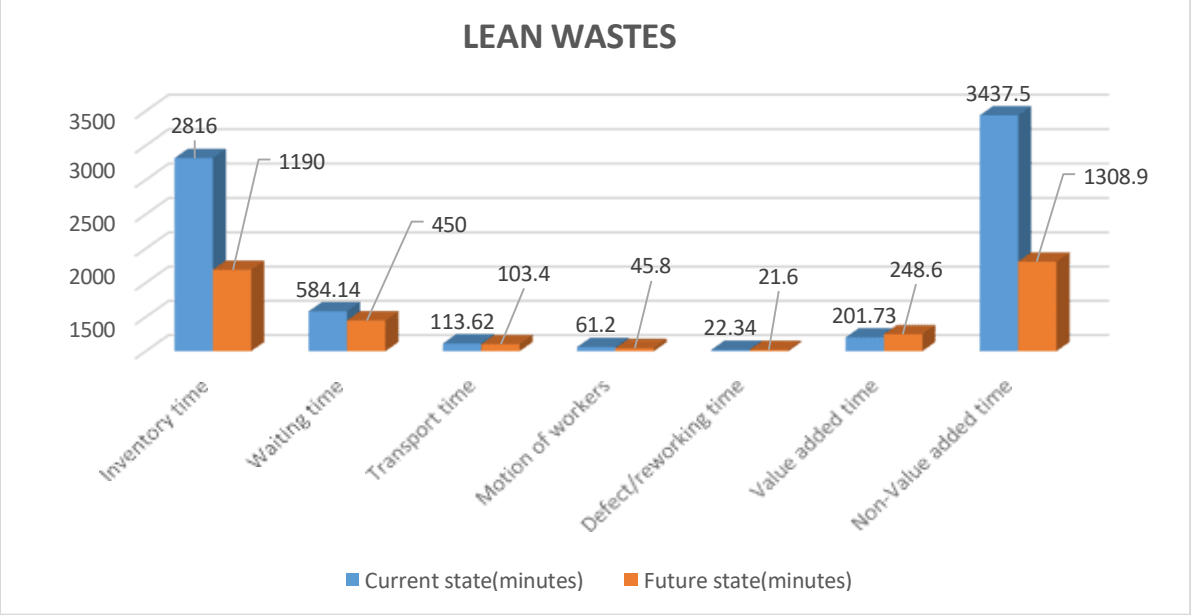

Figure 12: Compare Current and Future VSM of Lean Wastes

The above figure shows current waste is high so in the future if the company implements the VMS technique, then the lean waste will decrease.

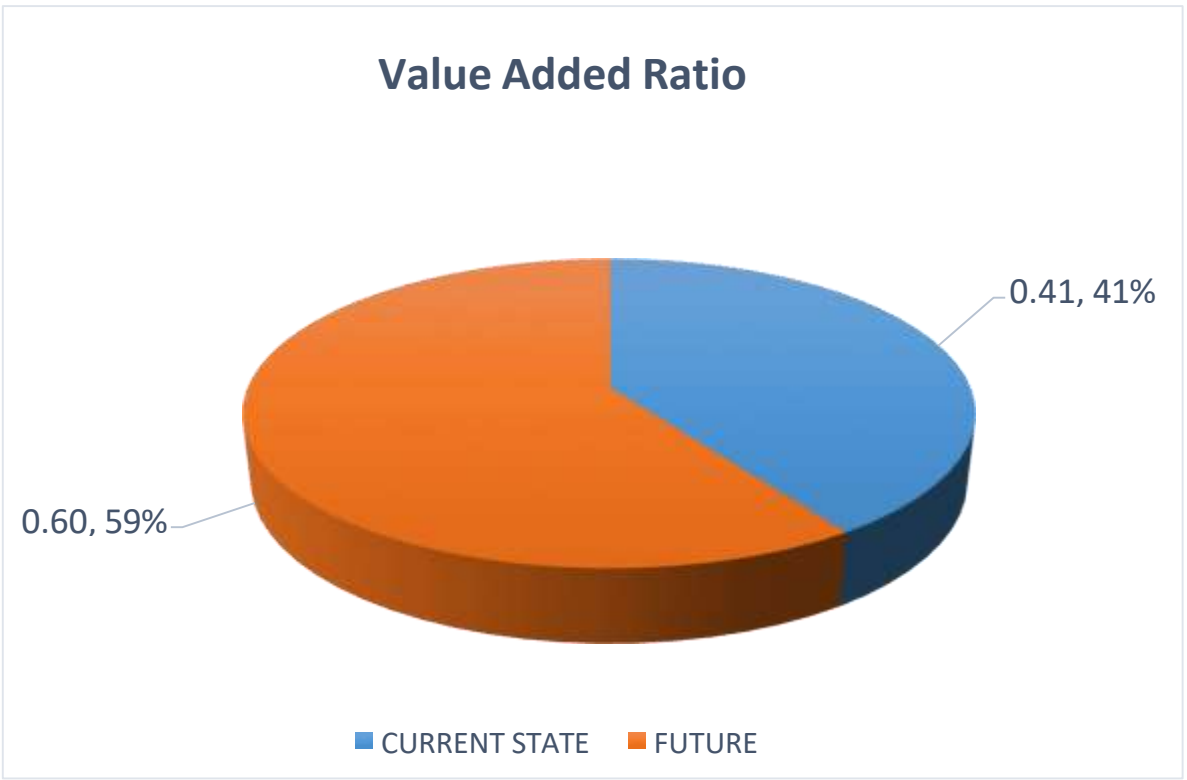

Figure 13: Graph of Value-Added Ratio Compare of Current and Future VSM

The above graph shows the comparison of the value-added ratio of current and future VSM.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Based on the analysis/results of this study, it is concluded that the VSM can be a simple and effective tool for the Textile industry to visualize & analyze the Lean wastes that occur in information, production & material flow. It is also observed that the traditional way to develop VSM is time-consuming and due to its static nature sometimes it fails to provide the eye bird view of whole the system with accurate & reliable data. Hence Future work could focus on creating a unified dashboard where the diagram as well as the comparisons of future & current state maps can be digitized/displayed in one place to analyze the lean wastes and performance of the overall production unit.

Recommendation

The revolution of Industry 4.0 emphasizes the methods of obtaining digital data to provide dynamic & quick solutions to the problems faced by the industries. Hence it is suggested that the process of VSM should be digitized to visualize and analyze the lean wastes.

As of now, VSM seems to be the most effective tool to fulfill most of the objectives of lean manufacturing systems. Hence it is suggested that the Pareto & OEE analysis followed by VSM should be mandatory to achieve the high-quality performance of Lean systems.

It is also noticed that implementation of the future state of VSM requires the process of re-engineering, so it is suggested that long-term training is mandatory to be given to the employees for better results of improvement opportunities.

It is also reported that the focus of many researchers & practitioners remains the reduction of lean waste in the production area of the company. Hence it is suggested that supply & transportation are also potential areas for the reduction of lean waste to improve customer service.

Recommendations

To transform the value stream holistically Expansion of Lean Principles Consider the advantages of incorporating pull systems and just-in-time (JIT) inventory management into the cutting, checking, and packing processes. Develop training programs to ensure that all staff members are aware of lean processes and are capable of actively participating in them. Implementing employee engagement initiatives will help to promote a culture of continuous improvement. To improve material flow within the stitching section, investigate the use of Kaizen or other inventory control techniques. The research focuses on eliminating the lean waste unlined-balancing issues and non-value-added ratio. And analyses the results through graphs. This study improved the building's first-floor nonvalue-added activities and unlined balancing issues. Further, work on this topic and can focus on the different production areas like stitching checking Quality control, and so on.

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