TEXTILE REPORT

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CONTENT

List of Illustrations

List of Abbreviations

- **INTRODUCTION**
- **OBJECTIVES AND METHODOLOGY**
- **CASE STUDIES**
- **FINDINGS, RECOMMENDATIONS AND ACTION POINTS**
- **ANNEXURE**

LIST OF ILLUSTRATIONS

ILLUSTRATION NUMBER	NAME
1	FLOW CHART OF 5 M'S OF PRODUCTION
2	FLOW CHART OF HOW TO INCREASE PRODUCTIVITY.
3	FLOW CHART OF THE PARAMETERS OF THE CASE STUDY.
4	FLOW CHART OF THE ORGANISATIONS/UNITS SURVEYED.
5	MAP OF JAIPUR INTEGRATED TEXCRAFT PARK PRIVATE LIMITED
6	HEADOFFICE OF RANGOTRI (RAJASTHAN)
7	GOODWILL DESIGNCRAFT PRIVATE LIMITED (RAJASTHAN)
8 A	FLOW CHART OF RANGOTRI (RAJASTHAN)
8 B	FLOW CHART OF SCREEN PRINTING IN GOODWILL DESIGN TEXCRAFT PRIVATE LIMITED (RAJASTHAN)
9	CENTRAL WATER RESERVOIR WHICH STORES THE TREATED WATER FROM CETP
10	CETP FUNDED BY THE EUROPEAN UNION AS A JOINT COLLABORATION BETWEEN SWITCH ASIA AND THE EUROPEAN UNION
11	MAP OF M/S D.S. ENTERPRISE
12	THE DRYER MACHINES TO REMOVE MOISTURE FROM ACID WASHED CLOTHES
13	FLOWCHART OF PROCESS IN M/S D.S. ENTERPRISE (WEST BENGAL)
14	PICTURES OF PROCESS IN M/S D.S. ENTERPRISE (WEST BENGAL)
15	THE ENTIRE COLOUR OF THE CANAL DYED BLUE WITH THE WASTEWATER
16	WASTE WATER FROM M/S D.S. ENTERPRISE
17	CONTAINERS OF DYES AND CHEMICALS
18	NO PROTECTIVE EQUIPMENTS IN M/S D.S. ENTERPRISE
19	MAP OF INTERNATIONAL LEATHER CLOTHIERS (WEST BENGAL)
20	SIGNBOARD OF INTERNATIONAL LEATHER CLOTHIERS (WEST BENGAL)
21	FLOWCHART OF PROCESS OF INTERNATIONAL LEATHER CLOTHIERS
22	FLOWCHART OF THE PERCENTAGE OF MALE AND FEMALE WORKERS
23	MAP OF SARAT INDUSTRIES PRIVATE LIMITED (WEST BENGAL)
24	FLOWCHART OF PROCESS IN SARAT INDUSTRIES PVT LTD
25	PICTURES OF THE MACHINES FOR KNITTING INTO FABRIC ROLLS QUALITY CONTROL
26	PICTURES OF MACHINERIES USED FOR STEAM ROLLING THE WASHED CLOTHES
27	COTTON END WASTE DEPOSIT ON THE TOP OF THE MACHINES
28	PACKAGING AND WASTE CONTAINERS LYING ON THE UNIT FLOORS
29	PACKAGING PRODUCTS IN UNIT'S VEHICLE TO BE TRANSPORTED TO THE BUYER
30	MAP OF G.L.K PRINTERS (WEST BENGAL)
31	RAW MATERIALS SUCH AS THE CHEMICALS AND DYES ARE IMPORTED SOURCED FROM INTERNATIONAL SUPPLIERS THROUGH LOCAL DEALERS
32	FLOW CHART OF PROCESS IN G.L.K PRINTERS (WEST BENGAL)
33	MACHINES USED FOR HEAT PRESS
34	CHEMICALS AND WASTEWATER ARE DISPOSED IN THE SAME OUTLET TO THAT OF THE DOMESTIC WATER OUTLET
35	VARIOUS WORK PROCESSES IN G.L.K. PRINTERS
36	ANALYSIS OF FINANCIAL CAPITAL
37	EXPORT MARKET OF INTERNATIONAL LEATHER CLOTHIERS

LIST OF ABBREVIATIONS

Abbreviation	Full name
• C&D	Construction and Demolition Waste
• CETP	Common Effluent Treatment Plant
• CGWA	Central Ground Water Authority
• ETP	Effluent Treatment Plant
• GSM	Grams per Square Metre
• MSME	Ministry of Micro, Small & Medium Enterprises
• PP	Polypropylene
• R&D	Research and Development
• SoPs	Standard Operating Procedures

INTRODUCTION

The textile industry in India is a significant contributor to the country's economy, with substantial market size and potential for growth.

Textile industries employ more than 45 million people directly and more than 100 million people indirectly, contributing 2% to India's GDP and 7% to industrial production as of 2021. It has a market size of 223 billion U.S. dollars and falls among the top five global exporters in various categories like natural fibre, MMF spun yarn, filament yarn, woven fabric and home textiles (Kumar, 2023).

The market size of the textile industry in India has been projected to grow, as it is expected to reach $250 billion by 2030, with a 12% compound annual growth rate (CAGR) (Statista, 2023) [4]. This growth is further emphasised by the estimation that the total textile exports from India are expected to reach $65 billion by fiscal year 2026, and this figure is projected to further grow at a 10% CAGR from 2019-20 to reach $190 billion by 2025-26 [3] (India: Textile Industry Market Size 2026, 2023).

However, the Indian textile industry is grappling with significant environmental challenges related to pollution and wastage. The use of chemicals and dyes during the manufacture of textiles generates an enormous quantity of waste as sludge, fibres and chemically polluted waters, that accounts for approximately 20% of global industrial water pollution.

The chemically polluted textile wastewater degrades the quality of the soil and water when it mixes with these natural resources and its dependent habitats and environment. As a consequence of such high quantities of solid and liquid waste, textile industries are now facing major problems in environment pollution.

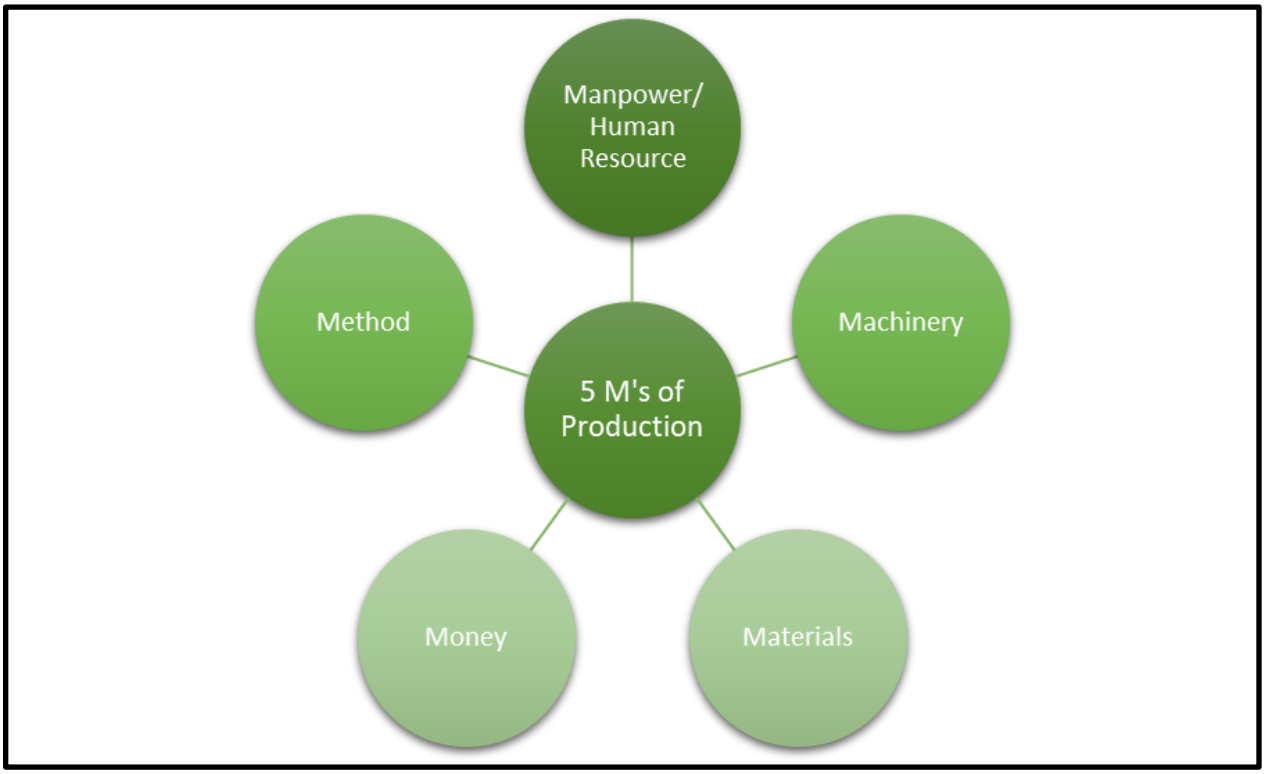
This indicates a substantial environmental impact caused by the Indian textile industry's practices, emphasising the urgent need for sustainable and eco-friendly manufacturing processes to mitigate these adverse effects.

What is productivity?

Productivity refers to the measure of efficiency that compares the output of goods or services to the input of resources used in their production. It reflects how effectively and efficiently resources such as labor, capital, time, and materials are utilized to generate valuable outputs. Productivity is a key metric for assessing the performance of individuals, businesses, industries, or entire economies.

The 5 M's of production refers to: Manpower, Machinery, Materials, Money and Method.

ILLUSTRATION 1: FLOW CHART OF 5 M'S OF PRODUCTION



Implementation of Productivity at textile industry:

- **Manpower (People):**
  - Specialised Skill Sets: Given the diverse and intricate nature of textile manufacturing, investment in cultivating specialised skills among the

workforce is imperative. Expertise in textile engineering, advanced fabric technologies, and nuanced understanding of machinery operations ensures adaptability and excellence.

- Innovation-Driven Workforce: Cultivating a culture of innovation within the workforce, where employees are encouraged to contribute to process refinement and product development, fosters an environment conducive to continuous improvement.

- **Materials:**

  Sustainable Sourcing Strategies: Recognizing the growing importance of sustainability, implementing comprehensive sourcing strategies that encompass environmentally responsible practices and traceable supply chains not only aligns with global ethical standards but also enhances the industry's resilience.

- **Machinery:** Textile production heavily depends on machinery and equipment. Proper maintenance, optimization of production lines, and investment in modern technology are essential for efficient production management in the textile industry.

  Intelligent Automation: Beyond mere machinery upgrades, incorporating intelligent automation with machine learning algorithms facilitates predictive maintenance, real-time adjustments based on environmental conditions, and optimal resource allocation, thereby pushing the boundaries of production efficiency.

  Interconnected Systems: Integration of machinery into a network of interconnected systems enables seamless communication between different stages of production, fostering a holistic approach that enhances overall process synchronisation.

- **Methods:** Optimization of production methods is key to ensuring high productivity and quality standards in the textile industry. This includes adopting advanced manufacturing processes, implementing lean manufacturing principles, and continuously improving production techniques.

- **Money:** Financial management is integral to production management in the textile industry. It involves cost control, budgeting for material procurement, machinery upgrades, and investment in research and development to drive innovation and efficiency.

By effectively managing these 5 M's, textile industry production management can achieve higher productivity, cost efficiency, and excellence in delivering quality textile products to the market.

ILLUSTRATION 2: FLOW CHART OF HOW TO INCREASE PRODUCTIVITY

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https://textilelearner.net/factors-influencing-productivity-in-textile-industry/
https://textilelearner.net/basic-procedure-of-production-planning-textile-industry/
Rao, C. V. S. (1989). Productivity, Technology and Indusrtial Relations in Textile Industry. *Indian Journal of Industrial Relations*, 144-156.

OBJECTIVES AND METHODOLOGY

OBJECTIVES

The objectives of this study are two folds:

A. **Conduct audits** of production chain (scope for productivity enhancement without any additional energy/water consumption) in Kolkata and nearby places in West Bengal, and Jaipur and nearby places in Rajasthan, with the objective to ascertain quantitative factors for developing the sustainability metre. The scope of the **production chain** in MSME (Micro, Small and Medium Enterprises) units is to assess the efficiency, quality, and sustainability of the textile production processes.
    a) **Raw Material Analysis:** Examine the quality and sourcing of raw materials used in the production process. Evaluate their compliance with quality standards and environmental regulations.
    b) **Process Evaluation:** Analyse the entire production process, from pre-processing (cleaning, blending, and carding) to spinning, weaving, knitting, dyeing, printing, finishing, and packaging (Scope 1). Assess the efficiency, quality control measures, and waste generation at each stage.
    c) **Machinery and Equipment Inspection:** Evaluate the condition, performance, and efficiency of textile machinery and equipment, including looms, knitting machines, dyeing machines, printing machines, and finishing equipment. Identify any outdated or inefficient equipment that may impact quality or productivity.
    d) **Water Usage and Conservation:** Examine water consumption in different processes and recommend water-saving measures. Assess the effectiveness of water treatment and recycling systems.
    e) **Waste Generation and Management:** Analyse waste generation at various production stages, such as waste fibres, dye sludge, and chemical waste. Propose strategies for waste reduction, recycling, and proper disposal.
    f) **Worker Health and Safety:** Review occupational health and safety practices to ensure that workers are operating in a safe and healthy environment. Identify potential hazards and recommend measures for improvement.

B. **Provide recommendations and action plan:** Provide a detailed report with findings, recommendations, and an action plan for addressing the identified issues and improving overall efficiency, quality, and sustainability.

METHODOLOGY

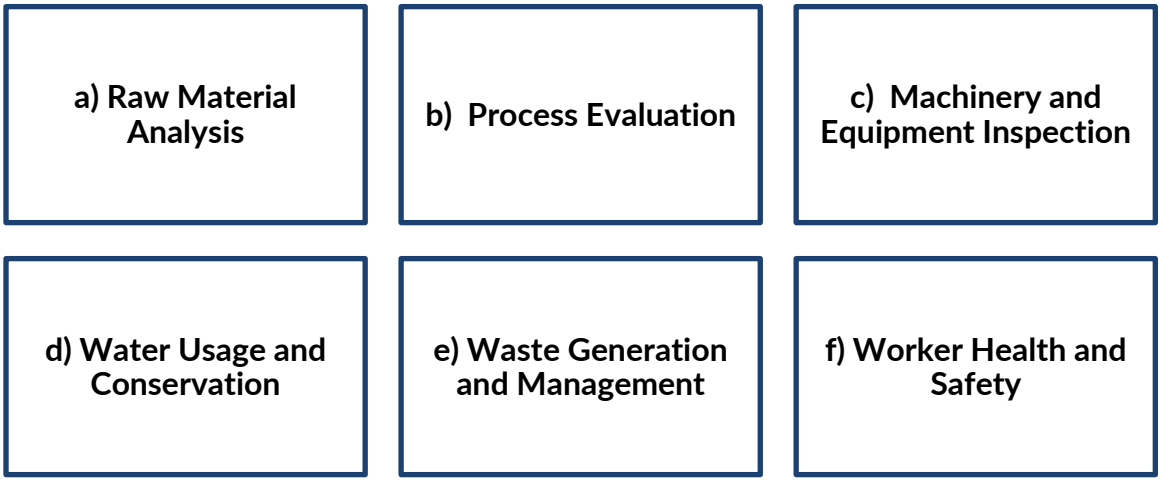
RESEARCH DESIGN:

Exploratory research was used to conduct audits on the production chain (scope for productivity enhancement without any additional energy/water consumption) in Kolkata and nearby places in West Bengal, and Jaipur and nearby places in Rajasthan.

The reason why this approach was selected are because:

a) Through this audit, we aimed to investigate certain domains that have not previously been studied in-depth, like the following:

ILLUSTRATION 3: FLOW CHART OF THE PARAMETERS OF THE CASE STUDY.



b) Initial desk-top research revealed that the MSME textile sector is unstructured and a more structured audit may not yield sufficient information required for the report, its recommendations and action plan. Exploratory research is also referred to as interpretive research or a grounded theory approach due to its flexible and open-ended nature, it was identified as the best approach under such conditions.

Due to the use of exploratory research, the findings have been qualitative and primary in nature. Post extensive desk top research, a semi-structured questionnaire (Annexure 1) was framed based on the six domains mentioned above.

SAMPLING METHOD:

The sample was pre-identified by the Foundation for MSME Clusters. Accordingly, the field research was conducted in 2 units of Jaipur and nearby places in Rajasthan and 3 units of Kolkata and nearby places in West Bengal. The names of the organisations/ units surveyed are as follows:

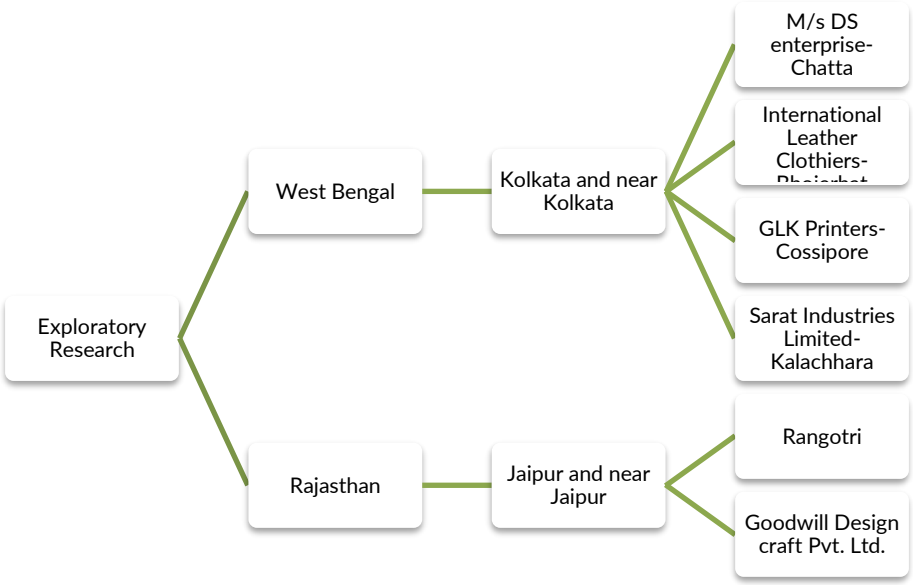


ILLUSTRATION 4: FLOW CHART OF THE ORGANISATIONS/UNITS SURVEYED.

The dates when the audits were conducted are as follows:

Date	Day	Location
November 23,2023	Thursday	Rangotri- Jaipur, Rajasthan
November 24,2023	Friday	Goodwill Design Craft Pvt Ltd.- Jaipur, Rajasthan
November 28,2023	Tuesday	M/S DS Enterprise- Chatta, West Bengal
December 05,2023	Tuesday	International Leather Clothiers- Bhojerhat, West Bengal
December 06,2023	Wednesday	Sarat Industries Limited- Kalachhara, West Bengal
December 06,2023	Wednesday	GLK Printers- Cossipore- West Bengal

MEASUREMENT TOOLS:

During the field visits, two types of data extraction techniques were employed; observation and semi structured questionnaire (Annexure 1).

Observation as a data collection method is classified as a participatory study, because the researcher has to immerse in the setting of the respondents, while taking notes and/or recording. Observation data collection method may involve watching, listening, reading, touching, and recording behavior and characteristics of phenomena.[1]

On the other hand, the semi-structured questionnaire helped in eliciting freedom of responses while also revising and prodding in-depth in some of the topics of the research. Photographs were captured and recording using mobile phone's sound recorder were documented through photographs for visual representation in the report.

AUDITING, ANALYSIS, RECOMMENDATIONS:

Comprehensive data from both primary (on-site visits) and secondary sources through desktop research were compiled for analysis, corroboration and for framing recommendations and action plans.

LIMITATIONS OF STUDY:

The research faced multiple hurdles, the most important being the reluctance of the respondents to respond to the audit. This happened due to refusal to participate, fully or partially by the organisation/ unit.

There have been instances when the dates, days of field visit as well as organisations/units had to be changed as the respondents were hesitant to respond.

This is because, while

> *"India is a world leader in textiles and possesses the entire manufacturing value chain, from fibre to apparel, and provides the distinct advantage of backward integration.*
>
> *India has one of the most liberal investment policies for foreign investments in the textile and apparel sector with 100 per cent foreign direct investment (FDI) allowed through the automatic route." – Mr. Deepak Bagla, Director & CEO, Invest India.*

On the other hand, the textile industry in India, in the MSME sector is mostly unstructured and often non-compliant to certain national and international standards and regulations.

[1] Observation - Research-Methodology

Eg. 20 percent of all fresh water pollution is made by textile treatment and dyeing[2] (most of our respondents were in this sector). Moreover, the toxicity, Leachate Pollution Index (LPI), and risk assessment of the leachate of hazardous sludge are very rarely and scantly studied.[3]

As a result, dates, days, units were repeatedly changed till the responses were received.

Date	Venue	Reason
November 11, 2023	Goodwill Designcraft Private Limited, Jaipur (Rajasthan)	The owner of the unit was not available to give us a tour of the site
November 24, 2023	Marudhara Dyetech Private Limited (Rajasthan)	The owner refused to participate in the survey
November 28, 2023	Chatta unit in Kolkata (West Bengal)	The owner refused to participate in the survey
December 05, 2023	Dankuni unit in Kolkata	The owner refused to participate in the survey

The other is the time limitation. The data collection and report were done in a limited time frame, made challenging due to the repeated change of dates for collecting data, which further delayed preparation of the report.

And the third limitation is the possible limitation of bias as explorations were only conducted among those units that provided consent for interviews.

[2] Pollution by Textile Industry - Pollutants of Water, Air, Land, Environmental Pollution By Textile Industry - Fibre2Fashion

[3] Assessment of Toxicity Characteristics in Leachate from the Textile Industry–Based Sludge Using Leachate Pollution Index | Water, Air, & Soil Pollution (springer.com)

CASE STUDIES

I. TEXTILE UNITS IN JAIPUR AND NEARBY LOCATIONS, RAJASTHAN

The audit was conducted in the textile industry in Jaipur Block, Rajasthan. In 2006, the members of the Jaipur Block joined forces to establish Jaipur Integrated Texcraft Park Private Limited. The primary objective of this cluster was to develop top-notch infrastructure and eco-friendly facilities for textile units across India. This collaborative initiative was made possible through the combined efforts of the European Commission's SWITCH Asia Project, the Government of India's SITP Scheme for Integrated Textile Parks, and the Consortium of Textile Producers (COTEX).

In a significant global move in 2011, Jaipur Bloc showcased its members' products collectively at the Maison et Objet fair in Paris, France. This strategic collaboration for international markets stemmed from extensive market research conducted by the All-India Artisans and Craftworkers Welfare Association (AIACA) and the guidance of Traidcraft, a UK-based organization dedicated to development through trade.

ILLUSTRATION 5: MAP OF JAIPUR INTEGRATED TEXCRAFT PARK PRIVATE LIMITED

Two textile industries were studied, viz.,
i) Rangotri: is an international supplier which deals with acid wash, dying, stitching and block printing of fabrics[4].

[4] https://www.rangotri.com/process

ii) Goodwill Design Craft Private Limited: specializes in a comprehensive screen-printing process, which involves fabric washing, dyeing, and screen-printing utilizing discharge methods and conventional screen-printing processes.

ILLUSTRATION 6: HEADOFFICE OF RANGOTRI (RAJASTHAN)

ILLUSTRATION 7: GOODWILL DESIGNCRAFT PRIVATE LIMITED (RAJASTHAN)

1.a RAW MATERIAL ANALYSIS:

The raw materials, including chemicals and dyes, are procured from local markets such as Sanganer and Bagru. Sanganer and Bagru are in Jaipur district. While, Sanganer is located about 16 kms from Jaipur, Bagru is on other side, about 30 kms on Jaipur – Aimer Road. Typically, vegetable dyes are used for Sanganeri and Bagru prints. While, traditional Sanganeri prints are always on a white or pastel colour background and are famous for its artistry and intricacy of designs, Bagru is famous for its alizarine red and iron black. Sanganer and Bagru prints are essentially on 100% cotton fabrics.[5]

These suppliers are located approximately 51-100 km from the factory and offer high-quality products at competitive prices. The raw materials are transported by road in public transport.

1.b PROCESS EVALUATION:

The process evolution includes a rolling machine, hydro extractor, extract recycling pump, air compressor, dryer, washer, steam roller, and maintenance. The rolling machine operates for 8-10 hours per day, with a water channel for extract recycling and a steam roller for pigment rolls. The production process depends on the job work at hand, but the company has a capability to produce 2000 metres per day. The first day of production consists of steam, stitching, fabric assembly, and dying, while the second day is when the finished material is ready for assembly and measurement.

[5] http://txcindia.gov.in/html/B_Ethnic%20Printing%20clusters.pdf

ILLUSTRATION 8A: FLOW CHART OF RANGOTRI (RAJASTHAN)

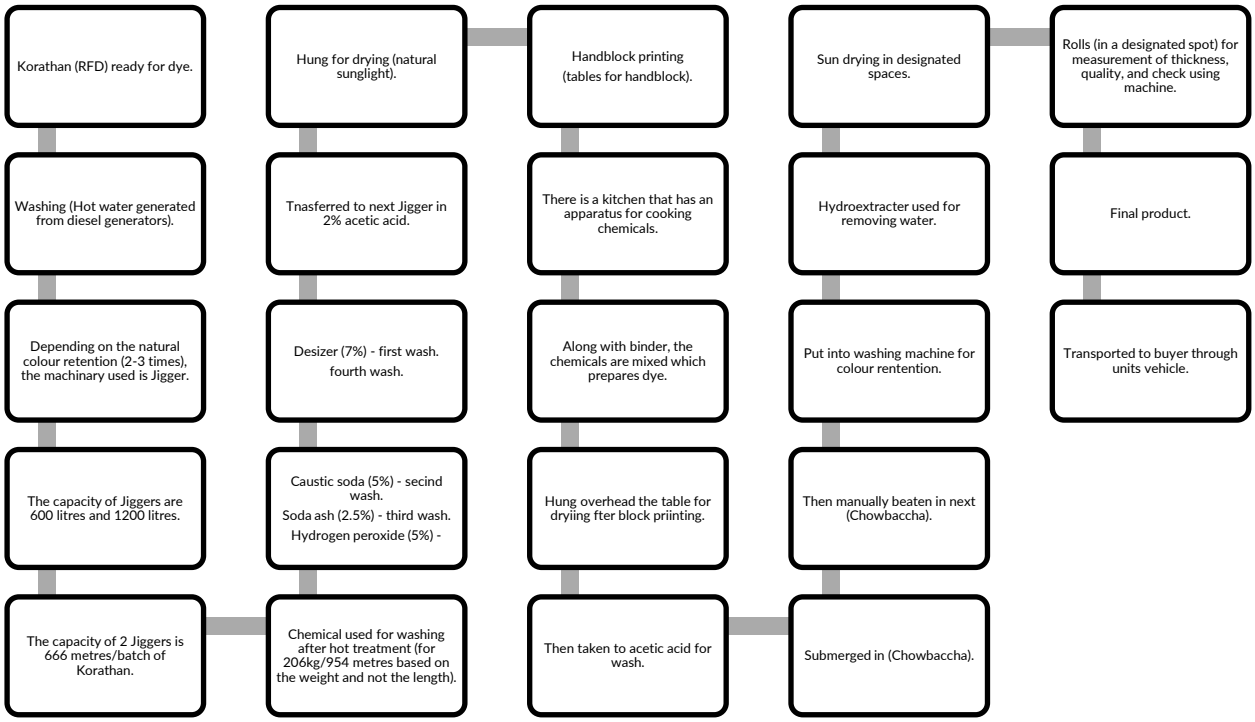
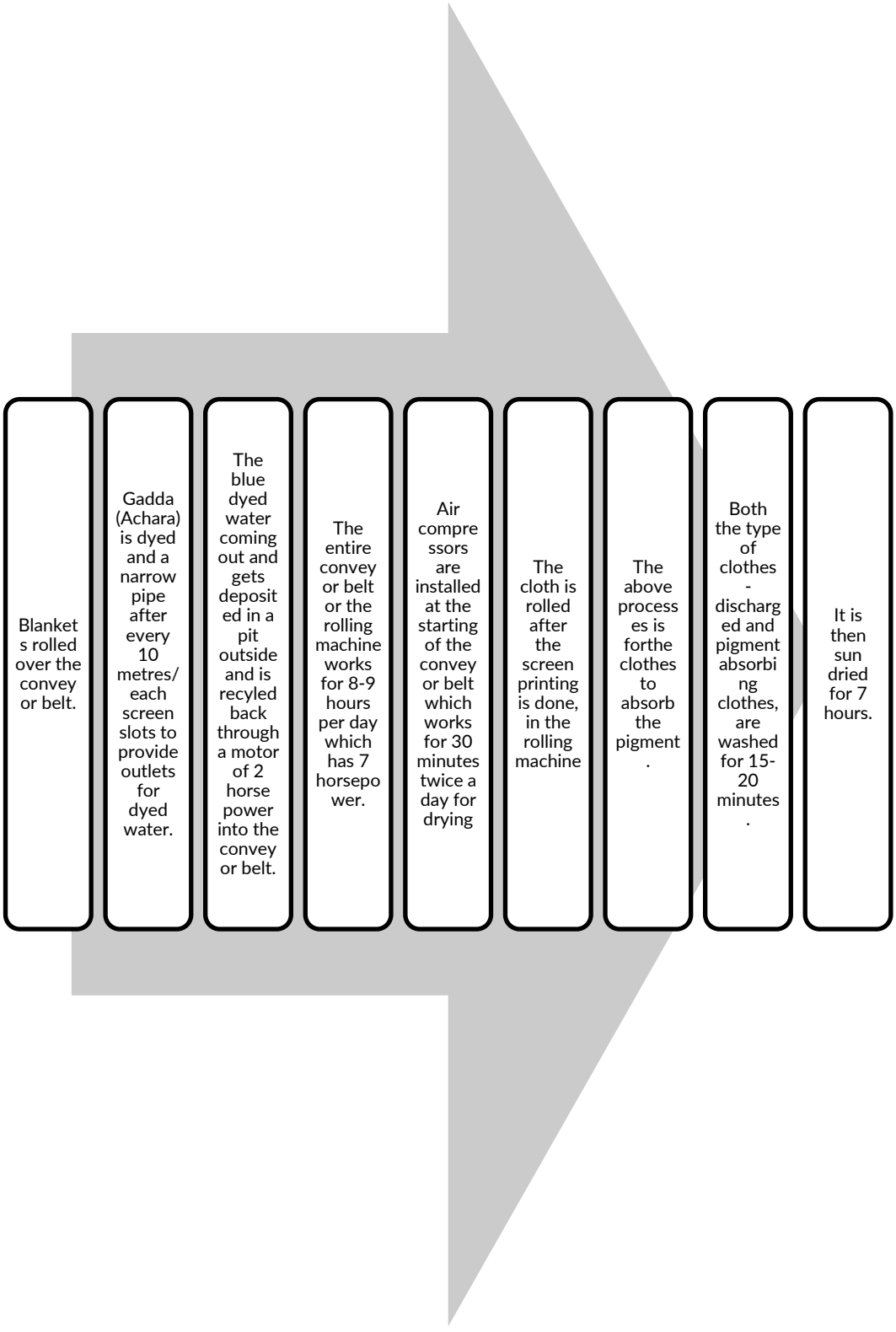


ILLUSTRATION 8B: FLOW CHART OF SCREEN PRINTING IN GOODWILL DESIGN TEXCRAFT PRIVATE LIMITED (RAJASTHAN)



1.c MACHINERY AND EQUIPMENT INSPECTION:

The machines are 6-10 years old but are still working with 80-90% efficiency. They maintained the machines through Annual Maintenance Contract from Suppliers Local contractors. They need repairing every 7-10 years.

1.d WATER USAGE AND CONSERVATION:

Water is sourced from the nearby Central reservoir in the textile park, which is stored in the individual underground tank.

The production process uses varying amounts of water. Waste water is released into a Central Erosion Treatment Plant (CETP), but the drainage system is not clear. Waste water from hydro extractors and washing machines are treated and recycled. A common CETP recycles water, and individual industries retrieve it from a central reservoir.

ILLUSTRATION 9: CENTRAL WATER RESERVOIR WHICH STORES THE TREATED WATER FROM CETP

ILLUSTRATION 10: CETP FUNDED BY THE EUROPEAN UNION AS A JOINT COLLABORATION BETWEEN SWITCH ASIA AND THE EUROPEAN UNION

1.e WASTE GENERATION AND MANAGEMENT:

Waste is generated at various production stages, including waste fibres, dye sludge, and chemical waste. The waste is dispersed to CETP channels, recycled through the factory, and transported to a nearby disposal site. There is no end buyer for the waste, as it is not much and the water is recycled. The waste is sold at a rate/unit and there is no dedicated process for recycling.

1.f WORKER HEALTH AND SAFETY:

While Rangotri has 49 workers (46 male and 3 female), Goodwill has 30 (29 male and The workers bring their own food from the home. Basically, they bring 2 rotis, 1 vegetable and 1 dal. So, the risk of wastage is very less. In the factory there is no canteen for the workers but the administration plans to build a canteen in the factory.

II. TEXTILE UNITS IN KOLKATA AND NEARBY LOCATIONS, WEST BENGAL

2. M/S D.S Enterprise
Village and post office – Chatta Kalikapur,
PS- Maheshtala,
Kolkata - 700140
West Bengal.

Introduction: The unit is mainly responsible for jeans washing, dying, and design techniques such as using manual stretching and fading by ironing and colouring using potassium permanganate.

ILLUSTRATION 11: MAP OF M/S D.S. ENTERPRISE

*Edited using google maps and paint

2.a RAW MATERIAL ANALYSIS:

The raw materials transported to the factory are chemicals, dyes, raw cloth materials, water, and thermocol balls. The thermocol balls are used in the dryer machine along with acid dying[6].

ILLUSTRATION 12: THE DRYER MACHINES TO REMOVE MOISTURE FROM ACID WASHED CLOTHES

The chemicals are brought from Bara Bazar since the owner's residence is Bara Bazar, and there are collaborations with dealers there. Bara Bazar is also the unit's wholesale market place. The thermocol balls are sometimes bought from retail shops opposite the factory in emergencies. The raw materials are transported to the factory within a range of 51-100 km on road via private vehicles.

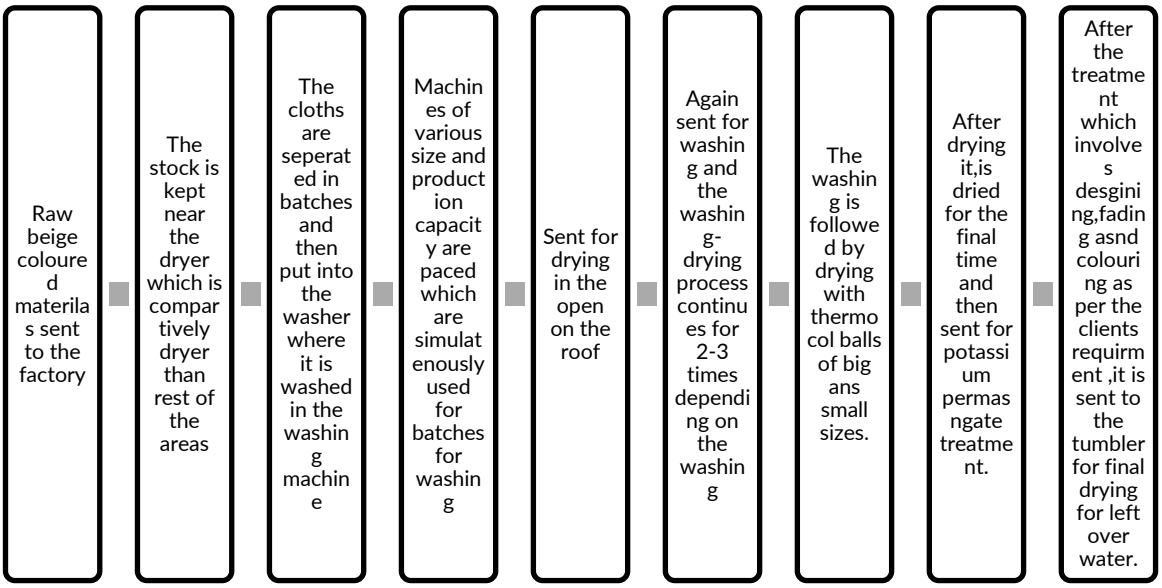
It is an unstructured unit with limited regards to compliance – social, environmental, legal.

2.b PROCESS EVALUATION:

The process of the unit is illustrated below:

[6]https://www.academia.edu/79582069/Investigation_on_Effect_of_Acid_Wash_with_Thermocol_Ball_on_Physical_Properties_of_Knitted_Garments

ILLUSTRATION 13: FLOWCHART OF PROCESS IN M/S D.S. ENTERPRISE (WEST BENGAL)



2.c MACHINE AND PROCESS EVALUATION:

The machinery in use ranges from 6 to 10 years old, undergoing maintenance every six months. According to the unit representative, no machine currently exhibits more than 80-90 percent efficiency. Although they believe that upgrading to better machinery could reduce man-hours and enhance overall efficiency, there is hesitation due to potential disapproval from the owners.

ILLUSTRATION 14: PICTURES OF PROCESS IN M/S D.S. ENTERPRISE (WEST BENGAL)

2.d WATER USAGE AND CONSERVATION:

There is unrestricted extraction of water from the borewell. Since the water is provided by the Municipality free of cost, there is no motivation to look for alternative options such as rainwater harvesting or looking for alternative machines that consume lesser water to give the same production capacity.

The following washing machines require the following amount of water per day. On an average, they are used three times a day.

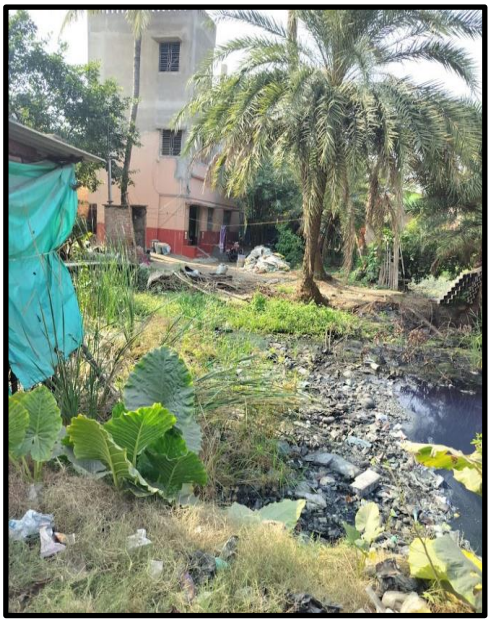
- 150 kg machine (1200 ltr)
- 100 kg machine (700 ltr)
- 75 kg machine (500 ltr)

2.e WASTE GENERATION AND MANAGEMENT:

The current practice at the facility involves releasing untreated water directly into a nearby water body, causing it to take on a bluish hue, rendering it completely unusable.It is reported that generally more than 1500-3000 litres of wastewater are released into the pits as illustrated in pictures below. Small shop owners, situated temporarily above these water bodies, have reported experiencing a nauseating smell. Chemicals from the discharge leach into the soil, percolating down to the aquifers below, posing a threat to both residents and the fauna. The community has accepted that these water sources are unfit for drinking, using them only for purposes other than consumption[7].

A recent study (Gupta, 2019) pointed out that the "water pollutants such as, turbidity, biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), nitrate (NO3) and heavy metals lead (Pb), fluoride (F), and iron (Fe) created from release of effluent are beyond the permissible limits of IS:10500 (India) and WHO (2005)., It threatens human health. The results show the heavy metal pollution index (HMI) of surface water (1050>100) before coming across wastewater, wastewater (1193>100), surface water (1931>100) at the lower end, conditions are critical as HMI crosses the critical limit of 100."[8]

ILLUSTRATION 15: THE ENTIRE COLOUR OF THE CANAL DYED BLUE WITH THE WASTEWATER



[7] https://www.academia.edu/37724212/Environmental_Degradation_Due_to_Jeans_Factories_at_Chatta_Kalikapur_Area_in_Thakurpukur_Maheshtala_Block_of_South_24_Paraganas_West_Bengal

[8] Impact on Surface Water and Human Health Due to Toxic Waste Water Released From Bleaching and Dyeing Units at Maheshtala Textile Cluster, West Bengal, India by Biman Gati Gupta :: SSRN

Waste generated includes wet and dry waste, with plastic drums sold to scrap dealers at a low rate (5-6 rupees per kg) and sorted by a nearby recycler. However, there are challenges in segregating and disposing of dry and wet waste.

Potassium permanganate spraying waste and thermocol ball disposal are unregulated, and the employees dispose wet waste in open drains.

Currently, none of the two vents (air pipes) are working, thus increasing the concentration of chemicals in the air within the factory. This is also creating additional health hazard in the community from the factory pollution.

ILLUSTRATION 16: WASTE WATER FROM M/S D.S. ENTERPRISE

ILLUSTRATION 17: CONTAINERS OF DYES AND CHEMICALS

2.f WORKER HEALTH AND SAFETY:

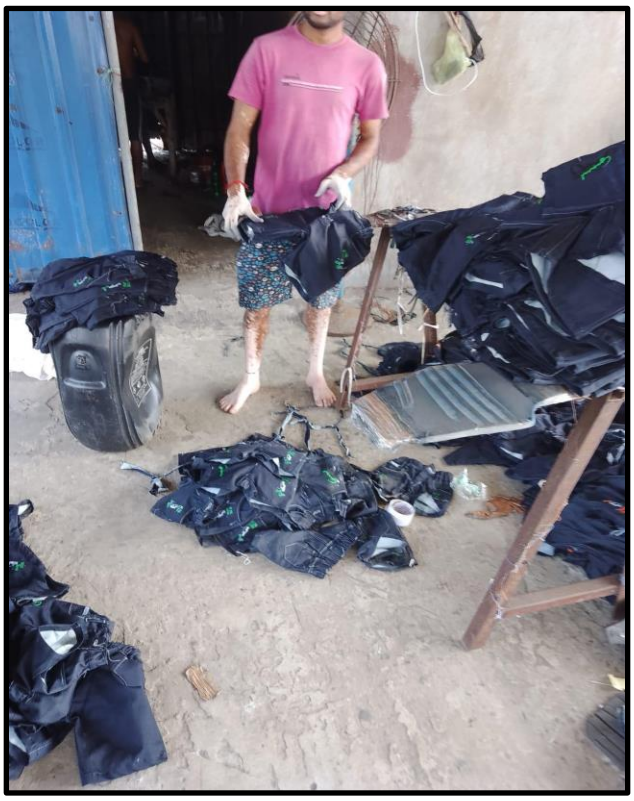
There are 12 permanent workers locally hired from the nearby area, with a male-to-female ratio of 10:2. Females are undervalued under the context of their inability to perform labour-intensive tasks in comparison to their male counterparts. The workers claim to be skilled and trained independently (through observation and on-job learning).

There is a perceptible inattention to health and safety risk of the workers and labourers. Short- and long-term use of degraded water in the ecosystem is concerned with ill-health, premature death, and reduced life expectancy. Remediation through separation, recycling, and conservation of water sources are indispensable to protect Human Health (Gupta, 2019).[9]

There have been no training programs, or capacity-building initiatives provided by the factory or the owner. Moreover, apart from the one-hour lunch break scheduled from 2:00 PM to 3:00 PM, no extra breaks are allotted during the 12-hour shift from 8:00 AM to 8:00 PM

[9] Impact on Surface Water and Human Health Due to Toxic Waste Water Released From Bleaching and Dyeing Units at Maheshtala Textile Cluster, West Bengal, India by Biman Gati Gupta :: SSRN

ILLUSTRATION 18: NO PROTECTIVE EQUIPMENTS IN M/S D.S. ENTERPRISE



3. INTERNATIONAL LEATHER CLOTHIERS
P.O: Koralberia, Bhjerhata,
P.S – K.L.C
South 24 Parganas

International Leather Clothiers is a premier global supplier specializing in knitting, stitching, and manufacturing finished garments, particularly shirts and fire safety wears, for an international clientele.

ILLUSTRATION 19: MAP OF INTERNATIONAL LEATHER CLOTHIERS (WEST BENGAL)

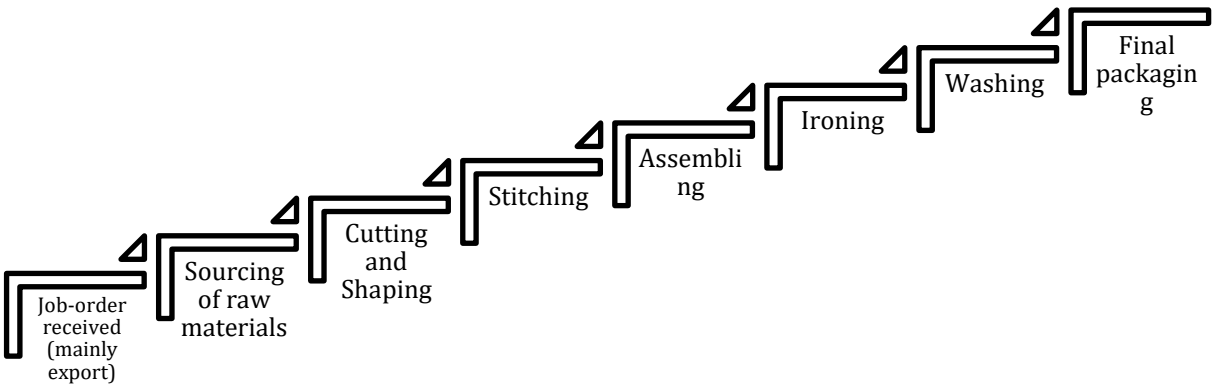
ILLUSTRATION 20: SIGNBOARD OF INTERNATIONAL LEATHER CLOTHIERS (WEST BENGAL)

3.a RAW MATERIAL ANALYSIS:

The raw materials come from Ludhiana, where they get good quality products. The suppliers are approximately 1900 km from the factory. The raw materials are transported by road through private transport.

3.b PROCESS EVALUATION:

ILLUSTRATION 21: FLOWCHART OF PROCESS OF INTERNATIONAL LEATHER CLOTHIERS



The completion of a batch typically takes 1-2 days, with batches usually consisting of 200-300 units, according to the representative. Workers are compensated based on the number of finished units they complete, receiving payment for the specific tasks associated with each unit. Occasionally, the completion of a batch may extend to 2-3 days.

3.c MACHINERY AND EQUIPMENT INSPECTION:

The machine produces 200 units of products in two days or a batch. The production capacity is 52000 units per month.

They pack the final material by hand and wrap the product in a plastic packet. The machines are 4-5 years old. A local contractor services their machine every 6 months.

3.d WATER USAGE AND CONSERVATION:

The water is supplied through the borewells by the Municipality free of cost. However, as per the representatives, there is an ongoing decision with the owner to install a mechanism for rainwater harvesting.

3.e WASTE GENERATION AND MANAGEMENT:

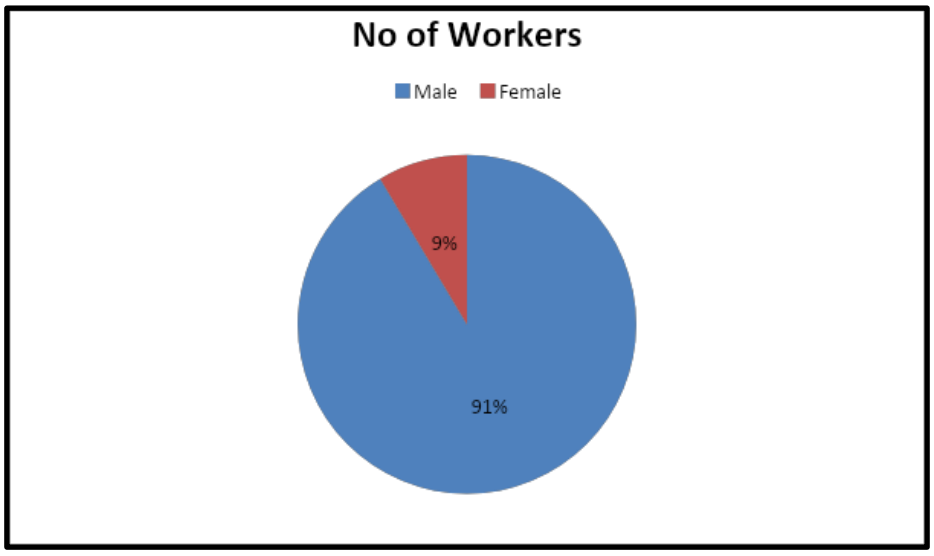
The unit is currently facing issues with proper waste disposal. Food waste, plastic waste, and various miscellaneous waste are being burned at the back of the unit, posing tremendous health hazard. Construction and demolition waste remain to be properly disposed of. Open drainage channels are in place for wastewater flow. Plastic containers, polythene wrappers, and cardboard boxes are either stored for future use or incinerated. There is a lack of frequent visits by waste pickers, and there is hesitancy to dispose of packaging materials. However, representatives mentioned that larger waste cloth pieces, such as cut pieces, are often utilised as raw materials for stitching, particularly in the elbow region. Despite this, nearby rag pickers are willing to purchase these waste cloth pieces at a rate of 5-6 rupees per kilogram.

3.f WORKER HEALTH AND SAFETY:

There are concerns regarding the health and safety of workers, particularly related to issues like back pain. Currently, there is no limit on the number of units workers can handle

per day, and the minimal wage per unit incentivizes them to work longer hours, especially during peak delivery periods. This prolonged and intense work schedule may lead to potential long-term health issues, including problems such as respiratory issues, head related, vision related and other issues.

ILLUSTRATION 22: FLOWCHART OF THE PERCENTAGE OF MALE AND FEMALE WORKERS



Women are undervalued with a notion that they cannot perform labour intensive tasks as efficiently as men. Only 9% of the total work force are women. No canteens are available in the factory. The workers bring their food from their home, they basically bring bhat (rice), dal (pulses), sabji (vegetables). The workers come from nearby villages. The working hours are from 8 am to 9 pm for 6 days/ week (13 hours/ day x 6 days/ week). Sundays are weekly off, in addition to the national holidays.

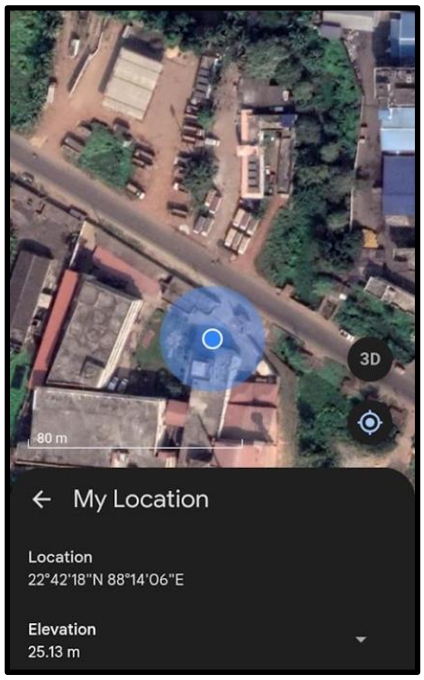
4. SARAT INDUSTRIES LIMITED.

Krishna Ram Pur,
Kalachhara,
West Bengal 712705.

INTRODUCTION:

Sarat Industries Limited engages in the comprehensive process of yarn dyeing, fabric knitting, and processing, which includes dyeing, bleaching, and finishing. They do job order work.

ILLUSTRATION 23: MAP OF SARAT INDUSTRIES PRIVATE LIMITED (WEST BENGAL)



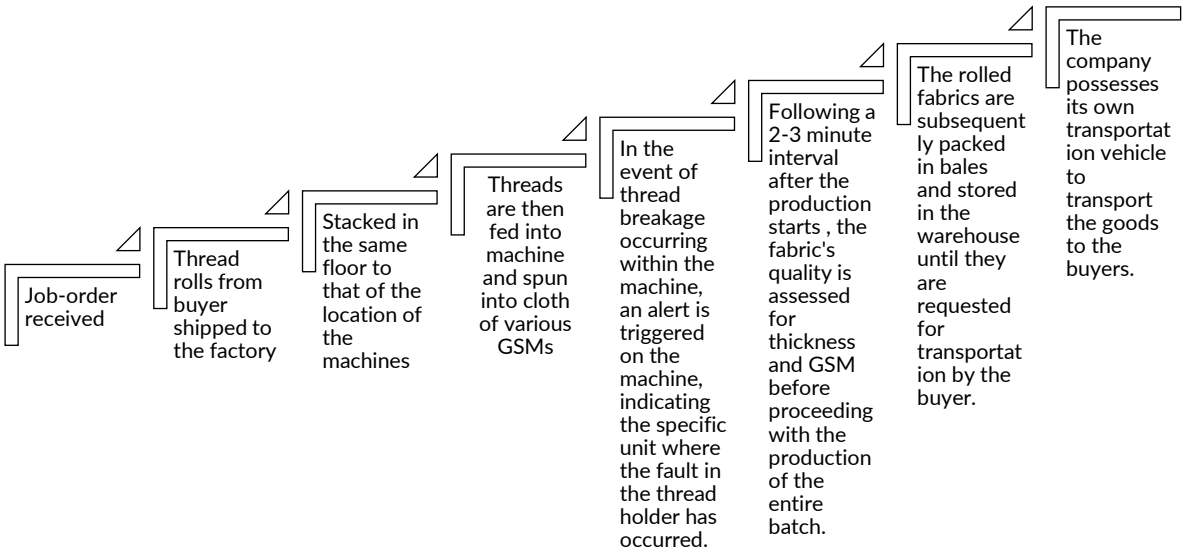
4.a RAW MATERIAL ANALYSIS:

The process starts with the buyer/ customer sending the thread count and the length of the fabric to be spun. The financial transaction is based on how much per kilogram this factory will be able to deliver as per the client's instructions. The threads are pre rolled in a cardboard roll and transported to this factory.

The factory, comprising three floors, houses 12 machines on the top floor for making fabric out of threads of various thicknesses (40/1, 60/1), including a blend of cotton and polyester garments or all-cotton products. Unfortunately, during our visit, we were unable to explore the dyeing process as part of the unit was closed.

4.b PROCESS EVALUATION:

ILLUSTRATION 24: FLOWCHART OF PROCESS IN SARAT INDUSTRIES PVT LTD



Transporting the clothes to the third floor for primary production instead of the second floor poses challenges for fire safety evacuation.

Each machine is assigned a dedicated worker responsible for tasks ranging from thread installation to cleaning and oiling the machines every 15 days. These workers also monitor and assess the efficiency of the machines regularly.

4.c MACHINERY AND EQUIPMENT INSPECTION:

Some of the machines used are sinkers, interlock, rib. The sinkers, which are around 5-6 years old, require individual maintenance and servicing like oiling and blowing air, that are done by the workers themselves. The factory has both updated and outdated machines kept on the factory floor.

ILLUSTRATION 25: PICTURES OF THE MACHINES FOR KNITTING INTO FABRIC ROLLS QUALITY CONTROL

4.d WATER USAGE AND CONSERVATION:

Steam rollers compress the rolled fabrics to remove moisture from the rolled fabrics. The fate of the water in terms of procurement and the disposal is unclear.

ILLUSTRATION 26: PICTURES OF MACHINERIES USED FOR STEAM ROLLING THE WASHED CLOTHES

4.e WASTE GENERATION AND MANAGEMENT:

Regarding waste generation and management, there is ambiguity in wastewater management and proper disposal of "tulo" deposited on top of the machines. Stringent quality control is done to minimise wastage.

ILLUSTRATION 27: COTTON END WASTE DEPOSIT ON THE TOP OF THE MACHINES

Chemical storage containers and unused parts of machinery are present but have not been disposed of yet.

ILLUSTRATION 28: PACKAGING AND WASTE CONTAINERS LYING ON THE UNIT FLOORS

4.f WORKER HEALTH AND SAFETY:

Workers are hired every month, from within a 1-kilometre radius. They carry their own food. They work in 12-hour shifts. The factory provides in-house training for fire safety and risk management.

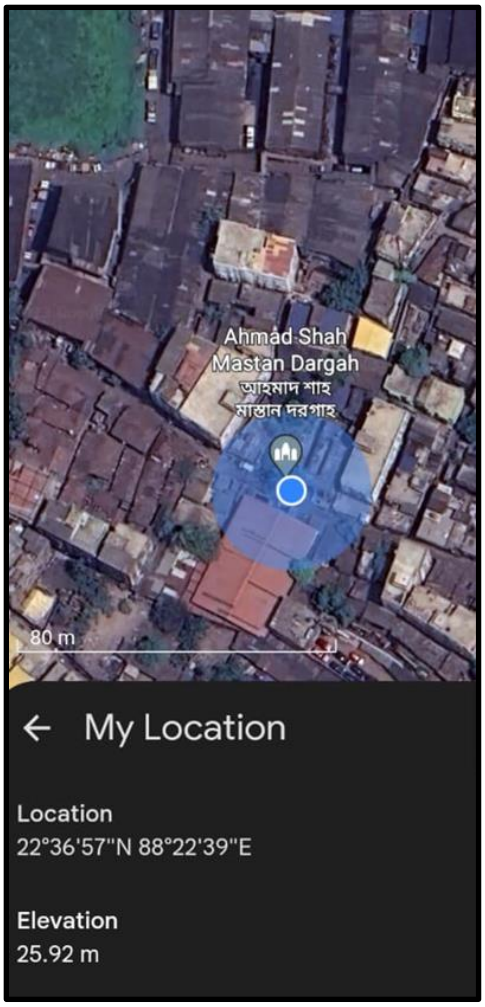
ILLUSTRATION 29: PACKAGING PRODUCTS IN UNIT'S VEHICLE TO BE TRANSPORTED TO THE BUYER

5. G.L.K PRINTERS
East Kolkata Township, Sawdagarh Pally,
Ward Number 6,
Kolkata, West Bengal 700002

INTRODUCTION:

This is a screen-printing unit, where screens are made according to the specifications of the client.

ILLUSTRATION 30: MAP OF G.L.K PRINTERS (WEST BENGAL)



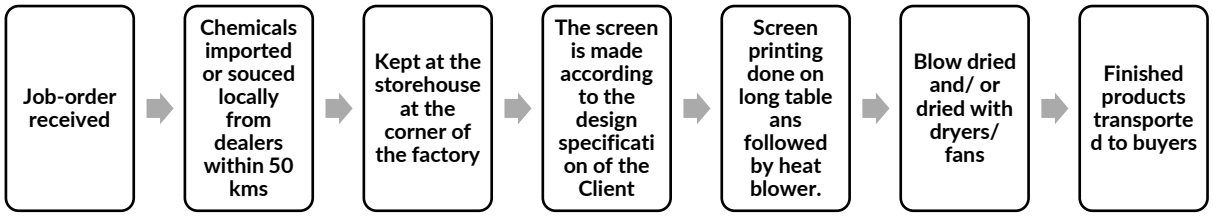
5.a RAW MATERIAL ANALYSIS:

The chemicals are either locally sourced from a long-term dealer located within 50 kms.who are distributors of dyes from international countries like Taiwan or Malaysia from companies such as Sitchechem and Silflex. The location of the dealer delivers the chemicals and the dyes to the factory at their own cost.

The buyer sends the cloth material to be printed to the factory. Frequently, the factory owner personally transports the cloth from the buyer using his own vehicle. However, there are instances when the buyer bears the cost of sending the material at their own expense.

ILLUSTRATION 31: RAW MATERIALS SUCH AS THE CHEMICALS AND DYES ARE IMPORTED SOURCED FROM INTERNATIONAL SUPPLIERS THROUGH LOCAL DEALERS

ILLUSTRATION 32: FLOW CHART OF PROCESS IN G.L.K PRINTERS (WEST BENGAL)



The compressor for the heat dryer is situated near the kitchen near the LPG gas cylinder. There is a potential risk of fire and health safety issue.

5.c MACHINERY AND EQUIPMENT INSPECTION:

The factory has 15-year-old machines that need to be updated. The heat dryers, heat press for design making are comparatively recent purchases that are 5 years old.

ILLUSTRATION 33: MACHINES USED FOR HEAT PRESS

5.d WATER USAGE AND CONSERVATION:

The exact water consumption could not be determined, but it was found that they use the equivalent of 4 times the volume of 16 buckets of water daily. Fresh water from Talla Tank is used for cooking, cleaning, chemical mixing, dye washing and for all work.

ILLUSTRATION 34: CHEMICALS AND WASTEWATER ARE DISPOSED IN THE SAME OUTLET TO THAT OF THE DOMESTIC WATER OUTLET

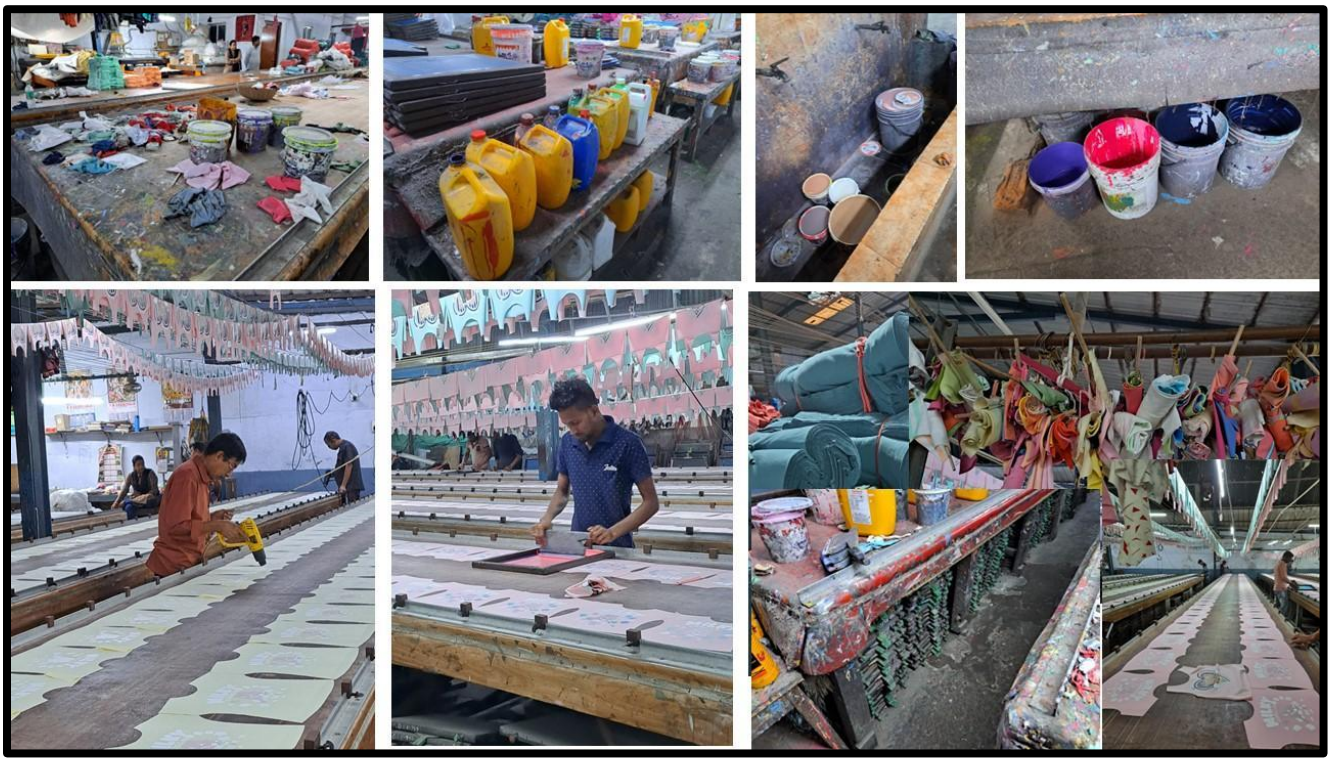
5.e WASTE GENERATION AND MANAGEMENT:

Wastewater, along with kitchen waste, is discharged into the drain. Chemicals are rinsed near the tap from where they are sourced. Small fabric wastes are sold at a nominal rate periodically to Kabaddiwalas.

5.f WORKER HEALTH AND SAFETY:

Workers are required to complete a 16-hour shift while residing in the unit. These workers are contractual, and there have been no reported health and safety issues. However, it has been noticed that there is a lack of protective equipment when workers are engaged in tasks such as spraying steam, handling dyes, or cleaning paints.

ILLUSTRATION 35: VARIOUS WORK PROCESSES IN G.L.K. PRINTERS



FINDINGS, RECOMMENDATIONS AND ACTION POINTS

MACRO FINDINGS:

i) **HUMAN CAPITAL:**

a) ROLE OF LEADERSHIP: Leadership has a tremendous role in providing a clear vision, direction and support for a change process. To be successful, the leadership needs to be aware of their surroundings and the people in them. This includes being aware of the latest trends, technologies and changes in the marketplace.[10]

For example, out of the three units visited in West Bengal, the one visited in Bhojerhat (International Leather Clothiers) had a state-of the art solar-powered energy facility. Solar power is clean energy and helps reduce energy bills. Contrastingly, the Chatta unit (M/S D.S Enterprise) not only used diesel-based energy, but had two of its vents not working, thereby creating a health and hygiene risk among the workers and the community.

b) ROLE OF WORKERS: Both skilled and unskilled workers are employed at the factories – in monthly payrolls or as contractual labour. They work in exploitative conditions. Some of them are as follows:

- Working 12-13 hours for 6 days a week as reported by all the factories surveyed in West Bengal. Additionally, Sundays are dedicated to cleaning the factory floor/ machineries etc. This violates India's Factories Act, which states that no worker should exceed more than 48 hours a week (or 60 hours with overtime), nor should they be made to work for more than nine hours in one day.[11]
- Sleeping on factory floors with chemicals. E.g. The workers of G.L.K Printers (West Bengal) sleep inside the factories amidst chemicals, dyes, fumes.
- There are notable deficiencies in food safety practices, such as at G.L.K Printers and M/S D.S Enterprise (West Bengal), where food is stored near dyes and chemicals, thereby posing potential health hazards, like asthma, attention deficit hyperactivity disorder (ADHD), heart difficulties, cancer, obesity, and others.
- Women are undervalued for their skill sets. All the units except Chatta (M/S D.S Enterprise), West Bengal have a gender ratio of 20%, which is low. Otherwise, the units prefer not to train/ retain/ recruit the women since they have a notion that women cannot compete with labour-intensive work with men.

[10] The Power Of Awareness For Leaders (forbes.com)
[11] Indian factory workers supplying major brands allege routine exploitation - BBC News

ii) MANUFACTURED CAPITAL:

The manufactured capital (distinct from natural physical objects) that is available to an organisation for use in the production of goods or the provision of services depends on the size of the factory. These include:

a) **Buildings:** The types of buildings vary. Some are structured, and guarded like Sarat Industries Pvt Ltd (West Bengal) and Jaipur Integrated Texcraft Park Private Limited (Rajasthan), while others like Chatta (M/S D.S. Enterprise), West Bengal work more like an unstructured, community unit. Due to resistance within the locality regarding compliance officers visiting the sites, there is a noticeable absence of an effective compliance mechanism, leading to inadequate management of wastewater, emissions, and labour-related matters.

b) **Equipment:** To embark on a path toward sustainability, it is imperative to update certain equipment, such as the beam dyeing machine, hank dyeing machine, and warp dyeing machine, to align with the specific requirements of different fibres and yarn types.

c) **Infrastructure:** Waste and water treatment plants are absent in all the factories visited in West Bengal. However, in the Jaipur Integrated Texcraft Park Private Limited (Rajasthan), there is an ETP (Effluent Treatment Plant) commissioned by the European Union which collects and gives back the treated water back to the central reservoir used by the units.

iii) FINANCIAL CAPITAL:

Most of the financial capital available to the organisation for use in producing goods is obtained through operations and, in some cases, through bank loans. Cash flow management is particularly challenging in the garments industry due to the lengthy production cycles and extended credit terms.

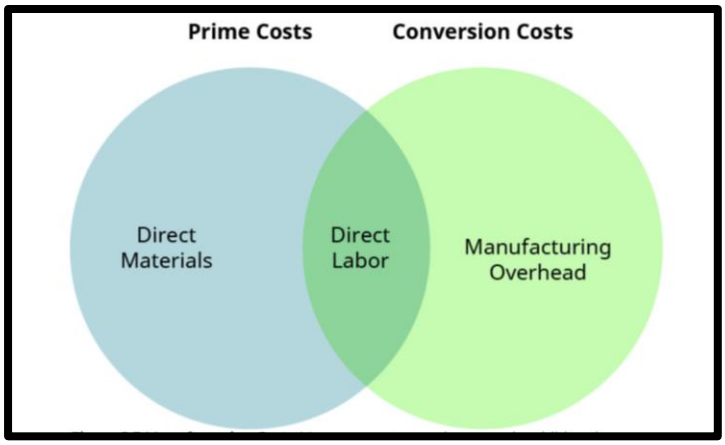


ILLUSTRATION 36: ANALYSIS OF FINANCIAL CAPITAL

Source: 8.1 Job Order v. Process Costing – Financial and Managerial Accounting (unizin.org)

iv) NATURAL CAPITAL:

"Textile production is the world's second most polluting industry second to the oil industry, accounting for approximately 1.2 billion tons of greenhouse gas emissions (more than for international flights and maritime shipping combined) (Change 2018)."[12]

However, our findings show limited awareness of sustainability and using natural capital in the production process. For instance, at Chatta (M/S D.S. Enterprise), West Bengal waste disposal from potassium permanganate spraying and thermocol balls is unregulated. Approximately 12 employees generate wet waste without proper disposal practices. And so is the concept of recycling, reusing. Eg. Water wastage is rampant. The current practice at the Chatta (M/S D.S Enterprise) involves releasing untreated water directly into a nearby water body, causing it to take on a bluish hue, rendering it completely unusable. It is reported that generally, more than 1500-3000 litres of wastewater are released into the pits created nearby[13].

v) SOCIAL AND RELATIONSHIP CAPITAL:

[12] Circular Economy and Sustainability of the Clothing and Textile Industry | Materials Circular Economy (springer.com)

[13] https://www.academia.edu/37724212/Environmental_Degradation_Due_to_Jeans_Factories_at_Chatta_Kalikapur_Area_in_Thakurpukur_Maheshtala_Block_of_South_24_Paraganas_West_Bengal

Social and relationship capital plays an important role

a) **ROLE OF GOVERNMENT:** The government has a very big role to play in regulating, influencing and protecting various aspects of the economy. Eg. The textile industry in Jaipur and nearby places in Rajasthan are either into screen printing or block printing. It was observed that since they were located in an integrated park, it resulted in integration of facilities such as a central reservoir for water extraction, integrated effluent treatment plant to name a few.

   The Indian Government has implemented these Integrated Textile Parks (SITP), Rajasthan as a Scheme to provide the industry with state-of-the-art infrastructure facilities for setting up their textile units. The scheme aims to create new parks of international standards as potential growth centres. Under the scheme 54 textile parks were sanctioned all over India and has so far attracted an investment of Indian Rupees (INR) 142.44 billion and generated direct/indirect employment of 105,709 persons.[14]

   However, the textile units of Kolkata and nearby places in West Bengal visited were fragmented and not governed by integrated parks. Hence lacked cohesion, structure and regulation.

b) **ROLE OF PEERS AND SUPPLY CHAIN STAKEHOLDERS:** The cluster or the ecosystem plays an important role. The price competitiveness among the peers do not help the factories to experiment even if they want to. Additionally, the factories are dedicated to their long-term suppliers, who have still not shifted towards sustainable or natural production processes. For example, the units at Chatta (M/S D.S. Enterprise) in Kolkata (West Bengal) procure their chemicals and dyes from Bara Bazar. In contrast, International Leather Clothiers import their raw materials from Ludhiana.

c) **ROLE OF CUSTOMERS:** The Customer pull and push is of utmost importance to the MSMEs. There is a distinction between international clients and local clients. For instance, in contrast to International Leather Clothiers (West Bengal) and Rangotri (Rajasthan), which predominantly cater to international buyers, the efforts of the other factories toward adhering to green standards appear to be either non-existent or more of a greenwashing strategy.

[14] pib.gov.in/PressReleaseIframePage.aspx?PRID=1945172

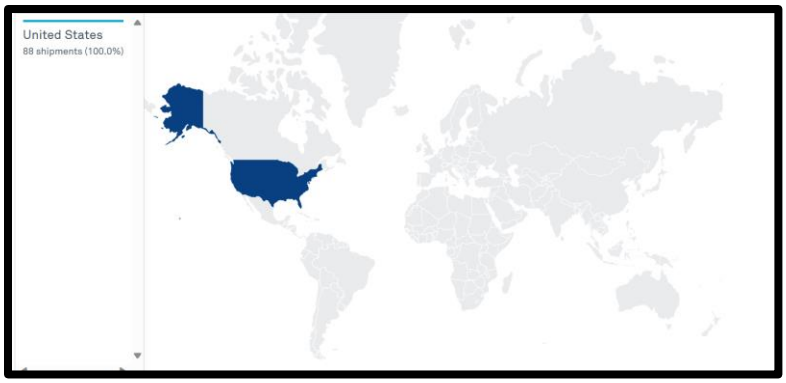


ILLUSTRATION 37: EXPORT MARKET OF INTERNATIONAL LEATHER CLOTHIERS

Source: Intl Leather Clothiers, 71, Topsia Rd, Topsia, Kolkata, West Bengal 700046, India | Supplier Report — Panjiva

For example, International Leather Clothiers (West Bengal) caters to the export market and hence comply to some of the international regulations. On the other hand, Chatta (M/S D.S. Enterprise) in Kolkata (West Bengal) sells at the wholesale market in Mangala Haat in Howrah (West Bengal), and as a result there is complete breakdown of any visible regulatory practices.

vi) INTELLECTUAL CAPITAL:

Intellectual capital refers to the organisational, knowledge-based intangibles.

a) Limited knowledge, understanding and application of intellectual property, such as patents, copyrights, software, rights and licences. Eg. Although there are licence to establish, licence to operate in units in Rangotri and Goodwill Design Craft Private Limited (Rajasthan), there is no such statements by units in Kolkata (West Bengal) except for International Leather Clothiers.

b) Limited knowledge and understanding of 'Organisational capital' such as tacit knowledge, systems, procedures and protocols. No Standard Operating Procedures (SOPs) observed in some of the units in Kolkata, West Bengal.

c) Unstructured and informal intangibles associated with the brand and reputation of the organisation. For example, most of these units do job-work and as a result, do not have a recognisable brand of its own, except the ones catering to the international market.

RECOMMENDATIONS

These are indicative and not comprehensive.

RECOMMENDATION AS PER THE FOLLOWING VARIABLES:

a) RAW MATERIAL, PROCESS AND PRODUCTION:

The unit owners prefer to purchase dyes from close associates or opt for those available at a low cost, irrespective of their sustainability metrics. The lack of interest in acquiring sustainable dyes stems from customer demand of low-cost products. This means the unit owners do not prioritise sustainability or responsible sourcing.

Below are some sustainable dye options readily available in the market. It is imperative to provide proper training to the owners to encourage the adoption of such sustainable dyes. This not only safeguards the environment but also protects the company from potential shutdowns in the future due to increased scrutiny and compliance orders related to environmental standards.

Colour pallete used in alternation to the main colour

Table 4. Examples of dyes obtained from plants.

Origin	Plant	Scientific Name	Color	Source
Bark	Onion	*Allium cepa*	Brown	[20]
Flower	Lavender	*Lavandula* sp.	Grey	[45]
Leaf	Eucalyptus	*Eucalyptus* sp.	Brown/yellow	[45]
	Spinach	*Spinacea oleracea*	Green	[45]
	Thyme Bela Luz	*Thymus mastichina*	Yellow	[45]
	Pepper mint	*Mentha piperita*	Green	[45]
	Artichoke	*Cynara scolymus*	Green	[45]
	Boldo	*Peumus boldus*	Pink	[45]
	Blueberry	*Vaccinium myrtillus*	Purple/blue	[45]
	Green tea	*Camellia sinensis*	Brown	[45]
Rhizome	Saffron	*Curcuma longa*	Brown/red	[20]
Seed	Urucum	*Bixa orellana* L.	Orange/red	[20]
	Coffee	*Coffea arabica*	Brown	[20]

Table 5. Examples of dyes obtained from bacteria, mushrooms, and fungi.

Microbes	Name	Color	Source
Bacteria	*Chryseobacterium shigense*	Yellow	[47]
	Pseudomonas sp.	Brown	[47]
	Serratia plymuthica	Pink	[47]
	Vibrio sp.	Red	[48]
	Serratia marcescens	Red	[49]
	Chromobacterium violaceum	Violet	[50]
	Serratia marcescens	Red	[51]
	Escherichia coli	Blue	[47]
	Rugamonas rubra	Red	[50]
Mushrooms	*Sarcodon imbricatus*	Blue/green	[47]
	Hydnellum peckii	Beige/blue	[47]
	Cortinarius semisanguineus	Red/orange	[47]
	Phaeolus shcweinitzii	Green	[47]
	Pisolithus tinctorius	Brown	[47]
Fungi	*Fusarium oxysporum*	Pink/purple	[52]
	Monascus purpureus	Red	[52]
	Emericellanidulans	Red/brown	[52]
	Fusariumverticillioides	Red	[52]

[15]

Given the substantial demand for water, there is a pressing need to consider a more sustainable approach to the production process. Below are some proposed changes in the

[15] file:///C:/Users/susta/Downloads/sustainability-14-08353-v2.pdf

existing process. While implementing these changes would necessitate an investment in new machinery, the long-term benefits are particularly advantageous for regions facing water scarcity or where water has to be purchased. This strategic shift has the potential to significantly reduce the overall production costs over time.

Technology	Description
Plasma	This treatment promotes surface modification of polymeric/textile substrates, improves hydrophilic properties (chemical changes) and increases the surface properties (physical changes) of fibers/textile substrates. This surface modification increases the dyeability of the fiber and is an effluent-free and environmentally friendly process [56]. There are several benefits in applying plasma technology that are vital for sustainability, such as reducing the use of water, chemicals, and energy (compared with the conventional wet method), minimal consumption of chemicals, and no required drying process [57,58].
Supercritical CO_2	Supercritical carbon dioxide dyeing is a revolutionary and attractive ecological alternative to conventional wet methods in the textile industry [39]. The supercritical CO_2 process involves using less energy than conventional processes. The principle of the process is based on heating carbon dioxide (CO_2) above 31 °C, pressurized above 74 bar, where it becomes supercritical, a state of matter that is an expanded liquid or a strongly compressed gas [1,59]. For supercritical carbon dioxide dyeing, the CO_2 is heated to 120 °C and pressurized at 250 bar; the CO_2 penetrates the fibers, thus acting as a swelling agent during dyeing, i.e., increasing the diffusion of dyes in the fibers [59].
AirDye®	AirDye® technology is a sustainable solution for printing and dyeing. AirDye® uses the process of sublimation, i.e., transferring inks to fabrics using transfer paper combined with heat and pressure. All used paper is recycled, and the dyes are inert, which means they can return to their original state and be reused. Therefore, the AirDye® process has no harmful byproducts, which provides a significant reduction in energy and costs, as there is no need for screens, boilers, dryers, or chemicals [60]. The process uses up to 95% less water and up to 86% less energy, and reduces emissions by 84%, compared with conventional dyeing methods [60].
Ultrasonic	Dyeing with ultrasound technology causes dispersion, degassing, and acceleration of the diffusion rate of the dye or finishing chemicals inside the fiber [61]. In this process, the dispersion of dye molecules occurs individually, increasing the activation energy of the molecules and causing a rapid diffusion within the fiber structure to increase the dyeing rate [62]. The ultrasonic process can be applied in almost all preparatory wet processing operations, such as desizing, scouring, bleaching, and washing [63].

Sustainability **2022**, *14*, 8353 12 of 17

Table 6. *Cont.*

Technology	Description
Microwave	The microwave frequencies are between the radio wave bands and the infrared radiation of the electromagnetic spectrum, corresponding to the frequency band between 300 MHz to 300 GHz with a wavelength of 1 m to 1 mm (MAITI). Microwave technology offers uniform, rapid, and effective heating, which increases the dye molecules' diffusion in the polymers, resulting in a high exhaustion rate, high dye diffusion, and excellent color fastness properties [64–66].
Nano-dye™	The dyeing process called Nano-Dye, which is a continuous dyeing system in which reactive dye molecules are kept in individual nano stages to incorporate to cellulose, has the following advantages compared with the conventional dyeing process: no salt, use of up to 75% less water, use of up to 75% less energy, and up to 97% exhaustion [67]. The studies carried out by Nano-Dye Technologies Inc demonstrate that the indirect electrochemical reduction dyeing method with indigo dye has a low economic cost and excellent cyclical performance, which can significantly contribute to increasing the sustainability of dyeing in the production of denim [67].
Electrochemical	Electrochemical dyeing is an efficient process for the reduction and oxidation of vat and sulfur dyes, which are normally used for cellulosic fibers [5]. The studies carried out by Li et al. [68] demonstrated that the indirect electrochemical reduction dyeing method with indigo dye has a low economic cost and excellent cyclical performance, which can significantly contribute to increasing the sustainability of dyeing in the production of denim.

[16]

b) PROCESS EVALUATION:

The process in most of the units needs to utilise the empty spaces more and dumping of the empty dying containers. Although there is a recycler in most of the cases that they sell

[16] file:///C:/Users/susta/Downloads/sustainability-14-08353-v2.pdf

off to, there is still a need to maintain hygiene and maintenance of the floors to avoid risk. There is a need to build SoPs (Standard Operating Procedures).

c) MACHINERY AND EQUIPMENT INSPECTION:

There is normal maintenance of the machines in units of Kolkata since there are also issues with the moisture in the air causing corrosion. At the same time, in Jaipur, the maintenance is usually done during the holidays like Diwali. It is recommended for monthly maintenance in units like Jaipur while there is a requirement for the machines in Kolkata to keep corrosion prone instruments near designed rooms with ventilation on opposite sides of the wind flow.

d) WATER USAGE AND CONSERVATION:

The water in all the units is sourced locally, with the Jaipur units procuring water from the borewell and the central reservoir being integrated into a textile park. However, rainwater harvesting is not used except for Rangotri, which claims to have an underground storage for the rainwater. Similarly, the International Leather Clothiers in West Bengal are discussing rainwater harvesting setups. However, there should be voluntary planning to understand the catchment area.

e) WORKER HEALTH AND SAFETY:

There is an issue with the worker's safety with limited use of protective equipment while handling chemicals and dyes. Women are undervalued in a male dominated manufacturing industry. Training them in block prints or in the role of operators is recommended.

f) WASTE GENERATION AND MANAGEMENT:

There is a persistent challenge in managing wastewater and food disposal. It was noted that textile units in Rajasthan have integrated Effluent Treatment Plants (ETP), while units in Kolkata lack this infrastructure due to their fragmented nature and lack of centralized management. However, even in Rajasthan units, there were issues with waste management, such as the segregation of wet and dry waste. Comprehensive training on proper waste management is essential to address these challenges effectively. Leaching and ground water contamination is a challenge in these areas.

UNIT WISE RECOMMENDATIONS:

These are indicative and not comprehensive

1. RANGOTRI (RAJASTHAN)

Protective equipment is mandatory during two specific phases of the process. Firstly, individuals should wear protective gear before entering the water when handling the dried material post-acid wash, which is soaked in chemical water and manually beaten to achieve the desired colour. Similarly, when workers are placing the processed cloth on the table for block printing, prolonged use of the lower palm to press the blocks can result in issues with the palm bones, causing pain. Consequently, providing protective equipment to these workers is strongly recommended to prevent permanent damage to the palm bones.

2. GOODWILL ENTERPRISE (RAJASTHAN)

A significant concern has been identified with the condition of the floors where the machinery is operational. The floors are sticky due to a lack of cleaning, and the machinery is dangerously close to each other. This poses a severe risk of injury. The recommended course of action is to train the workers to reorganize and position the machinery at a safe distance from each other. This becomes particularly crucial given the presence of numerous unused spaces[17].

3. M/S D.S ENTERPRISE (WEST BENGAL)

The overall environment for workers and the surrounding area is compromised due to an unstructured environment. Immediate actions are required, starting with comprehensive training for managers and workers. Investing in safety masks for workers spraying potassium permanganate and other hard chemicals and dyes is crucial to ensure their protection. Moreover, there is a potential risk of food contamination because of the proximity of open-cut vegetables to chemical dyes. To address this concern, it is recommended to implement a warm water treatment process before discharging water into drains without treatment. Also, proper chemical disposal methods should be enforced,

[17] https://www.ilo.org/global/topics/labour-administration-inspection/resources-library/publications/guide-for-labour-inspectors/how-can-osh-be-managed/lang--en/index.htm

and thermocol balls in water should be prohibited to minimise environmental impact[18]. The working hours of the workers should be regulated to create a conducive environment.

Effective waste segregation, regulated pesticide waste disposal, and proper procedures for employee-generated wet waste are essential to address this. Exploring sustainable water discharge and waste management options is also crucial. The working hours of the workers should be regulated to create a conducive environment.

4. INTERNATIONAL LEATHER CLOTHIERS (WEST BENGAL)

Despite the unit making strides in sustainability, it has been noted that there is a need to implement rainwater harvesting. A thorough assessment of the catchment area is essential for this purpose. Additionally, the absence of a waste disposal mechanism is evident, and there is a specific need to remove construction and demolition (C&D) waste from the site. The working hours of the workers should be regulated to create a conducive environment.

5. SARAT INDUSTRIES (WEST BENGAL)

There is a need to consider the reallocation of floors to optimise energy usage, as a significant amount is currently wasted in transporting materials to the top floor. Also, effective waste management protocols are required to dispose of plastic drums, packing materials, and leftover parts from the machinery. The working hours of the workers should be regulated to create a conducive environment.

6. G.L.K PRINTERS (WEST BENGAL)

The air compressor responsible for supplying air to the heat dryer is located near cooking gas cylinders in the kitchen, creating a potential fire hazard, especially given its proximity to the kitchen area. Additionally, there are concerns about waste management, as kitchen waste and chemicals are being disposed of directly into drains within a confined and congested space. Worker residencies should be segregated from the factory floor area to create lesser health hazard. The working hours of the workers should be regulated to create a conducive environment.

18 https://www.academia.edu/37724212/Environmental_Degradation_Due_to_Jeans_Factories_at_Chatta_Kalikapur_Area_in_Thakurpukur_Maheshtala_Block_of_South_24_Paraganas_West_Bengal

ACTION PLAN

These are indicative and not comprehensive

a) RAW MATERIAL ANALYSIS

- Awareness regarding more sustainable/ responsible sourcing of raw materials.
- Water consumption needs to be measured and controlled
- Collaboration with suppliers who prioritize sustainability and ethical practices need to be established.
- Periodic regular audits to ensure suppliers adhere to environmental and labor standards.
- Facilitate on building more transparent and sustainable supply chains.
- Minimize waste generation at the source by optimizing production processes and reducing material waste during cutting and sewing.
- Adopt water-efficient practices and technologies to help reduce the environmental impact and can lead to cost savings for manufacturers.

b) PROCESS EVALUATION

- Creation of SOPs
- Regular cleanliness of factory floors is necessary to remove grease, chemicals, and oils on the floors to avoid accidents.
- Organize sessions on waste identification and proper disposal methods to minimize unit waste.
- Ensure that all machinery and equipment meet regulatory and safety standards.
- Keep abreast of any changes in regulations that may affect manufacturing processes.
- Implement eco-friendly practices, such as reducing energy consumption and waste generation, to align with sustainability goals and reduce the environmental impact of production.

c) MACHINERY AND EQUIPMENT INSPECTION

- Maintain detailed records of maintenance activities, inspections, and repairs. This documentation can help track the history of each machine and identify recurring issues.

d) WATER USAGE AND CONSERVATION

- Explore sustainable dyeing methods that use less water.
- Employ innovative dyeing technologies that enable precise colour control, reducing the number of dyeing cycles required.
- Adopt waterless or low-water finishing techniques, such as laser etching, ozone treatment, and air drying, to reduce water consumption in the final stages of jeans production.
- Replace traditional stone washing methods with environmentally friendly alternatives like cellulase enzyme washing.
- Invest in modern, water-efficient equipment to minimize water usage and optimize production processes.
- Consider machinery incorporating closed-loop systems, which recirculate and filter water for reuse.
- Implement and consider closed-loop dying systems that recirculate and filter dye baths, reducing the water required for indigo dying.
- Implement water usage monitoring systems to track water consumption at various stages of denim manufacturing.
- Use data and analytics to identify areas where water consumption can be reduced and efficiency improved.
- Implement water recycling systems within the denim manufacturing facility to treat and reuse water from various processes.
- Invest in advanced wastewater treatment technologies to purify water for reuse, thereby reducing the need for freshwater intake.
- Consider closed-loop dyeing systems that recirculate and filter dye baths, reducing the amount of water required for indigo dyeing.
- Explore sustainable dyeing methods that use less water. One such method is foam dyeing, which reduces water consumption by eliminating the need for large water baths.

e) WASTE GENERATION AND MANAGEMENT

- Minimize waste generation at the source by optimizing production processes and reducing material waste during cutting and sewing.
- Establish a system for recycling and reusing cotton and denim scraps, converting them into new fabrics, or using them in other products like insulation or cleaning cloths.

- Implement best practices for chemical management, including reducing the use of hazardous chemicals, properly storing chemicals, and ensuring safe disposal.
- Invest in wastewater treatment facilities to treat and purify water discharged from dyeing and finishing processes before it enters the environment.
- Invest in machinery that minimizes material waste during production and adopts eco-friendly processes like laser cutting and ozone treatment to reduce chemical and water use.
- Adopt lean manufacturing principles to reduce unnecessary steps, optimize processes, and minimize waste throughout the production cycle.
- Collaborate with suppliers who prioritize sustainability and waste reduction in their manufacturing processes.
- Reduce packaging waste by using eco-friendly materials, minimizing excess packaging, and exploring alternatives like reusable packaging.
- Train employees on waste reduction and proper waste handling practices to ensure everyone is actively engaged in minimizing waste.
- Ensure compliance with local, national, and international environmental regulations related to waste management.
- Maintain accurate records and reporting on waste generation and disposal to track progress and identify areas for improvement.
- Explore circular economy models, such as take-back programs and recycling initiatives for old jeans, to extend the product lifecycle and reduce waste.
- Communicate waste reduction efforts and progress to consumers and stakeholders to build trust and support for sustainable practices.

f) WORKER HEALTH AND SAFETY

- Conduct a thorough risk assessment of all processes within the manufacturing facility to identify potential hazards.
- Evaluate the risks associated with tasks such as cutting, sewing, dyeing, finishing, and handling chemicals.
- Provide comprehensive training to all employees on safe work practices, equipment operation, and emergency procedures.
- Ensure that workers are aware of the potential risks associated with their tasks and how to mitigate them.
- Offer regular refresher courses to keep employees informed about the latest safety protocols.
- Supply appropriate PPE, such as gloves, safety goggles, respirators, ear protection, and protective clothing, depending on the tasks and hazards involved.
- Ensure that workers wear PPE consistently and correctly.
- Regularly inspect and maintain PPE to ensure its effectiveness.

- Implement proper ventilation systems in areas where chemicals are used or where dust and particulate matter are generated.
- Monitor and maintain good indoor air quality to protect workers from exposure to harmful fumes, dust, and chemicals.
- Install safety guards and devices on machinery to prevent accidental contact with moving parts.
- Conduct regular inspections and maintenance of machines to ensure they are in safe working condition.
- Train operators to follow safe procedures when operating machines.
- Store chemicals in designated areas with proper labeling and safety data sheets (SDS).
- Train employees on the safe handling, storage, and disposal of chemicals.
- Provide eyewash stations, emergency showers, and spill containment kits in areas where chemicals are used.
- Install and maintain fire detection and suppression systems.
- Conduct fire drills and ensure all workers know evacuation routes and assembly points.
- Keep fire extinguishers accessible and regularly serviced.
- Develop and regularly review emergency response plans for scenarios such as fires, chemical spills, and accidents.
- Provide training on first aid and establish a dedicated response team.
- Maintain well-stocked first-aid kits and emergency supplies.
- Promote worker health and well-being through programs that address physical and mental health issues.
- Encourage regular health check-ups and access to healthcare services for employees.
- Encourage open communication and feedback from workers regarding safety concerns and potential improvements.
- Establish safety committees or representatives to facilitate worker involvement in safety initiatives.
- Ensure compliance with local, national, and international labor and safety regulations.
- Stay informed about changes in regulations and adapt policies and procedures accordingly.
- Regularly review and update safety protocols and procedures based on incident reports, near misses, and industry best practices.
- Foster a culture of continuous improvement and safety awareness.

ANNEXURE

ANNEXURE 1

SEMI-STRUCTURED QUESTIONNAIRE:

production chain (scope for productivity enhancement without any additional energy/water consumption),

RAW MATERIAL ANALYSIS:

Examine the quality and sourcing of raw materials used in the production process, such as fibres, yarns, dyes, chemicals, and auxiliaries. Evaluate their compliance with quality

standards and environmental regulations.

1. What are the raw materials used?
2. Where do you source your raw materials from for each of the items?
   - Locally
   - Regionally
   - Outside the state
   - Import
   - Any other (please specify)
3. Please mention the exact location.
4. What would be the approximate distance (if possible) of the supplier?
   - Less than 50 kms.
   - 51-100 kms.
   - 101 – 200 kms.
   - 201 – 500 kms.
   - 501 – 1000 kms.
   - More than 1000 kms.
5. How are the raw materials transported?
   - Public road transport
   - Private road transport
   - By air
   - Combination
   - Any other (please specify)

(try and capture mode of transportation)

6. Why do you source the raw materials from here?
7. Are the raw materials sourced sustainable?
   - Yes
   - No

8. If yes, how?
9. Do you monitor suppliers for adherence to sustainability practices?
    - Yes
    - No
10. Do you monitor suppliers for quality standards?
    - Yes
    - No
11. How do you continuously assess and evaluate the quality and consistency of raw materials from different suppliers?
12. What compliance do you look into while purchasing the raw materials?
    - Any standards?
    - Environmental regulations?
13. How do **you** ensure compliance with industry standards for safety, quality, and sustainability?

PROCESS EVALUATION:

Analyse the entire production process, from pre-processing (cleaning, blending, and carding) to spinning, weaving, knitting, dyeing, printing, finishing, and packaging. Assess the efficiency, quality control measures, and waste generation at each stage.

1. What is your production process?

Please document the entire macro process (from when the raw material enters the factory to leaving the factory)

2. Please document every minute function in each of the stages.
3. Please document the machineries used (make/ year of purchase etc.) for each function in each of the stages.
4. Please document the human resources used including manhours per action.
5. What is the time taken to complete production of a unit item from scratch?
6. What is the time taken to complete a batch?
7. What is the normal size of the batch?
8. What is the production capacity of each of the machinery per day?
9. How much is produced per day in real life?
10. Is there any discrepancy?
11. If yes, why?
12. How do you pack the final material?
    - By hand
    - By machine

- Any other (please specify)

13. What are the different packing materials used for the finished products?
14. Do you consider your packaging sustainable?
    - Yes
    - No
    - Don't know
15. If yes, why?
16. How do you deliver?
    - Public road transportation
    - Private road transportation
    - Air
    - Combination
    - Any other (please specify)

MACHINERY AND EQUIPMENT INSPECTION:

Evaluate the condition, performance, and efficiency of textile machinery and equipment, including looms, knitting machines, dyeing machines, printing machines, and finishing equipment. Identify any outdated or inefficient equipment that may impact quality or productivity.

1. How old are your machines/ equipment?

- Less than 1 years
- 1 – 5 years
- 6-10 years
- 11- 15 years
- 16 – 20 years
- More than 21 years

2. Are they working in full efficiency?

- Yes
- No
- Don't know

3. How do you maintain the machines/ equipment?

- Yourself
- Annual Maintenance Contract from Suppliers
- Local contractors
- Others (please specify)

4. What is the frequency of maintenance?

- Once every month
- Once every 3 months
- Once every 6 months
- Once every 7 months – 1 years

- Once every 1- 2 years
- Others (please specify)

5. Do you have any outdated/inefficient machine/ equipment that may impact quality/productivity?

- Yes
- No
- Don't know

6. If yes, why?
7. Do you have any machinery/ equipment that may need replacement?

- Yes
- No
- Don't know

8. If yes, why?

WATER USAGE AND CONSERVATION:

Examine water consumption in different processes and recommend water-saving measures. Assess the effectiveness of water treatment and recycling systems.

1. How much water is used in each of the stages of production?
2. Can you reduce the usage in any way?
   - Yes
   - No
   - Don't know
3. If yes, how?
4. Are you conscious of any other water-saving methods that can be used in your production process?
5. If yes, what?
6. What do you do with waste water?
7. Have you ever recycled waste water for production?
8. If yes, how?
9. If yes, since when?
10. If yes, are you satisfied?

WASTE GENERATION AND MANAGEMENT:

Analyse waste generation at various production stages, such as waste fibres, dye sludge, and chemical waste. Propose strategies for waste reduction, recycling, and proper disposal.

1. What kind of wastage happens at each production process? Please mention each item and how much approx.

Sl. No.	Name of Stage	Wastage	
		Kind	How much (please mention unit)

2. What do you do with the waste?
- Dispose as it is
- Sell
- Reuse/ Recycle
- Others (please specify)
3. Is there any end buyer to any of the wastes generated/collected?
4. What is the rate/ unit at which the waste is sold?
5. Do you have a dedicated process to recycle the waste?
- Yes
- No
6. If yes, what?
7. If no, why?

WORKER HEALTH AND SAFETY:

Review occupational health and safety practices to ensure that workers are operating in a safe and healthy environment. Identify potential hazards and recommend measures for improvement. (Comprehensive Occupational Health and Safety (OSH) Workplace Risk Assessment Questionnaire - NimonikApp.com)

1. How many people work in your plant?
2. How many people work full time and how many contractual?
3. What is the gender ratio in the plant?
4. What are the working Hours and Holidays?

5. Have you identified manual tasks that may cause injury?
6. Have manual task risk assessments been adequately conducted?
7. Have all reported manual tasks, incidents, injuries and hazards been adequately investigated?
8. Have outcomes of investigations (if any) been reported to the person who raised the hazard within a reasonable timeframe?
9. Are control measures to reduce the risk of injuries reviewed after accidents have occurred?
10. Have control measures been put in place and maintained to eliminate or reduce the risks associated with hazardous manual tasks as far as possible?
11. Have people involved in organising, implementing and performing manual tasks been provided with adequate instruction and training?
12. Have workers who perform hazardous manual tasks received task-specific training during induction, and when their work tasks change?
13. Are workers aware of procedures for reporting hazardous manual tasks?
14. Have workers been asked for suggestions on safer ways to complete manual tasks?
15. Have equipment, layout and work organisation been considered to minimise the risk of injury from performing manual tasks?
16. Have lifting or carrying heavy loads been eliminated or minimised by changing systems (eg mechanisation) or using different equipment (eg mechanical lifts and trolleys)?
17. Has it been ensured that items that are heavy or frequently accessed are not placed above shoulder height or below mid-thigh height?
18. Is adequate space provided for areas where manual tasks are performed?
19. Are jobs and tasks organised so that workers have adequate breaks from sustained postures, repetitive movement and manual handling?

Intellectual Capital:

1. Have you filed any patents?
2. If yes, please provide details.
3. Is there any annual budget allocated for Research and Development (R&D)?
4. If yes, how much?

5. Have you conducted any R&D in recent times?
6. If yes, on what? If not, why?

1. Have you developed any new Products:
   - Yes
   - No
   - Don't Know

2. If yes, how long back?
   - 0-3 years
   - 4- 6 years
   - 7-9 years
   - More than 10 years

3. If yes, what were they?
4. Why was it necessary?
5. Are these sustainable products?
   - Yes
   - No
6. If yes, how?

- Expenditure on Organisational Change/Process Development:

.What is the expenditure on organisational change or process development within the textile manufacturing unit?
.How have these changes positively impacted efficiency or sustainability?

- Expenditure on Software Development for Internal Systems:

.How much has been spent on developing or upgrading internal software systems for the textile manufacturing process?
.What specific improvements or innovations have been introduced through these software developments?

- Sales Generated by R&D Derived Products:

.Can you quantify the sales generated specifically by-products derived from R&D initiatives?
.How are these sales contributing to the company's overall revenue?

General Questions:

.How does the company encourage and support innovation within the organisation?
.Are there dedicated teams or departments focused on research and innovation?
.How does the company stay informed about new technologies and trends in the textile industry?
.Is there a process for regularly evaluating and updating manufacturing processes to align with industry advancements?
.How is feedback from R&D initiatives incorporated into the production and marketing strategies?

Social and relationship capital

.How would you describe the work culture in your organisation? (Workers)
.Is there any Whistle blowing policy?
.Gender ratio in your organisation/company?
.Thoughts on making your organisation's workplace and the community strong.
.Are there policies to promote diversity and inclusion within the workforce?
.Are there team-building activities that you would like to implement for the betterment of the workplace?
.Do you think there should be any improvement in the relationship among the workers?
.Do you believe that the lack of ethical practices in the factory affects its ability to engage employees in social initiatives?
.Is there a system to monitor business practices for potential anti-competitive behaviour?
.Is there a documented process for quality assurance during production?
.What measures can an organisation take to enhance transparency and reduce corruption?

.Have your company faced any difficulties which resulted in lawsuits? Whether it has been resolved or not.
.How are customer feedback and returns used to enhance product/service quality?
.Have you encountered anomalies
.The company took measures to address human rights and labour practices grievances.
.Do you think your company should publicly discuss its existing lawsuits?
.Are the internal control systems' record-keeping practices subjected to regular review and audit? What comes to your mind about the company's social responsibility initiatives?
.How does the company's involvement in social projects influence customers' perception of its overall brand?

.Social Investment money spent on philanthropy?

Financial management

.How much financial capital is allocated to purchase machinery, equipment, and technology upgrades?

.What is the annual budget for maintaining and upgrading the factory infrastructure?

What are the ongoing expenses, and how are they managed to optimise efficiency?

III. What measures are in place to assess the return investment of capital investments made in the factory? How is the profitability being evaluated?

III. What strategies are employed to mitigate financial risks, such as market fluctuations, currency

III. exchange rates or unexpected expenses?

ANNEXURE - 2

Type of cloth machineries	Application	Machine	Advantage	Disadvantage
Fabric				
	This industrial dyeing machine is mainly used for dyeing polyester fabric.	**Jet Dyeing Machine**	· This machine needs a low liquor ratio · Fabric shows low crease formation · Can dye in high temperature and pressure · Lengthwise tension on fabric is less · Need lesser time to dye	· Fabric rope may be entangled · Maintenance cost is high · In the case of rope breakage, reloading rope is complicated · Foam forming chemicals have to be avoided · While dyeing accessibility is limited
	Used for all kinds of fabric	**Winch Dyeing Machine**	· Operating method is simple and easy · Lengthwise tension is less compared to jigger dyeing machine · Any types of fabric can be dyed · Can be used for desizing and washing	· Every batch needs sewing and cutting for joining and cutting the rope. · Need more time for loading and unloading · Liquor ratio is too high · Can't dye in high temperature · Need to operate under atmospheric condition

	Usually used for automotive fabrics, nylon ballutes, tricots, and acetates.	**Beam Dyeing Machine**	· Can be dyed in high temperature and pressure · Both yarn and fabric can be dyed · Can work with low liquor ratio	· Production time is high · Uneven dyeing may occur · Loading/unloading time is high · Need extra mechanism for beam winding · Need to operate under atmospheric condition
		Jigger Dyeing Machine	· The fabric is dyed in open width form · Fabric remains dimensionally stable · Need low liquor ratio · Loss of heat and liquor is less · Low risk of crease formation	· Lengthwise tension on fabric is high · Sometimes uneven dyeing occurs · Washing off is a little bit tough due to the low liquor ratio · May cause yarn breakage on the fabric due to over tension
	Mainly used for dyeing polyester.	**Solvent Dyeing Machine**	· Water usage is too much low · Need less time · Solvent can be recycled · Saves energy for heating	· Raw material for dyeing is expensive · Need different types of extra mechanism · Can't be used for all types of fabric · Need skilled manpower

			· Even dyeing throughout the fabric	
	Used for both cellulosic and manmade fibers.	**Padded Mangle Dyeing Machine**	· Done on a continuous process · Need less time · Wash off can easily be done · Can be used to serve different wet process operations	· Batching is complicated · Need high liquor ratio · Batch to batch shade variation occurs · Uneven dyeing occurs · Need high manpower
Lab Dyeing Machine				
	Used as a yarn and fabric sample dyeing machine	**IR Beaker Dyeing Machine**	· Easy and user-friendly · Loading and unloading is easy · Can dye in high temperature · No pressure leakage · Can dye in low liquor ratio	· Limited amount of samples can be dyed · Power consumption is high · Maintenance cost is high

			· Need lesser time for dyeing	
	Used for all kinds of fabric.	**Jigger Lab Dyeing Machine**	· Can dye as actual jigger machine · Actual rope tension can be used · Rotation value can be used · Can dye in a low bath ratio	· Can't be used in high temperature · The operation procedure is complicated
	Used for every kind of fabric and yarn	**Oscillating Lab Dyeing Machine**	· Dyeing time is low · No pressure leakage · Can dye in low liquor ratio	· Can't dye in high temperature · Power consumption is high · Loss of heat is very often
Yarn Dyeing Machine	Every type of yarn can be dyed. They are dyed in cheese, cone, and linear cylindrical packages.	**Package/Cop/Cheese Dyeing Machine**	· Can be dyed in low liquor ratio · Yarn transportation is easy	· Need extra machines for back process and after process · Uneven dyeing may occur

			· Can dye in high temperature · Fully pressurized dyeing	· Fastness properties are a big issue
	Almost every type of dye classes can be used by this machine.	**Hank Dyeing Machine**	· Yarns can directly be dyed · Yarns are dyed in atmospheric condition · Machine price is low · Same liquor can be used for different batches · Operation module is easy	· Every batch needs sewing and cutting for joining and cutting the rope. · Need more time for loading and unloading · Liquor ratio is too high · Can't dye in high temperature · Need to operate under atmospheric condition
	Only used for cotton fabric, especially for denim manufacturing.	**Warp Dyeing Machine**	· Production is high · Need less time · Can dye in high temperature · Can dye in high pressure · Need less liquor ratio · More economical	· Uneven dyeing may occur · Loading/unloading time is high · Need extra mechanism for beam winding
Fiber Dyeing Machine				

	Used for cotton and wool fibers.	**Continuous Loose Stock Dyeing Machine**	· Can be dyed in high pressure · Need low liquor ratio · Can dye in high temperature · No wastage of fibers · Big batches can be dyed in once	· Maintenance cost and time is high · Economically not profitable
	Used for cotton and wool fibers.	**Discontinuous Loose Stock Dyeing Machine**	· Dyeing and pretreatment can be done in separate chambers · Big batches can be done easily · Proper level dyeing is possible for the whole batch	· Dyeing time is high · Need close supervision · Rate of wastage is high

Adapted from online[1]

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[1] https://textiletuts.com/types-of-dyeing-machines/#google_vignette