EDUZONE: International Peer Reviewed/Refereed Multidisciplinary Journal (EIPRMJ), ISSN: 2319-5045
Volume 11, Issue 1, January-June, 2022, Impact Factor: 7.687, Available online at: www.eduzonejournal.com

Textile Industry 4.0 Transformation for Sustainable Development: Prediction in Manufacturing & Proposed Hybrid Sustainable Practices

Dr. Bharati Rathore

School of Fashion & Textiles Birmingham City University, United Kingdom

ABSTRACT

In today's scenario textile industry is playing the biggest role in the world's main sources of industry pollution and making the environment issues main concern across the globe. The innovation of technology has paved the path for textile industry transformation with the help of industry 4.0. This research article proposes thecombination ofproposed hybrid sustainable practicesand textile industry 4.0 transformation strategies for green & smart sustainable future. The PHSP's has three characteristics as follows: 1. Helps to resolve pollution to attain sustainable development, 2.Sustainability in terms of safety & resources of environment,and 3.Prediction in manufacturing before decision making. By taking the motivation from UNs' Goals of Sustainable Future Development & Importance of Sustainability, this research investigates, the textile industry 4.0 can comply with hybrid sustainable practices. To analyse the hybrid sustainable practices towards sustainable future, the enactment of Proposed Hybrid Sustainable Practices was integrated with Intelligent MESN (Modified Echo state Network) Model.We figured out that the current operations of sustainability and production in Textile/Garment industry can be predicted before decision making & feedback can be obtained at the same moment. It will help the textile/garment industry in the prediction of pre problems & we can resolve them before the problem occur whether it is related to sustainability or environmental pollution. For instance,the purpose of "Accountable & Sustainable Production & consumption", "Hygiene & Clean Water to help Environment", and "Action towards the Climate" can be resolved before the occurrence by Proposed Hybrid Sustainable Practices.

Keywords: Sustainability, Prediction in Manufacturing, Industry 4.0 Transformation, Sustainable Future, Textile/Garment Industry, Green & Smart Sustainable Future, Fourth Industrial Revolution

INTRODUCTION

Background

The era of industrial revolution is paving the path of Industry 4.0 with the modification in lifestyle & in working style as well. The 1st industry revolution enhanced new inventions & new technologies; 2nd IR contributed mass production and electricity; 3rd came with new IT systems & automation [1]. These three revolutions enabled the way for 4th IR. Every time industry revolution brought the enhancement of qualitative human life. Then, what is the purpose of 4th industrial revolution? How is it helpful in automated sustainable future from the textiles to produced garments? With the invention of 4th IR, what is the fashion industry is seeking for?

In todays' era consumers are very much attentive to qualitative products and raising specific requirements. So, the textile industry is also moving towards customised production. Looking forward, manufacturers are also adapting industry 4.0, specifically not only for massproduction but to successfully control the industry pollution [2].

The industry 4.0 in production was pioneered by Hanover Fair (Germany) in 2011 and it successfully attracted worlds' eye. That time very few industries were there who were introducing industry 4.0 conceptualization in their manufacturing/service operations due to uncertainty in terms of finance & also lack of technical knowledge. The whole world is now taking vouch for 4th industrial revolution with the integration of sustainability & automation with the inclusion of IOT (Internet of Things), BDA (Big Data Analytics) and CPS (Cyber Physical systems) [3]. The JAUF (Joint Apparel Union Forum) has confirmed that the developments which are taking place in textile industry, will provide a definite solution for the futuristic problem of sustainability, inadequacy of workers and will minimize the humanistic impacts in various stages of the production to surge the productivity. Consequently, there is a necessity to align the garment factories with industry 4.0 transformation & hybrid sustainable practices to save the planet [4].

The values which were being delivered by the industrial revolution 1.0, 2.0, 3.0 were providing adequate products and services at a lesser price and time through enhanced productivity. Now the question arises, why are we

focusing on industry 4.0? Are we repeating the same practices towards increasing productivity, decrease in prices only? To answer all these questions, it's necessary to recognise consumers & industry needs because every industrial revolution has paved the way to resolve so many concerns of society.To create existence in global competition, textile industry needs to adapt the transformation in manufacturing processes towards techno savvy production system to meet the rapid changes happening across the globe. It's really very important for factories to improve their efficacy in operations by attaining hybrid sustainable practices &prediction [5]. In the current scenario, there are so many controversies are happening around fast fashion regarding sustainability issue. Fast fashion is creating predisposal conditions, which directly capitulates enormous waste generation and creates huge pressure on the environment [6]. The Fashion brands have been imposed sustainable measures on themselves and due to sustainability focusing on organic cotton. For instance, in 2018 H&M occupied 43% sustainable cotton sourcing of total cotton consumption and fixed a goal that all the brands under the umbrella of H&M will use only recyclable and sustainable raw material by 2030 [7].

Aim of This Research

This research postulates that above mentioned technologies are being established to solve main three primary concerns –production, sustainability, environment. This research begins with the outlines of former industrial revolution, focusing their impacts on textile industry, and introduction of a new concept of hybrid sustainable practices to move towards predictedsustainable future [8].For this, a brief analysis has been done for manufacturing processes with 100% sustainable materials and automation in spinning, knitting, packaging & apparel confection. We are proposing to integrate all these production processes to PHSP &Intelligent MESN model which will predict all the inputs before decision making and will provide us the feedback to resolve if any issue occurs.

This research contributes the hybrid sustainable practices in fashion/textile industry and predicts the related feedback to reach final decision making. The results shows that sustainability in textile sector provides a number of ways to implement hybrid sustainable practices to attain sustainable future. However, these processes contribute unsteadily to the enhancement of environmental, social and economic sustainability [9].

Affirmation of Contribution

This research bestows to the garment sector by discovering how proposed hybrid sustainable practices can comply with recent manufacturing processes with the inclusion of intelligent MESN model. To our finest understanding, this one is the most comprehensive study to textile sector with the integration of PHSP & Intelligent MESN model. Most importantly, 'Hybrid Sustainable Practices' has been proposed from the perspective of textile sector which will embrace valuable decisions with feedback to the managers in Textile/Garment manufacturing industry [10].

RESEARCH CONTEXTUALIZATION

Industry Revolution 1.0

The industry 1.0 took place in Britain in between 1760 & 1830 and proliferated throughout Europe & USA. In this industrial revolution, steam engines permitted the common mechanism of industries and substituted the artisan method of human being expertise with the rapid production of end user commodities. In this era, coal started the replacement of other fuels like wood. In 1733, Flying shuttle which was patented by John Kay, propelled by a cord which gave surge in items consumption produced in looms. However, in1760 the invention became popular. In 1764, Spinning Jenny invented by James Hargreaves, a pinning machine which replaced manual method of yarn production. In 1779, an instinctive spindle in water frame was introduced, thatmade it possible to produce yarn which is highly qualitativeand transformed the domestic production of yarn into mass production. The First Industrial Revolution 1.0 introduced the coal as main reservoir of energy and the removal of iron ore was beneficially exploited in the 19th century [11].

Industry Revolution 2.0

Industrial Revolution 2.0 took place in between 1840 & 1870 and it played the role of prime catalyst in the mass production of electricity which caused a specific-repercussions on the productivity in the starting of 20th century. This industrial revolution was started in Germany, Britain & USA. Not only this, Industry Revolution 2.0 brought Japan's technological development. This Industrial Revolution is known by it's productivity increase &by new source of energy for textile industry. In 1828, the ring frame- new method of spinning was created by John Thorp, which was related to the huge amount of spinning of yarns in a single process. In 1847, with the launch of circular knitting machines, rib patterns were also introduced and in 1856, Matthew Townsen launched the latch needles to make the knitwear production easy. In 1851, the sewing machine was patented by Isaac Singer, by which the scenario was changed for production of clothes [12].

Industry Revolution 3.0

Industrial Revolution 3.0 which is known for digital revolution, engrossed on the transformation from manual to digital technology, having conclusiveideogram of the invention of integrated circuits that allow expanded computational capacity and diminished production costs. In resultant, information technology was introduced to textile industry which promoted a specific growth of economy. Industries started adopting digital logic circuits and embarked on the age of information technology. During third industrial revolution, microprocessors use, telecommunication, optical fibre, Computer-aided-design (CAD) were introduced. But there were two limitations in that: adjustments in clothes & colours. Along with it, 3D Modelling & digital printing were being adopted by textile industries [13].

Industry Revolution 4.0

Industrial Revolution 4.0 also called the combination of IOT (Internet of Things), CPS (Cyber Physical Systems), Cloud Computing& Big Data. Industry 4.0 is a completely a new development level rather than an extension of Industry 3.0. CPS is known as physical & engineering systems which is helpful in operations coordination, control & it is integrated by technology & communication centre [14].

After introduction of Industry 4.0 globally, manufacturing processes changed from analogue into automate intelligent production. Industry 4.0 started resolving problemsthrough the use of automation in operations by using CPS & IOT. CPS connects the resources &products with the help of data analysis & intelligent sensors technology to monitor the inventory in plant, any failure in demand & equipment, and this is most useful in maintenance management [15]. At the same moment, all the production processes levels are recorded, inclusive of product variability, machine failure and instability, modification in orders& so many other factors. Consequently, wearing material can be most effectively controlled, production wastes can be easily reduced and this will ultimately help in moving a step towards automated sustainable future and it will be helpful in increasing efficacy [16].

These automated hybridised sustainable practices are not only limited to production processes, but also, they will be applicable in purchasing (Inventory Management), sales, from suppliers to the company (Supply Chain Management), finally customers. However, these practices extend to assembly & distribution, quality control, time control, risk management, commodity development, environmental protection, pollution control and so many other things will be automatically controlled on immediate basis [17].

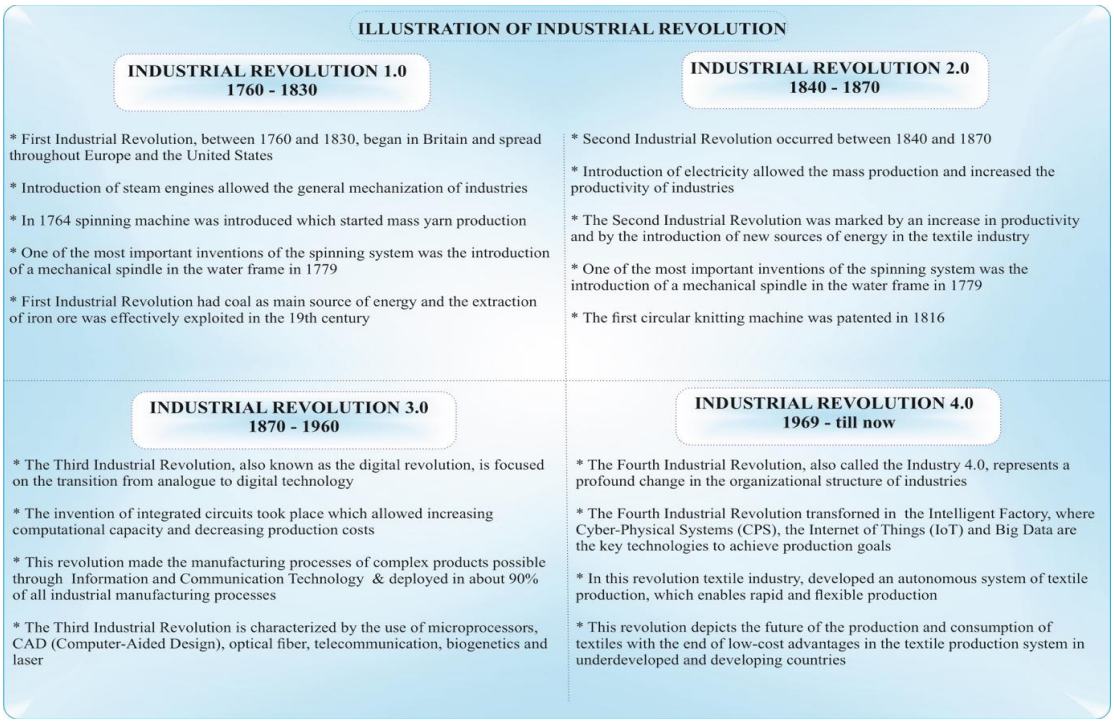

Figure 1. Illustration of Industrial Revolution

Resolution of Pollution in Textile Industry to Attain Sustainable development

Generally, Sustainable development which is also known as, 'Socially responsible economic development' tries to protect the base of resources and the environment to create benefit for future generations [18]. However, there are enormous changes which are required for the accomplishment of sustainable future. More significantly, to foster a

sustainable future of textile industry, it's really imperative to focus on achieving pristine, pollution reducing industry [19].

Textile industry is using various chemicals which are produced globally. These chemicals are used for wet processing in textile industry. Almost all of these chemicals have adverse impact on environment [20]. Cotton harvesting requires 0.5 million tons pesticides and around 9 million tons of fertilizers across the globe, 3.1% of agricultural land worldwide. However, the farmers health is deteriorating due to the chemicals used in cultivation of cotton and increasing the acute poisoning cases from pesticides [21].

Nitrogen & Phosphorus chemical are the main source of water pollution, which are used in cotton cultivation. They merge into rivers and produce algal blooms which creates the scarcity of oxygen in rivers.At the same moment, the research reveals that chemical products bring more Co2 effluent depletion [22].

Just a few years back, in 2011, Greenpeace took action and accused several giant-sized brands of the fashion industry, for instance- Adidas, Gap, Puma, Nike, Lacoste, H&M, whose actions are polluting the environment across the globe. These brand suppliers are leading to the discharge of numerous chemical substances in the rivers.However, not only the agricultural part of textile production is responsible for this environment pollution but also the fibersproduction also requires chemicals, such as dyes or finishing treatments. The microfibres and microplastics discharged from the textile industry during dyeing process, washing process are also polluting the oceans, seas by increasing these microelements in the oceans [23].

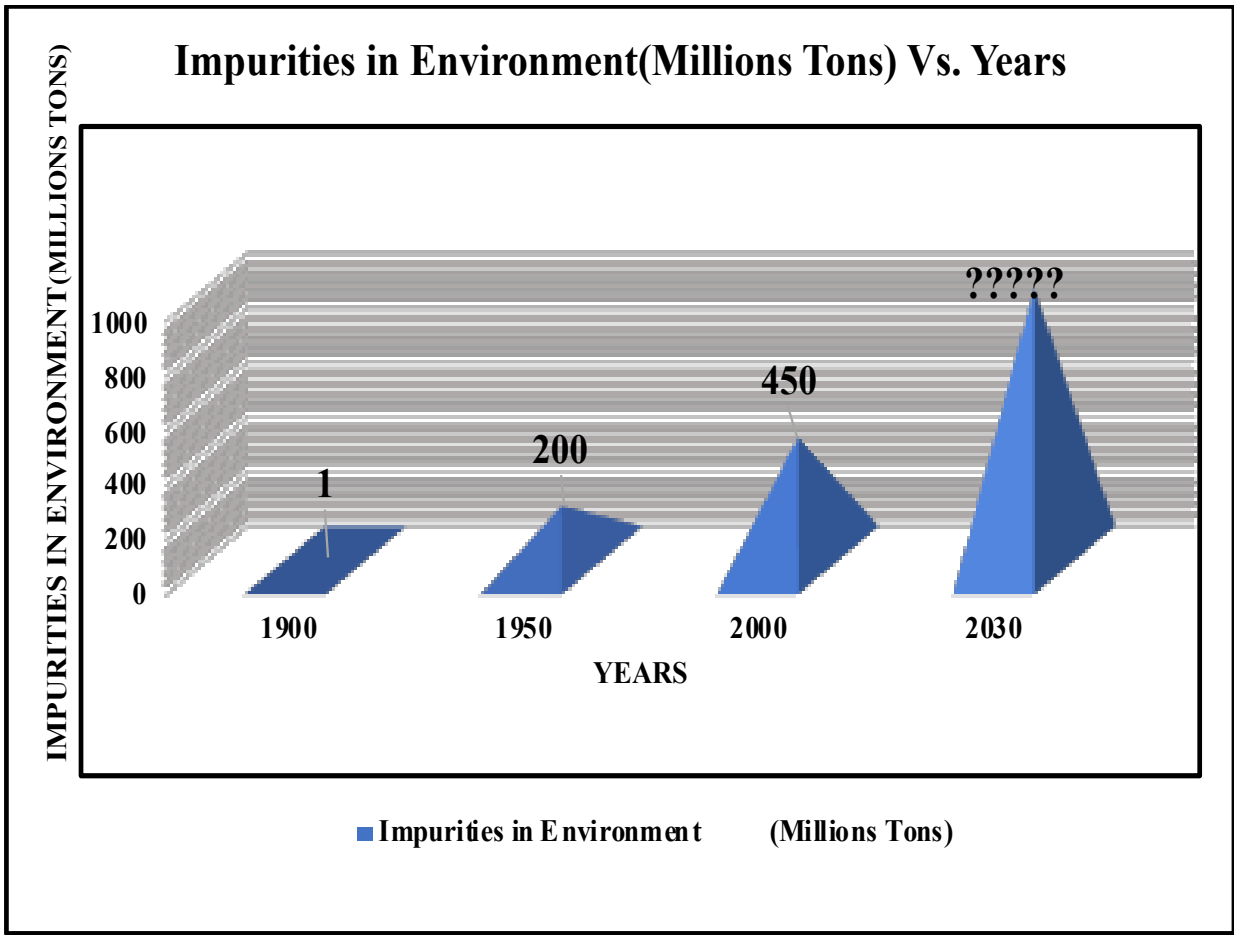

Figure 2. Impurities in Environment

This graph illustrates the co-relation of exponential growth in chemical production. This production was around one million ton in 1900 which increases to 200 million tons in 1950. It has been reached at 450 million tons in 2000. If this chemical production will grow with same pace, in future no one can imagine where it will reach?

The accumulated effects from this pollution are not limited to the surroundings of industrial areas only but this has been spread across the towns, cities through the poisoned fruits and vegetables selling at local markets. Ultimately, this pollution is giving impact on human health [24].

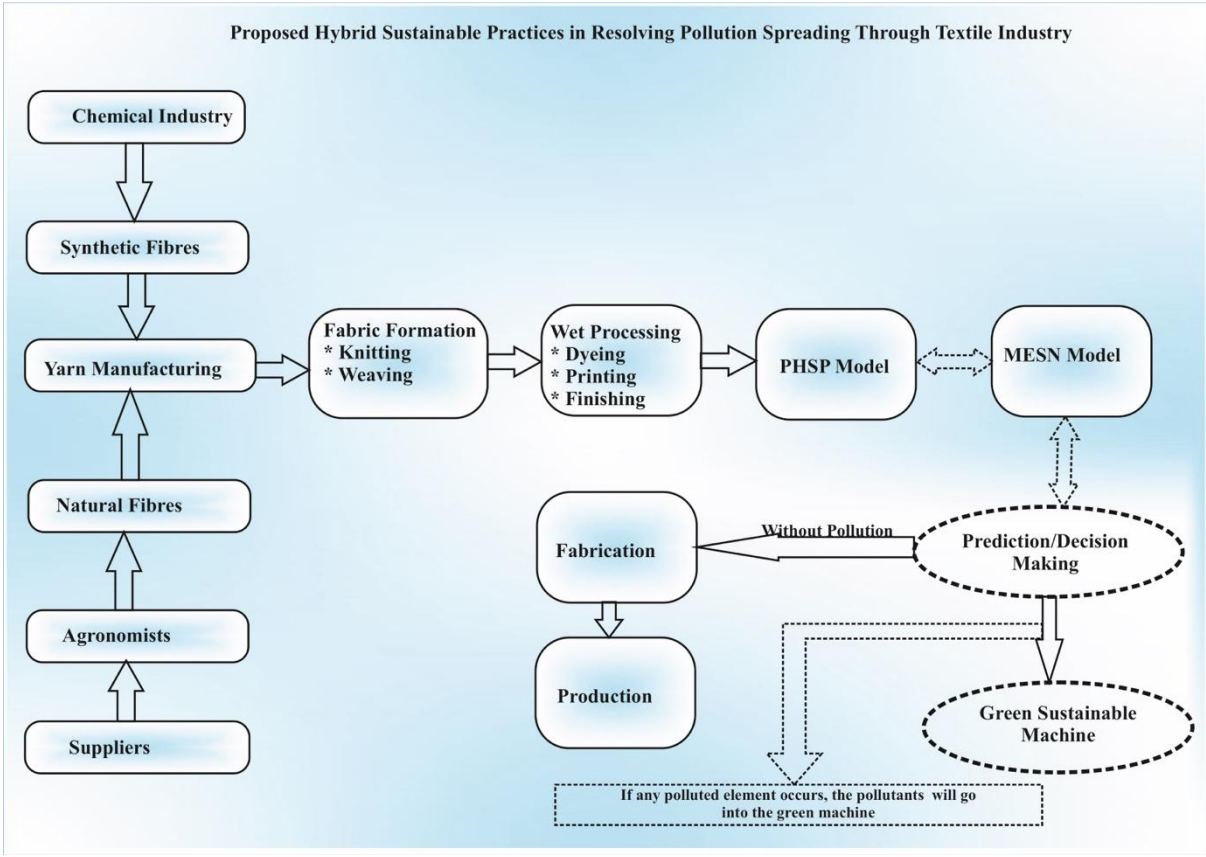

Figure 3. Proposed Hybrid Sustainable Practices in Resolving Pollution in Manufacturing

There is only one way to resolve this environmental pollution which is spreading due to textile industry, is to demolition of polluted discharges at the beginning. To act this course of action we are proposing hybrid sustainability process through 'Intelligent MESN Model'. We are proposing hybrid sustainable practices to clean the industrial emissions for its safe disposal to the environment [25]. This research paperenhancesthewayofpredictingandinitial stage warning and moves a step forward by amalgamating pollution prediction with MESN modelwhich furnishes a functional and profitable way for highpolluting industrial organizations to recognise and manage risk elements. Intelligent MESN (Modified Echo-State Network) Model works to enact as a predictor.In this Intelligent MESN Model, sensor nodes collects the whole data regarding targets and transmits that data to the base station. It works with the help of IOT & CPS and enhances the decision making without any delays [26].

Proposed Hybrid Sustainable Practices in Manufacturing Process

Manufacturing Process–(Analogue) Yarn Spinning to Final Product

The textile industry includes activities like raw materials treatment (production of different fibres), manufacturing of yarns through spinning, yarn weaving, yarn dyeing, production of knitted & woven garments, finishing activities, providing aesthetic properties to fabrics like bleaching, printing, dyeing, coating, impregnating, plasticizing etc. In the final stage, these fabrics transforms into a final product. These final products can be garment (knitted or woven), carpets, curtains, technical or industry related [27].

The production of fibres is the initial stagein textile process chain. These fibres are classified into natural & man-made fibres. According to the European Parliament Regulation (EU) No 1007/2011 introduced on 27th September 2011, it is mandatory to mention fibre constitution of textile goods on textile fibre names & related labels, aligns laws in all the European Union countries to protect consumer interests & reduce the frauds' risk [28].

The manufacturing process start with the processing of cotton fibre, which can be either man-made or natural fibre. These fibres will be processed through spinning. In that spinning process raw fibres will turn into yarn & that yarn will transform into fabric. That fabric can be prepared by a solitary yarn or assorted yarns. When the fabric is constructed, it's requisite to make it ready for final finishing. The final production stage includes, conversion of

fabric into readymade garments which is also a combination of various activities such as patterns cutting, sewing, quality checking, packing and in the final stage it goes for shipping to various channels [29].

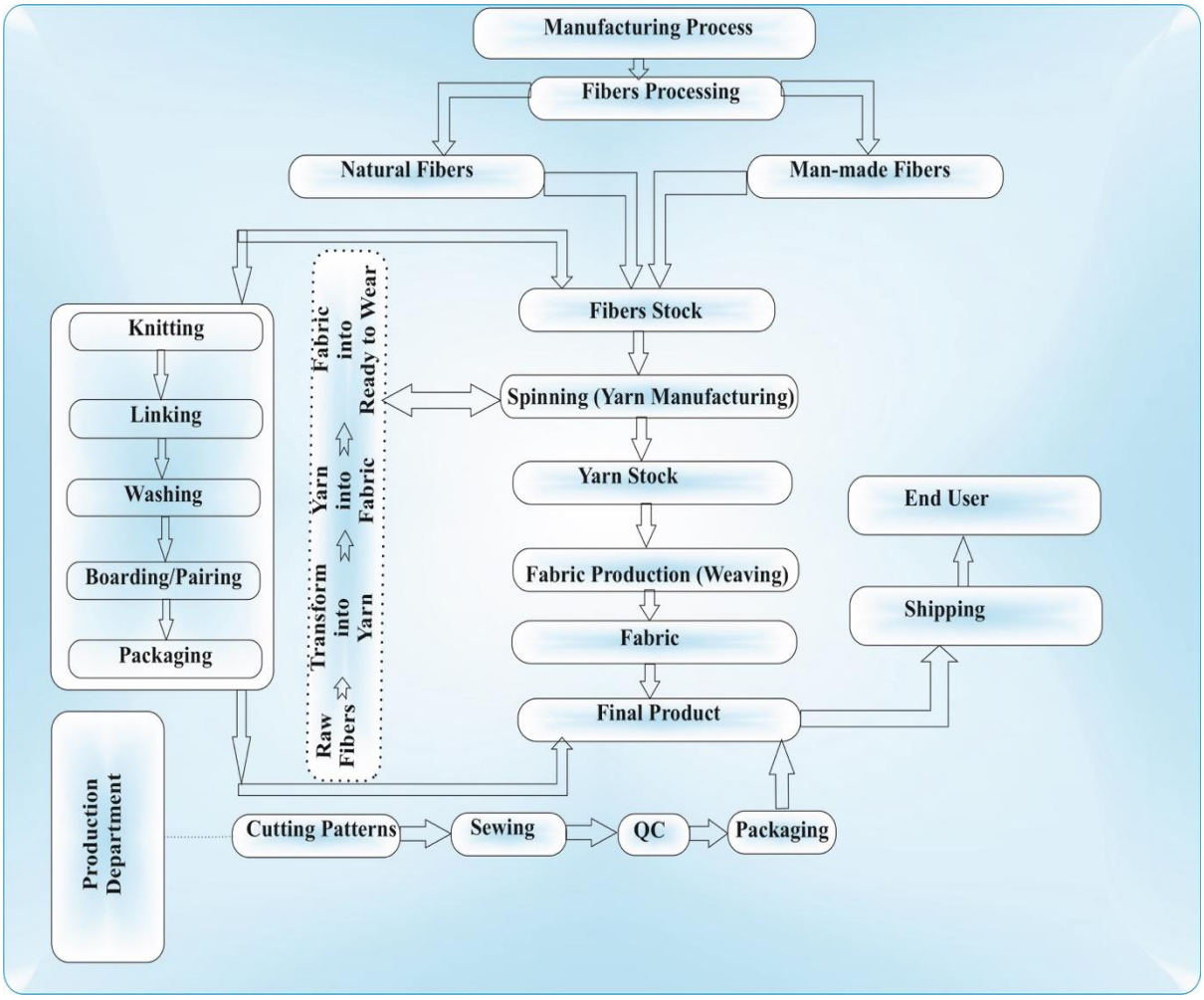

Figure 4. Manual Manufacturing Process

The spec sheet consists of technical drawings, measurements of products/samples, fabric samples, size charts which can be done manually or with the use of software. Sampling of the products consists of outlines drawing & grading of the size. The fabric cutting involves planning of cut outs that can be accomplished manually or through the software. To plan the cut outs it's necessary to know the features of fabric & sample fitting [30].

Hybrid Sustainable Practices in Textile/Garments Manufacturing

Sustainable practices are those practices which fulfill the requirements of present developments without putting them at the stake of future to encounter their own needs. Sustainable practices emerge on the cultural, technological, economical, social ground where the technological base is unavoidable asset. Modern technological advancement presents two characteristics: Resolving the recent issues and creating the new one which means, new modern technology brings advantages and its side effects automatically comes with it. Hybrid Sustainable Practices is a mission for the society, environment and closely linked to technology use [31].

As the result of increase in population, high life standards, emerging markets, life span in developing countries, the consumption of fibrous products is also increasing. Every year, consumption of fibres products is increasing between 1.5% – 3.0%which is co-related to society's increased incomes. Each gram of fibre consumption, activates the markets' textile production of fabric, yarn, garments [32]. Along with these desired manufacturing activities, unwanted after-effects of all these activities also occurs which brings harmful environmental effects.The world population has witnessed tremendous growth in the figures in past few decades and their living standards has also risen up with same pace. It directly affected the consumption of textile goods which automatically increases the textile production. The effects of their rising living standards are shown in the fastest growing worldwide consumption of textile which is faster than worlds' population growth [33].

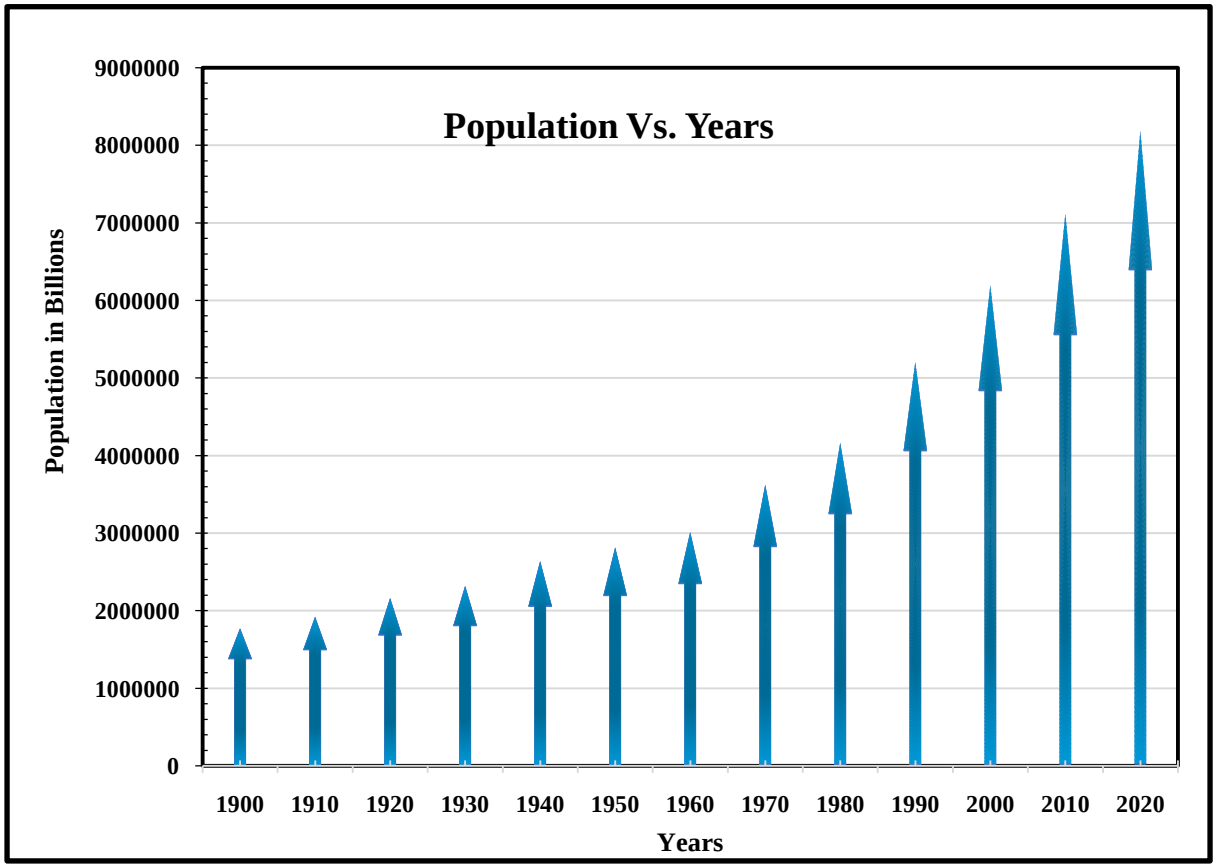

Figure 5. Population Surge Across the Globe

There is an exponential surge in population today, from a mere one billion in 1900 to above 8.1 billion today and prediction says it shall be 11 billion at the end of this century. With the per capita consumption of garments of 7 kg per individual per annum, it shall go over 51 billion kg of apparel production per year. Eventually, this production & consumption will grow with the surge in population & living standard in developing countries [34].

Garment industry is the main industry which affects the global environment pollution through the production & necessary raw materials' processing. Both of these are the main factors topollute global environment. There is one other factor, the waste which is the resultant of consumption of the textile goods and production. Even though the whole textile industry promises that all the wastes can be recycled but that's not true because a very small amount of textile waste can be recycled [35].

Currently, textile industries are working on the linear systems, it looks like in future, they will not be in a position to use these resources with full efficiency and will be helpful to reduce the environment pollution.

According to the recent global trends persist, by 2050, the textile industries are expected to portray a one fourth part of the worlds' carbon budget – 26%. If the recent trends are no shifted, non -renewable raw materials usage of textile industry will cross 300 million tons and the released amount of microplastic in the oceans will reach 22 million till 2050 [36].

A Hybrid Sustainable Practices in Fibre Production

In todays' scenario, technological improvement must be established while maintaining the equilibrium amongst people, profit & planet to make them set in hybrid sustainable practices. In the era of Industry 4.0, technology has become globalised and few products are available only in few organisations. Technology developers are playing a great role in technological era.

The role & responsibilities of designers, technology developers are more pervasive in textile/garment industry [37]. If any single initiative happens for a technology change on fibres production, yarn production, it directly effects soil, water, millions of people across the globe. Textile/Garment industry is the most extendable sector in the world. Every individual take participation in some part of apparel sector whether it is related to production, manufacturing

or consumer parts. Garment manufacturing chain begins with the fibre growing either related to natural fibre or man-made fibre [38].

The basic raw material for the textile is Fibre. Basically, there are two kinds of fibres: Natural & synthetic Fibre. Natural fibre is regenerated which can be redefined as well and the growing, processing and manufacturing processes related to this, can be redesigned. The another one is synthetic fibre which is mostly designed in the frame of sustainability and can be regenerated [39].

The concept of sustainable textile fibre design & development was nurtured in 1990s' and sustainable fibres were introduced to the market. Earlier, the consumption of fibres was limited to cotton, nylon, polypropylene, cellulosic regenerated fibre, polyester and wool but now it's' been extended to mostly on synthetic fibres. According to the reports, the extract from textile manufacturing, acrylic yarn and polyester has the least impact on the environment and cotton constitute the huge burden on environment [40].

Through this research paper we are introducing proposed hybrid sustainable practices in fibre production by taking an example of natural fibre 'Organic Cotton'. Organic cotton grows in eco-friendly environment where low impact materials & methods are used. This sort of production system reduces the use of toxins and pesticides and helps to build diverse agriculture. The whole process will take place in the frame of sustainable technology, proper manufacturing agriculture steps, cotton seeds and harvesting methods which are designed concerning the environment [41].

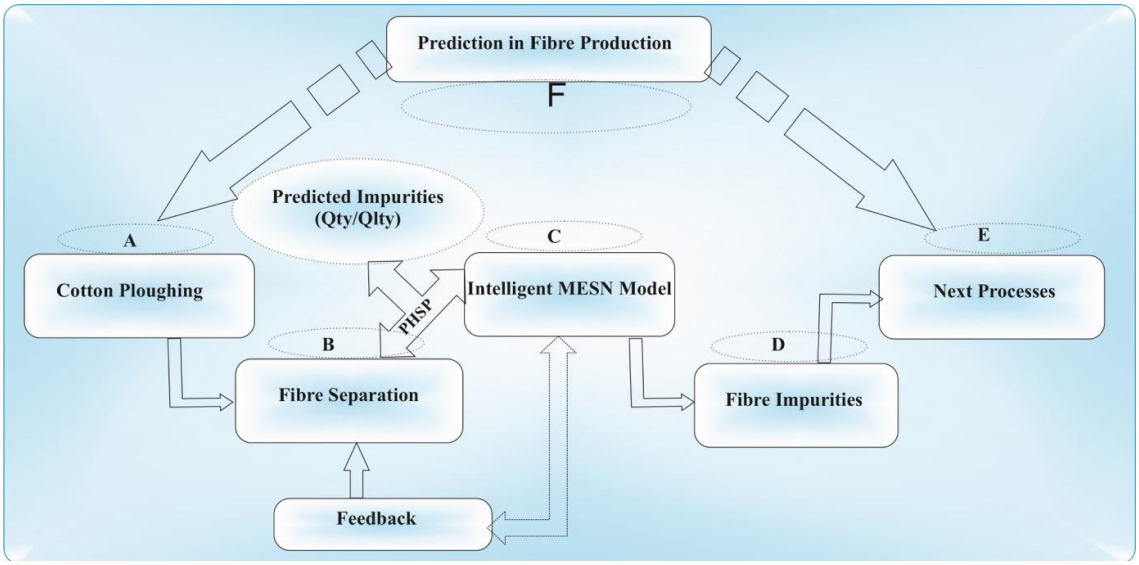

Figure 6. Hybrid Sustainable Practices in Fibre Production

This complete system encloses the multi-stages of cotton cultivation, fibers detachment through harvesting, impurities elimination from fibers. While performing this whole process, we can predict the available impurities by our 'PHSP Model'. To perform proposed hybrid sustainable practices, we are connecting separate fibre block to 'MESN Model' which will predict all the impurities quantity and quality both. To make any final decision, it provides us the feedback whether to remove those impurities or not. If we stop that process here then we can automatically increase sustainability in garments by removing impurities in cotton or in any other yarn [42].

BHybrid Sustainable Practices in Yarn Production

The next stage is yarn production jus after fibre manufacturing. There are certain factors to evaluate the sustainability level of fibre spinning technologies such as speeds of working machines, fibre type, various spindle lines, thickness of yarn, twist level [43]. Technologically, this system opens the cotton bales & eliminates the impurities, then stretches & twists the fibres, gathers the yarn generated and distributes it to blow room to separate them to transform it into yarn [44].

This spinning process is an electric energy intensive operation, that consumes almost 72% energy consumption of the whole plant and other process consumes rest of the energy. Spinning machines & their mechanisms consumes huge amount of energy to spin fibre into yarn. In fact, the consumption share of energy is not same with every yarn, it depends on the yarn count also. When we consider sustainability frame, spinning technology has highest influence on the environment [45]. The used fibre is biodegradable yarn. To improve the sustainability & reduced

energy consumption, is really a challenge, but with the use of PHSP model both can be achieved. We fix the Intelligent MESN Model to the proposed hybrid sustainable practices model (PHSP Model) to predict the lowest energy consumption and maximum speed of spindle machine [46].

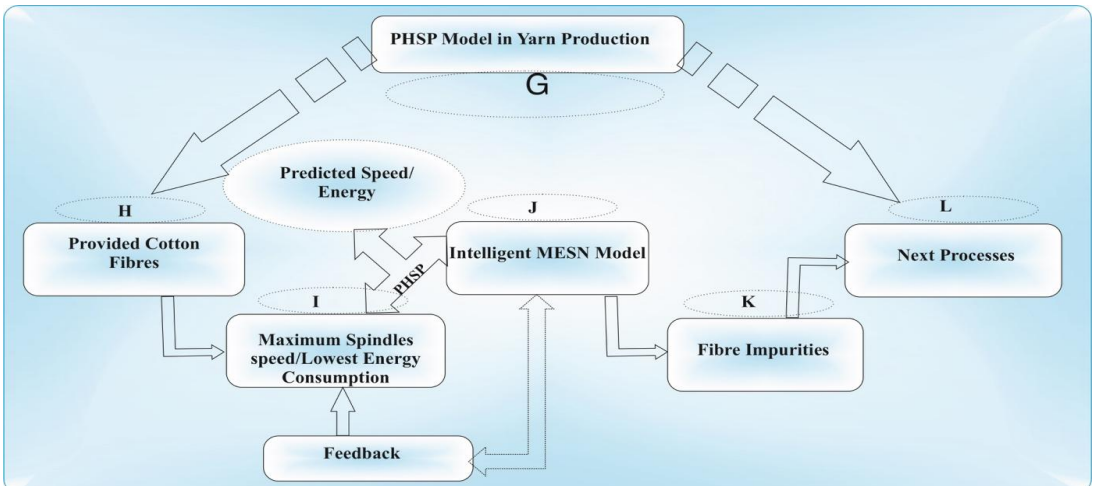

Figure 7. Hybrid Sustainable Practices in Yarn Production

CHybrid Sustainable Practices in Fabric Production

The fabric making can be performed in two ways: warp knitting & weft knitting. These processes will be performed in single cylinder circular knitting machines. In this particular machine, the components guide the formation of the fabric through the yarn guide and steel needle bed. Finally, yarn starts transforming into fabric [47]. In the middle of the process to turn yarn into fabric PHSP & Intelligent MESN Model are inbuilt to predict fibre impurities. Then this fabric goes for finishing processes. If we are not proceeding with the knitting process then we use weaving process to transform yarn into fabric. When the fabric is prepared, it goes for finishing process which involves the dyeing process where PHSP & Intelligent MESN Model are inbuilt in process to predict pollutants percentage to stop them to evacuate in the environment [48]. After dyeing process, the fabric changes into finished fabric. The last step is to transform finished fabric into final product which consists of various more steps like, spec sheet making, cutting, sampling, sewing etc. We fixe our PHSP & Intelligent MESN Model in between finished fabric and final product to predict the sustainability of that fabric to attain sustainability in future [49].

In todays' scenario mostly companies are taking sustainability initiatives in comparison to past decades. These initiatives, excellence and methodologies intensifies and evaluate sustainability results not only in agricultural production system but also adds value chain at various stages. Now it has become easier for consumers to recognize eco-friendly products due to various kind of brand endorsements [50].

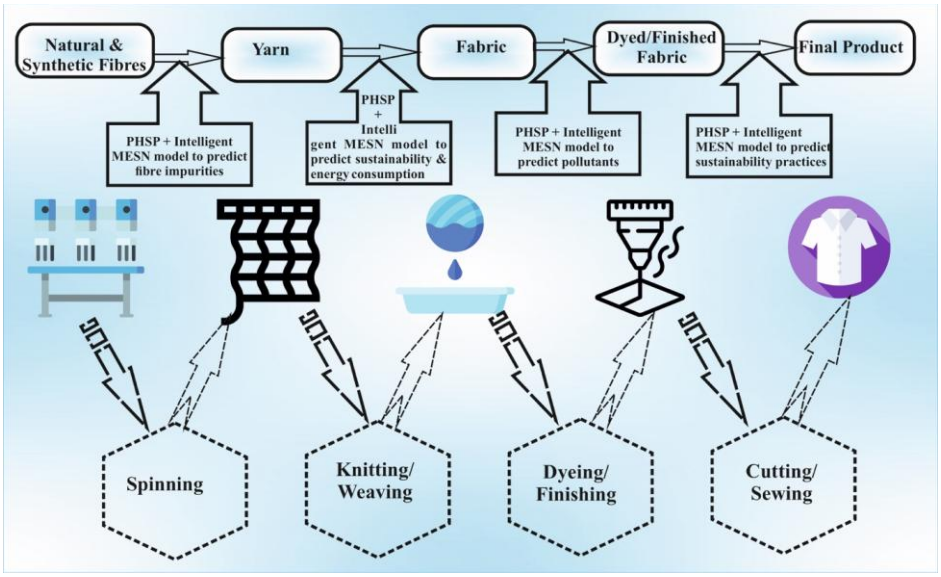

Figure 8. Hybrid Sustainable Practices in Fabric Production

Hybrid Sustainable Fibre Manufacturing & Environmental Impact

The hybrid sustainable fibre manufacturing is a socially responsible venture, which provides support to billions of small-scale farmers and low-income workers livelihoods. It's been elaborated that more than 60% of the world's fibre is grown in India, Pakistan & China, where these fibre crops are cultivated mainly by small scale & low-income farmers and workers and provides them their source of income. Almost 1.5-2 million farms in central & west Africa grows natural fibre with around ten million people employed in the region's sector of fibers [51].

During the ending phase of last century, lot of efforts were made to replace the use of natural fibres and it shows in different facets of life. To some extent these natural fibres has been replaced by few synthetic fibres like polyester, nylon, & acrylic. These fibres are cheaper than natural fibres and it's easier to manufacture them in bulk. These synthetic yarns have taken a big share of markets very soon [52].

For instance, In America (1939-1954) mostly women prefer to use silk hosiery which now has been dropped down from 93% to 0.2% and nylon percentage went on surge from 5% to 98.7%. These synthetic fibres are playing a role of a major contributor to carbon emission & wastes [53]. As per United Nations Industrial Development Organization, every person in the world is contributing in their life span by using clothes made by synthetic yarns, in carbon emission which is 19.8 tons of CO2 emission [54].

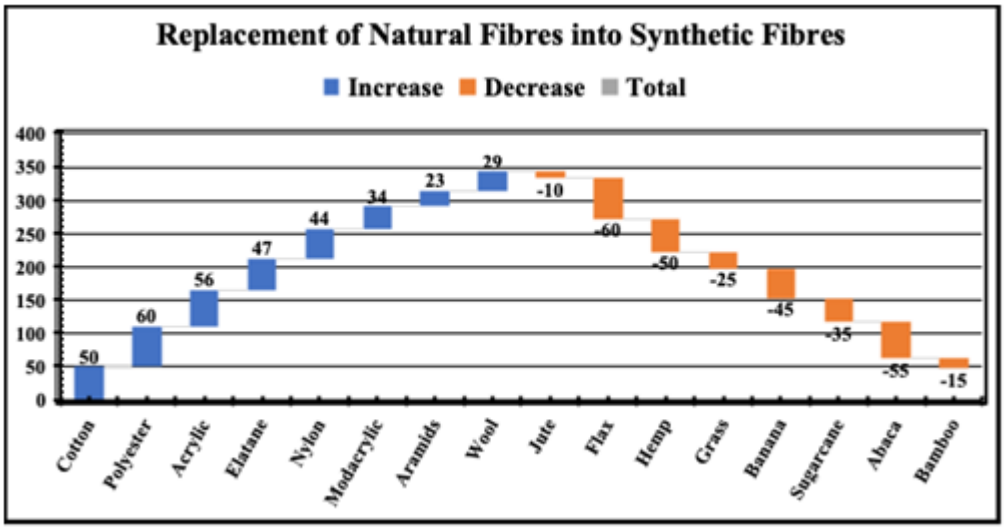

Figure 9. Replacement of Natural Fibre into Synthetic Fibre

At the time of product designing if we choose only those materials of renewable resources which contribute towards sustainability, also if they are utilised in such a way that the rate of their utilization should not go beyond the rate of renewal. In todays' scenario most of the textile industry is moving towards the agricultural fibres like flax, hemp, sisal etc and receiving considerable interest of consumers. This interest generated due to the environmental concern about synthetic fibres use and the other one is that they have possibility in weight & cost reduction [55].

Hybrid Sustainable Yarn Manufacturing & Environmental Impact

Due to the sudden surge in cost, energy, labour cost & raw material, spinning industry is facing a lot of problems and struggling to gain a net profit of 5%. Spinning industry is becoming less profitable and sale is also declining, Henceforth, it's very hard for spinning industries to maintain environment sustainability [56]. Eventually, keeping all these points in recognition it's necessary to adapt new technologies in manufacturing facilities [57].

Manufacturing of yarn includes so many mechanical processes and to perform those processes factories required a large amount of energy, also it produce a lot of waste, noise & dust which is the cause of environment pollution in terms of noise & air both [58].

The consumption of total energy in textile industry can be splited into weaving 25%, spinning 32%, chemical processing 40% and remaining 3% in various miscellaneous processes. As shown in Figure 10 [59].

The advance technology of yarn production, which is generally used to balance between demand & consumption, created the high impact on environment. This advance technology brought so many problems for the environment such as water, air, thinness of Ozone layer, deterioration in greenery. On the precautionary forefront, it's better to clean up before the pollution rather than clean up after pollution due to expensiveness and to maintain ecological

balance. The environmental issues in textile segment begins with the use of drugs which is being used in ploughing of natural fibres and on other side with the emissions in man-made fibres production. In this research paper, the solution for the problem of environment pollution and sustainability due to yarn manufacturing has been proposed which exist within the scope of sustainable future [60].

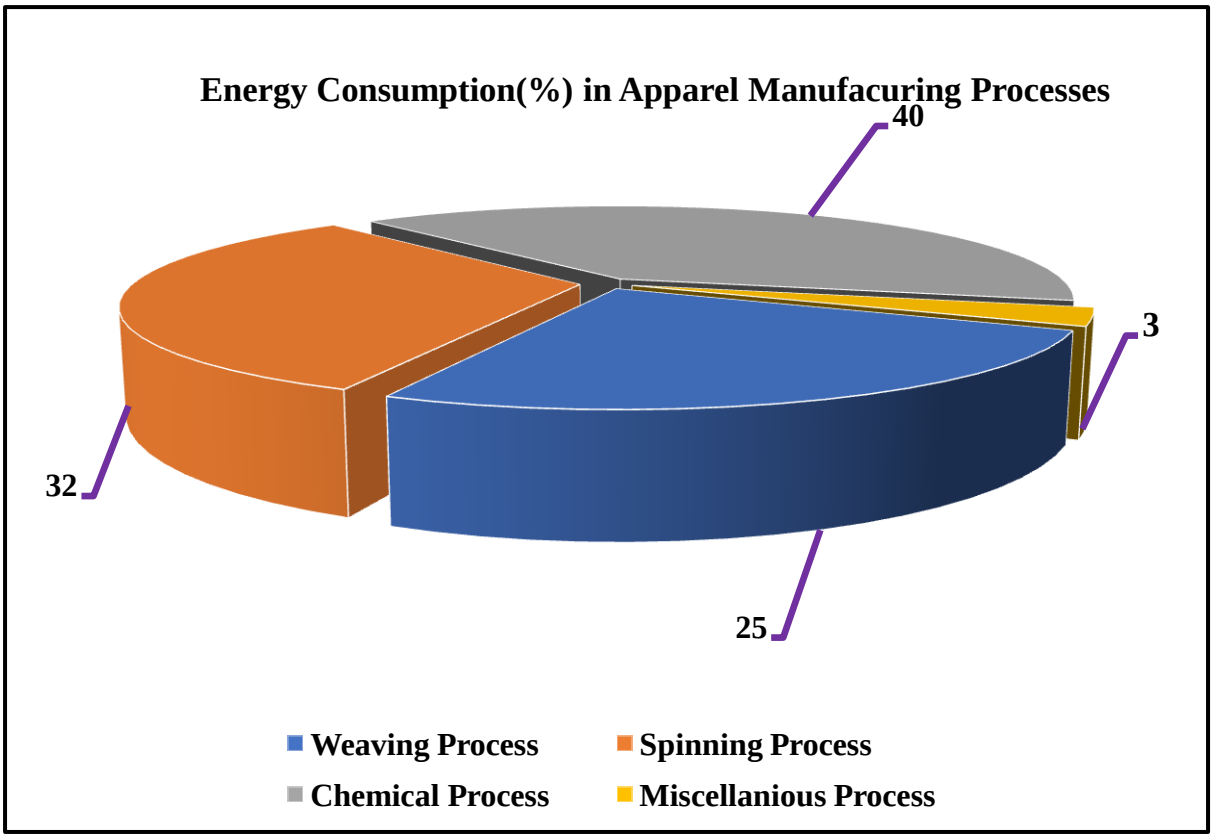

Figure 10. Hybrid Sustainable Practices in Fibre Production

Spinning industries generates solid waste & fibre waste. Generally, these solid wastes are thrown as landfill and other fibre waste material which cannot be used in products due to their inferior quality also go for landfills and rest of the material from fibre waste which can be utilised, remain with factories [61].

The globalised prominence of sustainability led the way to acquire new technologies to help in sustainable manufacturing that safeguard the energy & natural resources, which is non-polluting, cost effective and safe for everyone.This proposed hybrid sustainable model shall help the textile industry to use limited energy, highest efficacy in work, produce lesser dust and noise. This model evolves in spinning,weaving/knitting to implement effective results [62].

Future of Proposed Hybrid Sustainable Practices in Manufacturing Process

This research paper depicts Industry 4.0 with integration of PHSP to resolve two major problems in manufacturing industries. Almost every manufacturing unit encounter the issue of: Automation in predictions in manufacturing, Sustainability through Manufacturing.

In todays' scenario consumers awareness is increasing about the mass production negative impacts, for instance; deterioration of natural resources, increasing use of toxic chemicals, increase in landfills with textile wastage etc. It has led to the brands & manufacturers for environmentally sustainable practices. This global shift of consumer was well represented in global survey 2018 where almost 83% consumers said that they will definitely transform their buying habits to save the planet. Subsequently, fashion business people announced that environmental sustainability is the only biggest challenge in the industry in 2020 [63]. There are so many giant organisations of research who are focusing only on environmental sustainability from various perspectives and including different topics like buying attitude of consumers towards sustainable materials, products, packaging, sustainable business models [64].

The textile industry has complex manufacturing processes & long supply chains and this industry is a labor-intensive industry which requires a huge varieties& less volume customized production which can be fulfilled by a "Green & Smart Factory". To make "Green & Smart Factory" it's necessary to use "Proposed Hybrid Sustainable Practices" with the integration of "Industry 4.0". The green & smart factory need to fulfill three characteristics: Hybridized Production Network, Internet of Things, Cyber-Physical systems. Proposed hybrid sustainable practices can be used to supporttextile managers to play with fashion attributes and process that data to predict various properties of fashion products and process [65].

Proposed hybrid sustainable practices in textiles is the solution of many high-end applications such asfinding images and predicting fabric drape,predicting yarn &fibre, bending properties of fabrics properties and so many other applications.

Through this research paper we are proposing a model named as "Proposed Hybrid Sustainable Practices" in Green & Smart Factory which utilizes a "PHSP Model". In the given figure 3, PHSP Model has been shown. In this Green & Smart factory, manufacturing processes includes an efficient way to use Cyber Physical System, Internet of Things, Hybrid Production Network [66].

The factory set up includes a power grid for uninterrupted supply of power, excellent condition building to avoid any mis happenings, good mobility, excellent condition workplace & environment, adequate place for the employees for their homes [67].

In this PHSP model, MESN (Modified Echo State Network) model has been used to perform as a predictor which will help in decision making for machineries in manufacturing processes. This mesn model flawlessly chooses the weights of neurons in the interim layer of echo state network and lessens the shortcomings of ESN. This mesn model is adjusted in manufacturing processes based on PHSP model inputs.

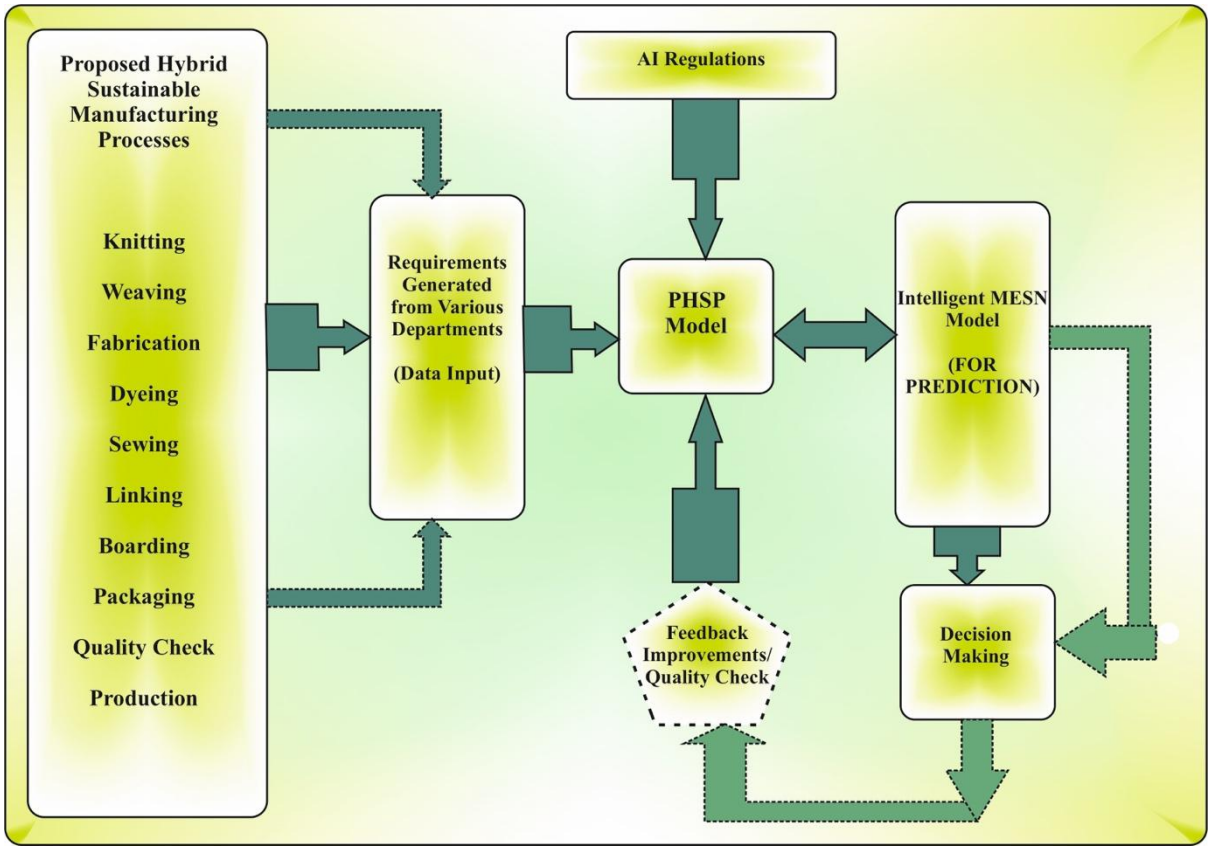

Figure 11. Proposed Hybrid Sustainable Practices in Textile Industry

Sustainability in terms of safety & resources of environment for sustainable Future

According to the reports of DNFI (Discover Natural Fibre Initiative) the globalised production of textile fibres was 109 tons in 2019, which is an increase of around 3 million tons in comparison to previous years and if it will be compared to last decade, then it registers a surge of 34 million tons. In today's scenario, fashion & textile sector,

considers organic cotton for highest order of sustainability. Organic cotton production is 0.3% of worldwide cotton production. The organic cotton market is little small as the prices are little higher for the people whose income is less to include organic cotton products in their wardrobes. Natural fibre such as organic cotton, considered as a pillar in future sustainability context. Cotton cultivators need to move towards hybrid sustainable practices model as it is secure and can be used in unfavourable conditions also, where the environment counters pollution impact [68].

Table 1. Natural Fibre Uses (National Cotton Council of America, 2016)

Sr. Num.	Illustration	Uses
1	Natural Fibre	Yarntwisting, weaving& knittingand converting into fabric
2	Fuzzes on seed	Cellulose as a raw material to develop plastics, papers, explosives,mattresses and Furniture cushions
3	Crushed seeds	Seed oil which is useful as oil for the purpose of cooking and dressing of salad, protein rich so used in food by products
4	Fibre plant leaves	work as soil enrichers and ploughing

Most of the industries are ready to pay higher prices for the cotton which have superior fibre features to gain excellent efficacy with highly compatible machineries.

In the above Table 1.1 cotton plant usage has been elaborated.
The studies highlight that today consumer awareness has also been increased and they prefer organic farming because it is beneficial for the environment and supports marketing also.Consequently, consumers who are using organic cotton and non-users as well have positive attitude towards sustainable agriculture and they usually buy local manufactured products. Organic cotton production is non-additive and benefitted for the environment also, so the available option, organic cotton is a healthy choice. In fact, organic cotton purchase supports the farmer, manufacturer, retailer who really wants to create difference in the community& planet [69].

The market share of cotton is increasing and the globalised market share of cotton (natural fibre) is approximate 40.6% which is almost similar to polyester (synthetic fibre) 42%. Polyester is a huge contender of cotton inclusive of enormous variations which can be integrated into the fibre to manufacture a new product which consists of almost samestandard to cotton. In spite of all these facts, cotton has the favouritism of consumers, which make the easier way to improve the market share of cotton. USA is the prime manufacturer of cotton, actively accompanied by Egypt, India, Australia, South Africa whereas Poland, Germany & UK play the crucial role of funding & support of organizations such as Bremen Cotton Exchange. The conventional method of cotton cultivation disregards all those concerns which generates sustainability issues inclusive of demolition of environment and well-being of human [69].

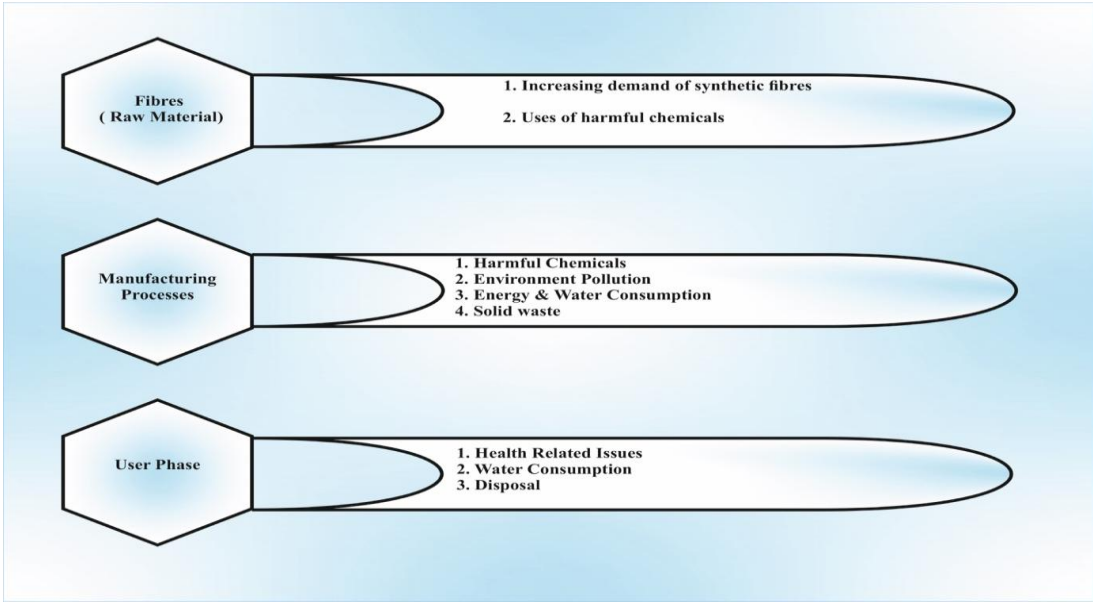

Figure 12. Sustainability issues in Textile Industry

Major issues in sustainability encountered by garments & textile sector are:

- Consumption of a huge quantity of water
- Carcinogenic nature of effluent
- Consumption of massive quantity of chemicals
- Direct discharge of waste into waterways

Water is the requisite need across the globe for domestic and industrial purpose. Somehow, the water scarcity is increasing. The United Nation announced 2013 as the International Year of the water cooperation and declared facts and figures about water resources around the world. The United Nations has declared that by the end of 2025, 2/3rd of the world population will face the scarcity of water and this will be a challenge for developing countries rather than developed one. Almost 40% of water resources has been polluted even the underground water has been contaminated by these textiles released carcinogenic chemicals. A major quantity has made the water polluted with textile chemicals & different kind of dyes and chemicals. It increases the salinity of water that affects agriculture. Almost 18%-22% of the world's water pollution is arising from dyeing and garments treatment in textile industries [70].

In a study, Greenpeace has declared that Indonesia is facing the severe water pollution, the released effluvium's in water bodies are highly alkaline and their pH is 14, that can burn the skin if directly comes into contact. This is creating a threat for under water lives and thundering the biodiversity of fresh water ecosystems [71]. To a great extent, natural fibres are being replaced by synthetic fibres. For instance, during winter woollen blankets were used worldwide but now with a great pace they are being replaced by polyester fleece [72].

Futuristic Recommendations to Maintain Sustainability

In this research paper we recommended various hybrid sustainable practices in manufacturing/textile sector. Now, co-relating them with social, environmental, economic aspects to maintain sustainable future [73].

Social Aspect to Maintain Sustainability

In textile sector due to the green stickers & eco labels act of showing the human health and environment issues to fulfill the purpose of "Good Health & Well Being" companies are disclosing their corporate social responsibility and sustainability reports, which helps to balance the transparency of purposes to attain better well-being environment [74]. Companies should increase the stakeholders/consumers participation to achieve social manufacturing for consumers benefits, they should approach celebrities to fulfill the aim of sustainable future by making the societies aware about sustainable practices [75].

Environmental Aspect to Maintain Sustainability

This research paper shows that SOI (Standards of International Operations), Regulations to preserve the environment, Investments in sustainability, EMSE (Environmental Management System Establishment) plays a key role in sustainability of environment [76]. However, Proposed hybrid sustainable practices should facilitate the sustainability in environment. It is recommended that to achieve the objective of "Clean Water & Sanitation", standards should be developed to use of water and effluents release. Everyone needs to focus on controlling the energy to achieve 'Affordable & Clean Energy'[77].

Economical Aspect to Maintain Sustainability

The economic sustainability can be increased by integration of sustainable value co-creation strategies & sustainable investment. The profitability & economic growth goes hand in hand and they can be increased by innovation in technology/technological advancement in textile sector [78]. Almost all the manufacturing firms are advised to employ cradle to cradle apparel design strategies in fashion industry and needs to amend social life cycle assessment for the monitoring of production. The fashion industry needs to increase the consumers and customers awareness on sustainable garments consumption and should be aware about eco-labelling [79,80]. From the perspective of economical growth "Idle Production & Consumption" are required.

Table 2.Sustainability Measures through social, economic and environmental aspects.

Sustainability Measures	Social	Economical	Environmental
Sourcing Process	Proper evaluation of suppliers under socio-environmental basis, Increase consumer participation through social manufacturing	Choose only those suppliers who can supply sustainable material, Outsource from International markets in cost effective way	Evaluate suppliers upon socio-environmental credentials, introduce carbon emission Tax scheme to deteriorate carbon footprint

Dyeing Process	Save water from the released waste from various dyeing processes	Reduce energy consumption, reduce usage of water, reduce carbon emission, implement Plasma treatment & enzymatic process	Use green dye pigments, levy carbon emission tax schemes on firms, apply screen printing approach
Production Process	Enhance consumer participation in social manufacturing	Increase green production by applying green practices	Apply clean manufacturing in textile sector
Supply Chain Process	Approach celebrities to run awareness about sustainability in societies	Increase the profitability & performance of textile sector by technological advancement	Increase the consumption of knitted fabrics rather than woven fabrics as knitted fabric are more eco friendly
Retail & Consumption Process	Utilize sustainable factors in advertising campaigns	Reduce the percentage of return products	Deteriorate the figures of clothes consumption

CONCLUSION AND AGENDA OF FUTURE RESEARCH

Major Findings & Summary of This Research

The main aim of this research paper is to propose hybrid sustainable practices and do the related prediction with the help of prediction model in textile industry to bring sustainable future. The manufacturing processes foresees the adoption of advance technology, the need for feedback and decision-making process, automate the sustainability in garments [81]. In fact, the second and third industrial revolutions brought so many innovations in various industries but Industry 4.0 is yet awaited to fully integrate into garments production and the main challenge into it is to keep abreast manufacturing industries with these innovations. By observation of technical developments throughout the history of textile industry, it is clear that textile sector always plays a pioneering role in transformation of textile manufacturing. This research paper also discusses the social, economical & environmental aspects of sustainability in textile industry [82]. From spinning of fibres, yarn manufacturing and transforming it into a final product consumes a lot of energy in various mechanical processes, emits greenhouse gases, releases pollutants in water and in environment, generates solid wastes etc. are all has been discussed in this research [83].

Agenda of Future Research

We here conclude this research paper by proposing hybrid sustainable practices in textile/garment sector along with prediction model. In this research paper we found few expository areas as follows:

AImplementation of Hybrid Sustainable Practices and Prediction in Textile Industry

The prior research in this area mainly focuses on one specific perspective, either related to sustainability in textile or in prediction in various technological tools. Therefore, we proposed research with combination of sustainability and prediction in textile industry to balance social, environmental and economic developments altogether [84].

BImplementation of Hybrid Sustainable Practices in the achievement of Sustainable Future

This research paper highlighted various perspectives of natural and synthetic fibres in knitting/weaving process, their potential across the globe, replacement of natural fibres by synthetic fibres and their use in different spheres of textile industry. Naturally grown fibres prevents the environment from harmful effect and develops the final product sustainable. Therefore, it is beneficial to do more research on natural fibres to strengthen and establish the sustainable future [82-84].

REFERENCES

[1]. Ślusarczyk, B., Haseeb, M. and Hussain, H.I., 2019. Fourth industrial revolution: a way forward to attain better performance in the textile industry. *Engineering Management in Production and Services*, *11*(2).

[2]. Karre, H., Hammer, M., Kleindienst, M. and Ramsauer, C., 2017. Transition towards an Industry 4.0 state of the LeanLab at Graz University of Technology. *Procedia manufacturing*, *9*, pp.206-213.

[3]. Hartmann, E.A. and Bovenschulte, M., 2013. Skills needs analysis for "Industry 4.0" based on roadmaps for smart systems. In *Using Technology Foresights for Identifying Future Skills Needs. Global Workshop Proceedings* (pp. 24-36).
[4]. Görçün, Ö.F., 2018. The Rise of Smart Factories in the Fourth Industrial Revolution and Its Impacts on the Textile Industry. *International Journal of Materials, Mechanics and Manufacturing*, *6*(2), pp.136-141.
[5]. Hornborg, A., 2006. Footprints in the cotton fields: The Industrial Revolution as time–space appropriation and environmental load displacement. *Ecological Economics*, *59*(1), pp.74-81.
[6]. Silvestre, B.S. and Ţîrcă, D.M., 2019. Innovations for sustainable development: Moving toward a sustainable future. *Journal of Cleaner Production*, *208*, pp.325-332.
[7]. Berkowitz, H., 2018. Meta-organizing firms' capabilities for sustainable innovation: A conceptual framework. *Journal of Cleaner Production*, *175*, pp.420-430.
[8]. Schaltegger, S. and Wagner, M. eds., 2017. *Managing the business case for sustainability: The integration of social, environmental and economic performance*. Routledge.
[9]. Manzi, T., Lucas, K., Jones, T.L. and Allen, J. eds., 2010. *Social sustainability in urban areas: Communities, connectivity and the urban fabric*. Routledge.
[10]. Csikósová, A., Janošková, M. and Čulková, K., 2019. Prediction of developments in the textile and clothing industry in Slovakia by selected indicators of financial analysis. *Fibres & textiles in Eastern Europe*.
[11]. Ghoreishi, M., Happonen, A. and Pynnönen, M., 2020, February. Exploring industry 4.0 technologies to enhance circularity in textile industry: role of internet of things. In *Twenty-first International Working Seminar on Production Economics* (p. 16).
[12]. Hidayatno, A., Rahman, I. and Irminanda, K.R., 2019, September. A conceptualization of industry 4.0 adoption on textile and clothing sector in Indonesia. In *Proceedings of the 2019 5th International Conference on Industrial and Business Engineering* (pp. 339-343).
[13]. Görçün, Ö.F., 2018. The Rise of Smart Factories in the Fourth Industrial Revolution and Its Impacts on the Textile Industry. *International Journal of Materials, Mechanics and Manufacturing*, *6*(2), pp.136-141.
[14]. Saggiomo, M., Wischnowski, M., Winkel, B., Nierhaus, M., Gloy, Y.S. and Gries, T., 2015. Industry 4.0 in the field of textile machinery-first steps of implementation. *Melliand International*, (1).
[15]. Ramaiah, G.B., 2021. Theoretical analysis on applications aspects of smart materials and Internet of Things (IoT) in textile technology. *Materials Today: Proceedings*, *45*, pp.4633-4638.
[16]. Fernández-Caramés, T.M. and Fraga-Lamas, P., 2018. Towards the Internet of smart clothing: A review on IoT wearables and garments for creating intelligent connected e-textiles. *Electronics*, *7*(12), p.405.
[17]. Vidmar, D., Marolt, M. and Pucihar, A., 2021. Information Technology for Business Sustainability: A Literature Review with Automated Content Analysis. *Sustainability*, *13*(3), p.1192.
[18]. Tayyab, M., Jemai, J., Lim, H. and Sarkar, B., 2020. A sustainable development framework for a cleaner multi-item multi-stage textile production system with a process improvement initiative. *Journal of Cleaner Production*, *246*, p.119055.
[19]. Almanza, A.M.H. and Corona, B., 2020. Using Social Life Cycle Assessment to analyze the contribution of products to the Sustainable Development Goals: a case study in the textile sector. *The International Journal of Life Cycle Assessment*, *25*(9), pp.1833-1845.
[20]. Heintz, J., Belaud, J.P. and Gerbaud, V., 2014. Chemical enterprise model and decision-making framework for sustainable chemical product design. *Computers in Industry*, *65*(3), pp.505-520.
[21]. Hong, M. and Chen, E.Y.X., 2017. Chemically recyclable polymers: a circular economy approach to sustainability. *Green Chemistry*, *19*(16), pp.3692-3706.
[22]. Kaur, G., Uisan, K., Ong, K.L. and Lin, C.S.K., 2018. Recent trends in green and sustainable chemistry & waste valorisation: rethinking plastics in a circular economy. *Current opinion in green and sustainable chemistry*, *9*, pp.30-39.
[23]. Bhaduri, G. and Ha-Brookshire, J. (2017), "The role of brand schemas, information transparency, and source of message on apparel brands' social responsibility communication", Journal of Marketing Communications, Vol. 23 No. 3, pp. 293-310.
[24]. Cousins, I.T., Vestergren, R., Wang, Z., Scheringer, M. and McLachlan, M.S., 2016. The precautionary principle and chemicals management: The example of perfluoroalkyl acids in groundwater. *Environment international*, *94*, pp.331-340.
[25]. Rathore, R.S., Sangwan, S., Adhikari, K. and Kharel, R., 2020. Modified echo state network enabled dynamic duty cycle for optimal opportunistic routing in EH-WSNs. *Electronics*, *9*(1), p.98.
[26]. Rathore, R.S., Sangwan, S., Kaiwartya, O. and Aggarwal, G., 2021. Green Communication for NextGeneration Wireless Systems: Optimization Strategies, Challenges, Solutions, and FutureAspects. *Wireless Communications and Mobile Computing*, *2021*.
[27]. Uddin, F., 2019. Introductory chapter: textile manufacturing processes. In *Textile Manufacturing Processes*. IntechOpen.
[28]. Huynh, N.T., 2020. Online defect prognostic model for textile manufacturing. *Resources, Conservation and Recycling*, *161*, p.104910.

[29]. Prasad, M.M., Dhiyaneswari, J.M., Jamaan, J.R., Mythreyan, S. and Sutharsan, S.M., 2020. A framework for lean manufacturing implementation in Indian textile industry. *Materials today: proceedings*, *33*, pp.2986-2995.
[30]. Chen, Z. and Xing, M., 2015, September. Upgrading of textile manufacturing based on Industry 4.0. In *5th International Conference on Advanced Design and Manufacturing Engineering*. Atlantis Press.
[31]. Cai, Y.J. and Choi, T.M., 2020. A United Nations' Sustainable Development Goals perspective for sustainable textile and apparel supply chain management. *Transportation Research Part E: Logistics and Transportation Review*, *141*, p.102010.
[32]. Cai, Y.J. and Choi, T.M., 2019. Extended producer responsibility: a systematic review and innovative proposals for improving sustainability. *IEEE transactions on engineering management*, *68*(1), pp.272-288.
[33]. Palamutcu, S., 2017. Sustainable textile technologies. In *Textiles and clothing sustainability* (pp. 1-22). Springer, Singapore.
[34]. Bullón, J., González Arrieta, A., Hernández Encinas, A. and Queiruga Dios, A., 2017. Manufacturing processes in the textile industry. Expert Systems for fabrics production.
[35]. Thomas, K.V., Bijlsma, L., Castiglioni, S., Covaci, A., Emke, E., Grabic, R., Hernández, F., Karolak, S., Kasprzyk-Hordern, B., Lindberg, R.H. and de Alda, M.L., 2012. Comparing illicit drug use in 19 European cities through sewage analysis. *Science of the Total Environment*, *432*, pp.432-439.
[36]. Blewitt, J., 2012. *Understanding sustainable development*. Routledge.
[37]. Goyal, A. and Nayak, R., 2020. Sustainability in yarn manufacturing. In *Sustainable Technologies for Fashion and Textiles* (pp. 33-55). Woodhead Publishing.
[38]. Adekomaya, O., Jamiru, T., Sadiku, R. and Huan, Z., 2016. A review on the sustainability of natural fiber in matrix reinforcement–A practical perspective. *Journal of Reinforced Plastics and Composites*, *35*(1), pp.3-7.
[39]. Le, T.N. and Wang, C.N., 2017. The integrated approach for sustainable performance evaluation in value chain of Vietnam textile and apparel industry. *Sustainability*, *9*(3), p.477.
[40]. van der Velden, N.M., Patel, M.K. and Vogtländer, J.G., 2014. LCA benchmarking study on textiles made of cotton, polyester, nylon, acryl, or elastane. *The International Journal of Life Cycle Assessment*, *19*(2), pp.331-356.
[41]. Muthu, S.S. ed., 2015. *Handbook of life cycle assessment (LCA) of textiles and clothing*. Woodhead publishing.
[42]. Telli, A. and Babaarslan, O., 2017. Usage of recycled cotton and polyester fibers for sustainable staple yarn technology. *Textile and Apparel*, *27*(3), pp.224-233.
[43]. Pavlinić, D.Z. and Geršak, J., 2004. Design of the system for prediction of fabric behaviour in garment manufacturing processes. *International Journal of Clothing Science and Technology*.
[44]. Tsai, W.H., 2018. Green production planning and control for the textile industry by using mathematical programming and industry 4.0 techniques. *Energies*, *11*(8), p.2072.
[45]. Gómez, A.M.M., González, F.A. and Bárcena, M.M., 2018. Smart eco-industrial parks: A circular economy 38. implementation based on industrial metabolism. *Resources, conservation and recycling*, *135*, pp.58-69.
[46]. Zulfiqar, F. and Thapa, G.B., 2018. Determinants and intensity of adoption of "better cotton" as an innovative cleaner production alternative. *Journal of cleaner production*, *172*, pp.3468-3478.
[47]. Wang, S.; Wan, L.; Li, T.; Luo, B.; Wang, C. Exploring the effect of cap-and-trade mechanism on firm's production planning and emission reduction strategy. J. Clean. Prod. 2018, 172, 591–601.
[48]. Kapelko, M. and Lansink, A.O., 2015. An international comparison of productivity change in the textile and clothing industry: a bootstrapped Malmquist index approach. *Empirical Economics*, *48*(4), pp.1499-1523.
[49]. Kammerer, K., Pryss, R., Sommer, K. and Reichert, M., 2018, August. Towards context-aware process guidance in cyber-physical systems with augmented reality. In *2018 4th international workshop on requirements engineering for self-adaptive, collaborative, and cyber physical systems (RESACS)* (pp. 44-51). IEEE.
[50]. Gam, H.J., Cao, H., Bennett, J., Helmkamp, C. and Farr, C., 2011. Application of design for disassembly in men's jacket: A study on sustainable apparel design. *International Journal of Clothing Science and Technology*.
[51]. Hong, J., Zhang, Y. and Ding, M., 2018. Sustainable supply chain management practices, supply chain dynamic capabilities, and enterprise performance. *Journal of cleaner production*, *172*, pp.3508-3519.
[52]. Motta, W.H., Issberner, L.R. and Prado, P., 2018. Life cycle assessment and eco-innovations: What kind of convergence is possible?. *Journal of cleaner production*, *187*, pp.1103-1114.
[53]. Yan, S., Jones, C., Henninger, C.E. and McCormick, H., 2020. Textile industry insights towards impact of regenerated cellulosic and synthetic fibres on microfibre pollution. In *Sustainability in the Textile and Apparel Industries* (pp. 157-171). Springer, Cham.
[54]. Singh, Z. and Bhalla, S., 2017. Toxicity of synthetic fibres & health. *Advance Research in Textile Engineering*, *2*(1), pp.1-5.
[55]. Kozłowski, R. and Mackiewicz-Talarczyk, M. eds., 2012. *Handbook of natural fibres*. Woodhead Pub.

[56]. Barclay, S. and Buckley, C., 2002, May. Establishing and Managing Waste Minimisation Clubs in South Africa. In *Proceedings of the WISA Biennial Conference and Exhibition, Durban* (pp. 19-23).
[57]. Halpaap, A. and Dittkrist, J., 2018. Sustainable chemistry in the global chemicals and waste management agenda. *Current Opinion in Green and Sustainable Chemistry*, *9*, pp.25-29.
[58]. Zorpas, A.A., Lasaridi, K., Pociovalisteanu, D.M. and Loizia, P., 2018. Monitoring and evaluation of prevention activities regarding household organics waste from insular communities. *Journal of Cleaner Production*, *172*, pp.3567-3577.
[59]. Dahlbo, H., Aalto, K., Eskelinen, H. and Salmenperä, H., 2017. Increasing textile circulation—consequences and requirements. *Sustainable production and consumption*, *9*, pp.44-57.
[60]. Yadav, P., Singh, J., Srivastava, D.K. and Mishra, V., 2021. Environmental pollution and sustainability. In *Environmental Sustainability and Economy* (pp. 111-120). Elsevier.
[61]. Desore, A. and Narula, S.A., 2018. An overview on corporate response towards sustainability issues in textile industry. *Environment, Development and Sustainability*, *20*(4), pp.1439-1459.
[62]. DUDIN, M.N., VOYKOVA, N., FROLOVA, E.E., ARTEMIEVA, J.A. and KUCHERENKO, P.A., 2017. Strategic development of the textile industry in the context of the use of green manufacturing and logistics technologies. *RevistaEspacios*, *38*(33).
[63]. Alay, E., Duran, K. and Korlu, A., 2016. A sample work on green manufacturing in textile industry. *Sustainable Chemistry and pharmacy*, *3*, pp.39-46.
[64]. Lozano, F.J., Lozano, R., Freire, P., Jiménez-Gonzalez, C., Sakao, T., Ortiz, M.G., Trianni, A., Carpenter, A. and Viveros, T., 2018. New perspectives for green and sustainable chemistry and engineering: Approaches from sustainable resource and energy use, management, and transformation. *Journal of Cleaner Production*, *172*, pp.227-232.
[65]. Zhou C, Damiano N, Whisner B, Reyes M. Industrial Internet of Things: (IoT) applications in underground coal mines. Min Eng, 2017, 69, 50-56.
[66]. Kammerer, K., Pryss, R., Sommer, K. and Reichert, M., 2018, August. Towards context-aware process guidance in cyber-physical systems with augmented reality. In *2018 4th international workshop on requirements engineering for self-adaptive, collaborative, and cyber physical systems (RESACS)* (pp. 44-51). IEEE.
[67]. Schomburg, I., Jeske, L., Ulbrich, M., Placzek, S., Chang, A. and Schomburg, D., 2017. The BRENDA enzyme information system–From a database to an expert system. *Journal of biotechnology*, *261*, pp.194-206.
[68]. Kozłowski, R.M. and Mackiewicz-Talarczyk, M., 2020. Introduction to natural textile fibres. In *Handbook of Natural Fibres* (pp. 1-13). Woodhead Publishing.
[69]. Muthu, S.S. ed., 2017. *Sustainable fibres and textiles*. Woodhead Publishing.
[70]. Fletcher, K., 2013. *Sustainable fashion and textiles: design journeys*. Routledge.
[71]. Szirmai, A., Timmer, M.P. and van der Kamp, R., 2002. Measuring Embodies Technological Change in Indonesian Textiles: The Core-Machinery Approach. *Journal of Development Studies*, *39*(2), pp.155-177.
[72]. Salman, S.D., 2019. Partial replacement of synthetic fibres by natural fibres in hybrid composites and its effect on monotonic properties. *Journal of Industrial Textiles*, p.1528083719878843.
[73]. Boström, M. and Micheletti, M., 2016. Introducing the sustainability challenge of textiles and clothing. *Journal of Consumer Policy*, *39*(4), pp.367-375.
[74]. Moorhouse, D. and Moorhouse, D., 2017. Sustainable design: circular economy in fashion and textiles. *The Design Journal*, *20*(sup1), pp.S1948-S1959.
[75]. Bocken, N.M., Olivetti, E.A., Cullen, J.M., Potting, J. and Lifset, R., 2017. Taking the circularity to the next level: a special issue on the circular economy.
[76]. Zamani, B., 2014. *Towards understanding sustainable textile waste management: Environmental impacts and social indicators*. Chalmers TekniskaHogskola (Sweden).
[77]. Elsahida, K., Fauzi, A.M., Sailah, I. and Siregar, I.Z., 2019, December. Sustainability of the use of natural dyes in the textile industry. In *IOP Conference Series: Earth and Environmental Science* (Vol. 399, No. 1, p. 012065). IOP Publishing.
[78]. Kumar, V., Agrawal, T.K., Wang, L. and Chen, Y., 2017. Contribution of traceability towards attaining sustainability in the textile sector. *Textiles and Clothing Sustainability*, *3*(1), pp.1-10.
[79]. Koszewska, M., 2011. Social and eco-labelling of textile and clothing goods as means of communication and product differentiation. *Fibres & Textiles in Eastern Europe*, *19*(4), p.87.
[80]. Chen, L. and Lee, H.L., 2017. Sourcing under supplier responsibility risk: The effects of certification, audit, and contingency payment. *Management Science*, *63*(9), pp.2795-2812.
[81]. Gardetti, M.A. and Torres, A.L. eds., 2017. *Sustainability in fashion and textiles: values, design, production and consumption*. Routledge.
[82]. Dyck, B. and Silvestre, B.S., 2019. A novel NGO approach to facilitate the adoption of sustainable innovations in low-income countries: lessons from small-scale farms in Nicaragua. *Organization Studies*, *40*(3), pp.443-461.

[83]. Palamutcu, S., 2010. Electric energy consumption in the cotton textile processing stages. *Energy*, *35*(7), pp.2945-2952.
[84]. Zhu, Q., Sarkis, J. and Geng, Y., 2005. Green supply chain management in China: pressures, practices and performance. International journal of operations & production management.