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A SYMBIOTIC FUTURE OF TEXTILE INDUSTRY THROUGH INDUSTRIAL REVOLUTION AND SDG

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ABSTRACT
Textile account for 15% of the GDP and are transitioning to industry 4.O, the principles of Textile 4.o can accomplish objectives of SDG, social responsibility, economic expansion, and environmental preservation. It is imperative to look at how textile technologies could contribute to the achievement of SDG. Thus, paper investigates the textile technologies, how it helps the industry and SDG's. This is a conceptual paper that represents the theoretical perspective through literature survey, which results that the industry has certain possibilities for sustainable practice like implementing environmentally conscious and resource-saving methods, secondly reduction of energy use and waste. The paper concludes that textile being one of the dominant factors with all-around performance in terms of export, 4.O, GDP, job, and so on, SDG is more suitable for this, including Goals 8, 9, 12, and 17. Finally, the industry's emphasis on job creation and skill development, which helps to achieve the SDG's.

Keywords: Economic Growth, Industrial revolution, Textile industry 4.o. Technology upgradation, Sustainable Development Goals

1. INTRODUCTION
Millennium Development goals (MDGs) are focused on governments, organizations, and individuals where advancement is needed to happen and provide a framework for international cooperation. MDGs have contributed significantly in many sectors and laid the foundation for the SDGs. SDGs provide a universal approach to many concerns, involving a wider array of stakeholders that serve as a foundation for global development initiatives. SDGs place more emphasis on inclusivity, environmental sustainability, and the interconnection of global concerns to build on accomplishments based on the lessons learned from the MDGs. To address global difficulties, acknowledge the links between disparate issues and promote a common commitment to build a more sustainable and equitable world by 2030.SDGs were formulated by 193 UN members to address the global challenges and foster a more sustainable and equitable world.

The framing of the SDGs was driven by a recognition of the need for a coordinated and comprehensive effort to address global challenges and work towards a more sustainable, inclusive, and equitable world. The goals serve as a guiding framework for governments, organizations, and individuals committed to advancing sustainable development. The technology plays a crucial role in supporting

the achievement of the Sustainable Development Goals (SDGs). Here are several ways in which technology can contribute to advancing the SDGs:

a. Data Collection and Monitoring: Technology, including satellite imagery, sensors, and data analytics, facilitates the collection and monitoring of information related to the SDGs. This enables better decision-making, tracking progress, and identifying areas that require attention.
b. Digital Connectivity and Inclusion: Information and communication technologies (ICTs) can help bridge the digital divide and promote inclusivity. Increasing access to the internet and mobile technologies supports the SDGs by improving communication, education, and access to essential services in remote and underserved areas.
c. E-Government and Public Services: Digital technologies can enhance the efficiency and transparency of government services. E-government initiatives contribute to achieving SDGs related to good governance, public service delivery, and citizen engagement.
d. Healthcare Technologies: Telemedicine, mobile health apps, and other healthcare technologies can improve access to healthcare services, especially in remote areas. Technology supports health-related SDGs by promoting good health and well-being (SDG 3).
e. Renewable Energy and Smart Grids: Advanced technologies contribute to the development of renewable energy sources and smart grids. This supports SDG 7 (Affordable and Clean Energy) by promoting the use of sustainable and efficient energy systems.
f. Precision Agriculture: Technology in agriculture, including precision farming techniques, sensors, and data analytics, can enhance crop yields and resource efficiency. This supports SDG 2 (Zero Hunger) by promoting sustainable agriculture.
g. Education Technology: Digital platforms, online learning resources, and educational technology tools can improve access to quality education and lifelong learning opportunities, contributing to SDG 4 (Quality Education).
h. Financial Technologies (Fintech): Fintech solutions, including mobile banking and digital payment systems, can improve financial inclusion and support economic growth, aligning with SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth).
i. Waste Management Technologies: Innovations in waste management technologies, including recycling and waste-to-energy solutions, contribute to SDG 12 (Responsible Consumption and Production) by reducing environmental impact.
j. Blockchain for Transparency: Blockchain technology can enhance transparency and traceability in supply chains and financial transactions, contributing to goals related to responsible consumption and production (SDG 12) and partnerships for the goals (SDG 17).
k. Disaster Response and Resilience: Technology supports early warning systems, disaster monitoring, and response efforts, contributing to SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action).
l. Artificial Intelligence for Sustainable Solutions: AI can be applied to analyze complex data, optimize resource use, and develop innovative solutions for sustainable development challenges, contributing across various SDGs.
m. While technology offers significant opportunities, it is important to consider potential challenges, including ethical concerns, privacy issues, and the risk of exacerbating existing inequalities. Responsible and inclusive deployment of technology is essential to maximize its positive impact on the SDGs. The following are the reasons why SDG should be concentrated largely
n. *Global Challenges*: It provides an outline for addressing global challenges such as poverty, hunger, health related issues, inequality, climate changes and environmental degradation.

o. *Interconnectedness*: The objectives are related to one another because it is understood that advancement in one field relies on advancement in another field. The SDGs will promote a comprehensive strategy for development that considers the interrelationships between the social, economic, and environmental facets.
p. *Universal Applicability*: SDGs are applicable globally and it requires the coordinated efforts of all stakeholders along with the international cooperation too.
q. *Inclusivity*: The goal of the SDGs is to guarantee that no one is left behind in society, and to attend to the needs of underprivileged and marginalized groups. This makes sure that all people benefit from achievements on a large-scale basis and that development activities are equitable.
r. *Global Cooperation:* Global coordination is necessary to accomplish the SDGs because it enables the creation of partnerships and alliances that pool resources, share expertise, and tackle global concerns as a group.
s. *Measurable Targets:* The SDGs are a set of precise, quantifiable targets that provide a framework for monitoring global progress and holding relevant parties responsible. This makes tracking and assessing development initiatives easier.
t. *Time-Bound Goals:* Since 2030 is the target year for accomplishing the SDGs, there is a sense of urgency and a deadline for action. It makes it possible to work quickly and deliberately to meet deadlines for achieving sustainable development goals.
u. *Ethical and Moral Imperative:* The SDGs are based on moral ideals that include human rights, environmental sustainability, and social justice. This demonstrates the need to address moral issues when they influence stakeholders' health.
v. *Corporate Social Responsibility:* Companies who prioritize the SDGs will discover that their goals align with CSR principles. It involves incorporating ethical and sustainable principles into business operations to achieve social and environmental goals.
w. *Public Awareness and Engagement:* The people will be effectively informed about global challenges and inspired to support sustainable development activities by the SDGs.

2.NEED OF THE STUDY

The textile industry is the oldest form of industry that has survived over the decades by adapting the modern manufacturing process which paved the way for ecologically friendly and cost-effective products. The transformation was made possible through innovative technologies such as IoT devices, automated machine processing with Artificial Intelligence and 3D designing, which resulted in high-quality products. In India textiles account for 15% of the GDP and are transitioning to industry 4.O, which mostly works with IoT technology. As a result, it is critical to investigate the necessity of these sophisticated textile technologies as to how they would help the textile industry and the economy of the nation.

3. OBJECTIVE OF THE STUDY

- To explore the industrial revolution and Industry 4.O supports to achieve SDGs
- To examine the relativity of other SDGs on Industry 4.O

4.RESEARCH METHODOLOGY

The research is a conceptual paper that represents the theoretical perspective based on the review of various government records, published sources and databases that has keywords indicating textile, textile revolution, Industry 4.O, Industrial revolution, sustainable development, and SDG.

5. INDUSTRIAL REVOLUTION IN TEXTILE INDUSTRY

The Indian economy depends significantly on the textile sector which is essential to urban and rural development, that makes it vital to enhance the SDG for sustainability and economic progress. The textile industry, in the late 18^{th} and early 19^{th} centuries saw several profound technological, economic, and social advancements through the Industrial Revolution. During the industrial revolution, factory-based and mechanical textile production techniques were replaced with modern methods over conventional methods. This Industrial Revolution in the textile sector has changed economies and opened the door for modern manufacturing techniques that paved the way for industrialization. In addition to bringing up scientific improvements and economic wealth, it also brought up significant social and ethical issues pertaining to labor, working conditions and customs duties.

The industrial revolution in the textile industry has undergone several phases, often referred as "industrial revolutions" or "industry 1.O to 5.O" Each phase of the revolution represents a significant shift in technology, processes and automation involved in the manufacturing process.

5.1 Textile Industry 1.O - Mechanization (Late 18th Century)

5.1.1 Key Innovations*:* The first industrial revolution was marked the transition from agrarian handicraft-based economies to mechanized production and factory-based production.

5.1.2 Textile Impact: The invention of the spinning jenny, water frame and power loom mechanized devices at various stages of textile production has paved the way for efficiency and increased output.

5.1.2.1 Spinning jerry*:* Invented by James, which allows the single operator to spin multiple threats at the same time. It reduces both time as well as labor cost in the textile manufacturing process during this revolution.

5.1.2.2 Water frame*:* Invented by Richard, which allows the mechanized process of spinning cotton to yarn. It reduces the labor cost in textile manufacturing by working fast and 24/7.

5.1.2.3 Power loom mechanized: The power loom mechanized is a key innovation in this industrial revolution which is designed based on automated weaving process.

5.2 Textile Industry 2.O - Mass Production (Late 19th Century)

5.2.1 Key Innovations*:* The second industrial revolution started with the widespread adoption of steam power, electrification, and the development of assembly lines.

5.2.2 Textile Impact*:* Factories became larger and more efficient. Mass production of textiles increased significantly and synthetic dyes were introduced, expanding the range of available colors. Three major transitions happened in this revolution such as Mechanization, Mass production and improvised Communication and logistics system

5.2.2.1 Mechanization*:* This replaces human labor to mechanize the production process.

5.2.2.2 Mass Production*:* This introduces the assembly lines and standardized manufacturing processes, leading to increased efficiency and lower cost.

5.2.2.3 Communication and logistics System*:* This improved the networks and facilitated broader and more interconnected industrial operations.

5.3 Textile Industry 3.O- Automation (Mid-20th Century)

5.3.1 Key Innovations: The third revolution starts with automation and the use of computers marked machines. Computer Numerical Control (CNC) machines and programmable logic controllers (PLCs) became prevalent.

5.3.2 Textile Impact: This introduces the automation process that allows the industry precision of the manufacturing in the textile sector by using the computer-controlled looms and knitting machines that provides improved quality and reduced human labor.

5.3.2.1CNC

A technique termed computer numerical control (CNC) uses computers to manage industrial operations and machine equipment. It entails using computer software that has already been designed to control the motion and functionality of machinery, including routers, mills, lathes, and other machine tools. Numerous industries, including manufacturing, aerospace, automotive, and more, employ CNC systems extensively.

5.3.2.2 PLC

Specialized digital computers called Programmable Logic Controllers (PLC), are utilized in industrial automation and control systems. They are essential for managing equipment and procedures in factories, manufacturing plants and other industrial settings since they are made to function in challenging industrial conditions. PLCs are frequently used to automate complicated and repetitive activities, increasing the efficiency and dependability of production processes.

5.4 Textile Industry 4.O- Digitalization (Late 20th Century - Present)

5.4.1 Key Innovations: The fourth industrial revolution starts by the integration of digital technologies, including the internet, the Internet of Things (IoT) and artificial intelligence.

5.4.2 Textile Impact: Smart textiles, digital design, and Computer-Aided Manufacturing (CAM) became prominent. Supply chains became more interconnected and responsive to market demands.

5.4.2.1 INTERNET OF THINGS

The term IoT in textiles refers to the application of IoT technology to improve several elements of manufacturing, management, and monitoring processes in the textile industry. IoT refers to the process of attaching tangible items and gadgets to communicate and gather data for enhanced productivity and traceability.

5.4.2.2 Computer-aided Manufacturing (CAM)

The term "Computer-aided Manufacturing" implies the use of software and computer technology to assist in planning, directing, and carrying through various production processes in the textile industry. It is essential for automating and streamlining production procedures, which raises productivity, accuracy and quality in the products produced. The textile industry has undergone remarkable transformations throughout all the industrial revolutions, driven by technological advancements needs

and societal wants. Each phase has brought improvements in efficiency, scale, and the overall capabilities of textile production progress.

6. SDG AND INDUSTRY 4.O

Every country has a goal to move forward in the development pathway both in the economic and welfare areas, but in the current scenario, focusing on sustainability is also important. In 2015, 191 members of the United Nations General Assembly framed 17 major SDG goals that must be achieved by 2030 pertaining to environmental, political, and economic challenges. Out of the 17 major goals, the 4 goals pave the way for implementation of the Textile industry 4.O.

Figure: 1 - Relationship of SDG and Textile 4.o

Source: Own

6.1 DECENT WORK AND ECONOMIC GROWTH (SDG no. 8)

The goal mainly deals in promoting sustainable economic growth, inclusive & full protective employment, and decent work for all. Under this, there are 12 targets, 80 events that were conducted and 48 publications were done and 1893 actions were taken. In the India context, progress towards achieving the goal involves several key areas

a. *Economic Growth* - India is experiencing economic growth, but also some challenges such as income inequality persist. Efforts are needed to ensure that growth is inclusive and benefits all segments of the population.

b. *Employment* - India faces challenges related to unemployment and underemployment, particularly among the youth. Policies and programs to generate quality employment opportunities are crucial for the government.
c. *Decent Work* - Ensuring decent work involves addressing issues such as fair wages, safe working conditions and social protection.
d. *Informal Economy* - A significant portion of India's workforce operates in the economy. Efforts to formalize employment and improve working conditions in the informal sector are important for achieving the goals.
e. *Youth Employment* -With a large youth population, providing opportunities for meaningful employment opportunities and skill development is essential for the growth of the economy. Initiatives aimed at enhancing the employability of young people that are aligned with these goals.
f. *Entrepreneurship* - In the modern day, encouraging entrepreneurship and small and medium-sized businesses (SMEs) will help to create jobs that boost the economy. Policies that support an atmosphere that is favorable to entrepreneurship will be in line with the goals of SDG 8.
g. *Global Partnership for Sustainable Development* - India promotes collaboration, technology transfer and capacity building to address global issues in accomplishment of the SDGs.

6.2 INDUSTRY INNOVATION AND INFRASTRUCTURE (SDG No.9)

Enhancing industry, updating infrastructure, and making modern, sustainable, and dependable energy more accessible are the main priorities to achieve GDG No.9. India is pursuing SDG 9 through initiatives and procedures such as

h. *Infrastructure Development* - India made investments in enhancing the transportation, electricity, water, and sanitation systems. Increasing accessibility and connectedness across the country is the aim of these programs.
i. *Industrialization* -Policies and initiatives are currently being created to support industrialization that is both equitable and sustainable. This promotes environmentally friendly industrial practices that adds value to the production process and helps SMEs.
j. *Innovation and Research & Development (R&D)* - In several national domains, India has prioritized innovation and research and development. Two efforts aiming at promoting entrepreneurship, innovation and technical growth are "Make in India" and the National Innovation Mission.
k. *Access to Information and Communication Technology (ICT)* -Increasing access to information and communication technologies is one of SDG 9's primary goals. India has come a long way in terms of attaining digital inclusion by expanding internet and mobile phone penetration.
l. *Renewable Energy and Sustainable Practices* - India has set programs like the National Solar Mission, which promotes the use of clean and sustainable energy sources to achieve SDG 9.
m. *Smart Cities Mission* - The goal of India's Smart Cities Mission is to build high-standard, ecologically conscious, and technologically advanced cities. This includes the infrastructure and innovation components of SDG 9.
n. *Public-Private Partnerships (PPPs)* - PPPs play a vital role in development of Infrastructure facilities in India. Collaborations between the government and private sector entities are required for financing and implementing large-scale projects.
o. *Skill Development*- Skill development initiatives are important that ensures the workforce is equipped with the skills needed for modern industries. Programs such as Skill India concentrate on enhancing the process of employability in the workforce.

p. *Monitoring and Reporting* - Monitoring progress towards SDG 9 involves tracking key indicators related to infrastructure development, industrialization, and innovation. India participated in reporting mechanisms at the national and international levels that assess the progress.

q. While progress has been made, challenges remain, which include the need for sustainable practices, regional disparities and ensuring that the benefits of development are considered. Regular monitoring progress, policy adjustments and continued efforts are essential to achieve the targets that were outlined in SDG 9.

6.3 RESPONSIBLE CONSUMPTION & PRODUCTION (SDG no. 12)

SDG 12 concentrates on ensuring sustainable consumption and production patterns. The objective pushes nations to foster sustainable industrial practices, disentangle economic growth from resource use and lessen the negative effects of production. In India, several initiatives are framed in tune with the SDG 12 and they are

a) *NACC* - India has a National Action Plan on Climate Change (NACC) that focuses on the issues that are related with sustainable development that also includes sustainable consumption and production. This includes strategies for energy efficiency and reduction of the carbon footprint.

b) *Waste Management* - India has improved in the waste management practices to reduce environmental impact. Initiatives such as the Swachh Bharat Abhiyan, concentrates in promoting cleanliness and proper waste disposal.

c) *Resource Efficiency* - India has initiated the policies and incentives such as Natural Resource Efficiency Policy (NREP), Perform, Achieve and Trade (PAT) scheme, waste management rules that support resource efficiency which aim at effective usage of resources that are available within the country border.

d) *Renewable Energy Transition* **-** India is making strides in transition to renewable energy sources, such as solar and wind power. This transition contributes to sustainable energy consumption and production practices.

e) *Green Technologies and Innovation* - India has framed policies & initiatives that support the adoption of green technologies and innovation to promote sustainable practices in industries like Atal innovation Mission, FAME India, Pradhan Mantri Ujjwala Yojana. The emphasis on innovation aligns with the objectives of SDG 12.

f) *Corporate Social Responsibility (CSR)* - The CSR initiatives of companies operating in India often include projects related to sustainable development and involve activities such as environmental conservation, promoting sustainable agriculture, and supporting local communities.

g) *Consumer Awareness and Education* - India has initiated schemes such as Beti Bahao Beti Pdhao and Sarva Shiksha Abhiyan that are important for achieving SDG 12. Education campaigns and advocacy play a role in promoting responsible consumer behavior.

h) *Circular Economy Initiatives* - Government has taken initiative to promote products to enhance the circular economy, where products are designed in such a way to be reused, recycled, or repurposed, to contribute to SDG 12. This includes initiatives that will reduce the single-use plastics and promote recycling of products.

i) *National Green Tribunal (NGT)* - The NGT in India plays a vital role in addressing environmental issues and promoting sustainable practices. It considers the matters that are related to environmental protection and conservation.

j) *International Collaborations* - Government of India encourages industry to collaborate with international organizations which includes sharing of the best practices with other countries.

6.4 PARTNERSHIPS FOR THE GOAL (SDG No. 17)

SDG 17 emphasizes the requirement of global partnerships which requires collaboration among the government sector, the private sector and civil society at both the national level and international levels. Here are some of the aspects of SDG 17 in the context of India:

a. *Global Partnerships* **-** India is actively engaged in global partnership that address the common challenges that are related to sustainable development goals. This involves collaboration with other countries, international organizations, and non-governmental entities.
b. *Foreign Aid and Assistance* **-** India is a recipient and provider of foreign aid and assistance. As a growing nation, it is contributing to global developments by participating in international forums on various issues.
c. *Technology Transfer* - Transfer of technology is a crucial component of SDG 17. Through partnerships and cooperation, including technology exchange with foreign countries, India aims to improve its technological skills.
d. *Trade and Economic Partnerships* - Through promoting economic growth, trade agreements and partnerships support SDG 17. India participates in trade agreements on a regional and international level to promote economic cooperation.
e. *Capacity Building* - India engages in capacity-building programs and imparts its knowledge to other developing countries to help them realize their aspirations in fields like technology, healthcare, and education.
f. *Official Development Assistance (ODA)* - India is the recipient of official development assistance from various nations and global institutions. The initiatives and programs that attempt to address social and economic issues will be supported by this aid.
g. *Data Sharing and Monitoring* - The significance of data and monitoring for sustainable development is emphasized in SDG 17. India takes part in international initiatives to gather, examine, and disseminate data about the SDGs, helping to make progress and obstacles more understandable.
h. *Climate Change Mitigation and Adaptation* - Collaborative efforts with other countries are essential for addressing the impacts of climate change. In this regard, India actively engages in global discussions on climatic changes and participates in international agreements which includes the Paris Agreement.
i. *United Nations Development Program (UNDP) and Other Agencies* - India collaborates with UN agencies and other international organizations like the UNDP, to implement and support the projects that align with the SDGs goals.
j. *Corporate Social Responsibility (CSR)* - Companies that are operating in India engage in the corporate social responsibility activities that will contribute to the achievement of the SDGs, which include the partnerships with non-governmental organizations and community development initiatives.

7. INDUSTRY 4.O AND SDG

Industry 4.O is considered as the 4th revolution, which is identified by integration of digital technology, the Internet of Things, data analytics, artificial intelligence, and related advanced technologies in various sectors. The connection between the SDGs and Industry 4.O revolution lies in

the potential of technological advancements to contribute positively toward achieving sustainable development. Here are some ways in which Industry 4.O and SDGs are related:

a) *Innovation for Sustainable Practices:* Industry 4.O revolution enables innovative and more sustainable practices in manufacturing and other related sectors. For example, smart manufacturing processes will optimize resource use, reduce waste, and enhance energy efficiency, contributing to Responsible Consumption and Production - SDG 12.
b) *Efficiency and Resource Optimization:* Automation, data analytics and IoT in Industry 4.O revolution will lead to increased efficiency in resource utilization. This will also align with SDGs related to responsible consumption, sustainable production, and environmental sustainability.
c) *Energy Integration:* Industry 4.O revolution will facilitate the integration of renewable energy sources into the manufacturing processes sector. This will encourage SDG 7 (Affordable and Clean Energy) by using clean and sustainable energy.
d) *SCM Transparency:* Blockchain and other digital technologies associated with Industry 4.O revolution will enhance supply chain transparency. This is crucial for achieving goals related to SDG 12 and ensuring fair labor practices SDG 8.
e) *Inclusive Economic Growth:* Industry 4.O revolution has the potential to foster inclusive growth of the economy by generating job opportunities and promoting innovation. This aligns with SDG 8.
f) *Health & Safety Improvements:* Automation and robotics in Industry 4.O revolution will lead to safer working environments, reduced workplace injuries, and promotes the health and well-being of workers SDG 3
g) *Data for Decision-Making:* The data-driven Industry 4.O will allow for better decision-making and resource allocation. This supports various SDGs by enhancing the effectiveness of development initiatives.
h) *Smart Cities and Infrastructure:* Industry 4.O revolution technologies will contribute to the growth of smart cities and infrastructure, aligns with SDG 11 (Sustainable Cities and Communities).
i) *Global Collaboration and Connectivity:* Industry 4.O revolution fosters global connectivity and collaboration. This will facilitate the exchange of knowledge, technology, and resources, supporting SDG 17.
j) *Circular Economy Practices:* Industry 4.O revolution will support the transition to a circular economy by promoting the reuse and recycling of materials. This aligns with SDG 12.
k) Industry 4.O revolution will provide opportunities for positive contributions to the SDGs, it is essential to consider potential challenges such as job displacement, data privacy concerns and the digital divide. Effective policies, regulations and ethical considerations are important to harness the benefits of Industry 4.O in a way that aligns with sustainable development goals.

8.CONCLUSION

The SDGs were developed to maintain the sustained sustainability of the country's financial, social, and environmental attributes. Every member nation had devised a variety of growth-oriented initiatives to attain the aims and targets of SDGs. In this context, the Industrial Revolution had a crucial role in the development of the economy and advancement in technology. Textile industry being one of the dominant factors with all-around performance in terms of export, textile 4.O, GDP, job prospects, and so on, SDG is more suitable for this, including Goals 8, 9, 12, and 17. Finally, the industry's emphasis on job creation and skill development, which helps to achieve the Sustainable

Development Goals. India's textile sector is going through a revolutionary period characterized by SDG alignment, sustainable practices, and technology breakthroughs. Maintaining the sector's commitment to responsible production and consumption is essential to tackling social and environmental issues and providing economic growth. Sustained endeavors in this regard are imperative to augment the sector's advantageous influence on India's sustainable development.

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