



# Industry 4.0 sustainability in supply chain

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## Abstract

Globalization now has the difficulty of meeting the ever-increasing global demand for capital and consumer products while also preserving the social, environmental, and economic sustainability of human life. To meet this challenge, industrial value creation must be oriented toward long-term sustainability. Currently, the early industrialised nations' industrial value creation is defined by the transition to the fourth stage of industrialisation, known as Industry 4.0. This invention opens up a plethora of possibilities for achieving sustainable production. Based on recent researches, this research will give a state-of-the-art review of Sustainability in supply chain with application Industry 4.0. This research finds out the importance and implication of industry 4.0 application as a specific opportunity for sustainability in supply chain.

Key Words: Sustainability, industry 4.0, Supply Chain.

## 1. Introduction

### 1.1 Industry 4.0

In today's scenario the primary goal of company is to increase their profit. The transition to the fourth stage of industrialisation, known as Industry 4.0, is now shaping the generation of industrial value in the early industrialised countries. This development followed the third industrial revolution, which began in the early 1970s and was centred on the use of electronics and information technology to achieve high levels of factory automation.

The transition to Industry 4.0 is already having a significant impact on the supply chain. It is built on the creation of smart factories, smart goods, and smart services, all of which are integrated in an internet of things and services, also known as the industrial internet. In addition, these Industry 4.0 aspects are spawning new and disruptive business models. This shift to Industry 4.0 opens up a plethora of possibilities for achieving sustainability via the use of ubiquitous information and communication technology (ICT) infrastructure. Based on recent research and practises, this paper will give a state-of-the-art review of Industry 4.0. Industry 4.0's macro and micro views will be depicted and explored in this conceptual research paper which reflects and brings out the sustainability in supply chain.

Due to industrial development the nature has suffered a lot of exploitation such as climate change which is leading to excessive utilization of natural resources and resulting to the supply chain focussing only on economic targets has lost its rationality because it has to meet unlimited consumption of the economy the value of renewable resources and the issue of production using less harmful methods to nature have gained importance as the world cannot be a place to live without the sustainability of natural resources and the cooperation of all individuals, states and companies hence sustainability and environmental stability has become the major importance.

The aim of sustainable supply chain management is to provide information, materials, capital flow to reach social, environmental and economic goals while meeting the expectations of stakeholders in the supply chain network from suppliers to customers. New regulations in sustainable supply chain are made compatible with using environmentally friendly materials carbon emissions and ecological footprint to minimize pollution with waste management activities and promote recycling.

Industry 4.0, focus on integration of production with Information Technology. Due to technological factor the concept of industry 4.0 will be able to practice sustainable management strategies in complete supply chain. Industry 4.0 is directly related to sustainability performance (working conditions, working hours, skills, health and safety), this research paper will talk about positive and negative relationships (Stock et al., 2018; Bermer, 2015; Isaias et al., 2015; Beier et al., 2017). Industry 4.0 is enabling machines in the factory to become independent so that these machines can plan, program and produce goods automatically without operator. It improves flexibility in production which leads to an increased customization of products.

## 1.2 Sustainability

A paradigm is Industry 4.0 will pave the way for increased long-term industrial value development. This phase is mostly described in contemporary literature as a contribution to the environmental factor of sustainability. On the basis of intelligent cross-linked value creation modules, the allocation of resources, such as goods, materials, energy, and water, may be done more efficiently.

Aside from these environmental benefits, Industry 4.0 presents a significant possibility for achieving long-term industrial value creation in all three dimensions of sustainability: economic, social, and environmental. The prospects of sustainability in supply chain from an Industry 4.0 can be understood in the literature review below.

Environmental sustainability- this concept means to live within our environmental resources living in green environment bringing out sustainability ensures that the industry is consuming the natural resources like land, water, fuel etc. Hence to have a proper and bring about an optimum utilization of environmental factors the technology of industry 4.0 has given its huge contribution.

Economic sustainability means to utilize the natural resources in such a way that it bring about an operational profit to an organisation. When the organisation is earning on an average operational profit it cannot sustain its activities hence it is required to attain a good financial return so as to maintain an economic stability.

Social sustainability in respect to the organisation means that the company is using its resources in such a way that is benefited to the society and is according to their well-being. Achieving social sustainability ensures that the social well-being of a country, an organisation, or a community can be maintained in the long term.

## 2. Literature Review

Industry 4.0 and Sustainability has been given the major importance in this literature review using different perspectives to describe the concept of industry 4.0 and sustainability various literatures has been reviewed and summarized. (Kamble et al., 2018) gives his opinion on industry 4.0 developing a framework and

proposing that Industry 4.0 technologies aid process integration (human machine and shop-floor) leading to environmental and economic sustainability and automation and process safety. He said that Industry 4.0 relates to single economic outcome (cost, flexibility, productivity). Bag et al. (2018) identified various factors enabling supply chain sustainability in Industry 4.0 such as governmental support and technological standards, management commitment that leads to increased sustainability in an Industry. Industry 4.0 employs a variety of technologies. The internet of things (IoT), big data, smart manufacturing, and cyber physical system are the technologies. They investigate the functioning model and architecture of each of these technologies. The supply chain management concept and its levers, such as procurement, production, warehousing, logistics, and fulfilment, were investigated further. Following the collection of data from each and every element, a further investigation is conducted to determine the influence of Industry 4.0 on supply chain management. The study comes to a conclusion with an understanding of how the industry 4.0 technological revolution is impacting and bringing about a change in supply chain sustainability.

In the context of sustainability, this study of (Naseem & Yang, 2021) presents a literature overview, previous and current insights, and understanding about supply chain 4.0 and Industry 4.0. According to the literature, Industry 4.0 has a substantial influence on the supply chain network's long-term viability. This report also outlines the many Industries 4.0 technologies that contribute to the supply chain's long-term viability in company. This research examines a total of 55 publications. We suggested a paradigm for assessing the impact of Industry 4.0 technology on supply chains. The systematic literature review technique in Industry 4.0 and supply chain sustainability was applied in this research study. The information was gathered from databases (ScienceDirect, IEEE Xplore, and Google Scholar).

The industry 4.0 enablers of supply chain sustainability and to provide a research methodology to fill in the gaps in theory (Bag et al., 2018). The review uncovers several fascinating insights that will benefit the scholarly community. There has been little study on using Industry 4.0 technology to manage supply chain network sustainability. Only 10 papers out of a total of 53 papers focused on smart manufacturing, smart production systems, smart warehouse management systems, smart logistics, and sustainability, according to the authors. The social dimensions of supply chain sustainability have been largely disregarded in prior research projects. Finally, the authors identified 13 essential Industry 4.0 enablers that are critical to supply chain sustainability.

Beltrami et al. (2021) presents the state of the art concerning interrelations between Industry 4.0 technology and sustainability theory is summarised in this study. The basis for this inquiry was built by a targeted and thorough literature evaluation of 117 scientific papers. Industry 4.0 and sustainability performance; Industry 4.0 and sustainability practises; Industry 4.0, sustainability practises, and sustainability performance; and moderating variables were highlighted as four main topics. Following that, these challenges were defined and discussed in depth, with relevant research explicitly recognised.

### 3. Industry 4.0 enabling supply chain sustainability

In order to bring about a sustainable supply chain **6R** (i.e. reduce, redesign, reuse, recover, remanufacture and recycle) has been given the major importance and a complete emphasis on using closed loop product life-cycle management system which will minimize the damage caused by chain activities to the environment. As per the above literature review it has been determined that use of industry 4.0 technologies in companies will enable sustainable supply chain so as to optimize environmental, economic and social aspects. Some of the benefits of Industry 4.0 are as follows:

**Increase in Compatibility:** Previously, manufacturing companies primarily outsourced to regions where low-wage workers were available in order to stay competitive. To compete again, they are now investing on technology rather than pay. As a result of this technical improvement, all manufacturers are choosing locations based on technological development, client base, and demand research.

**Increase in Productivity and economic stability:** Automation, machine learning algorithms, robots, and analytics minimise human effort to complete the same task with low time and high accuracy in the end output. Human personnel are solely used to monitor and maintain the system.

**Increase in Profit & Revenue:** Industry 4.0 is not just a method for increasing production unit efficiency, but it also aids in preventative and predictive maintenance, as well as updates as needed. As a consequence, the company's profitability and revenue are increased while capital expenditure for production units is reduced.

**Optimisation in manufacturing process leading to environmental stability:** Closer cooperation along the whole supply chain becomes feasible with more connection, shared data, and improved analytics, which might contribute to higher efficiency, optimization, and innovation in the manufacturing business in the long term. Integrated systems and machine-to-machine communications will encourage more collaboration among manufacturers, suppliers, and other stakeholders along the value chain.

**Easing the tracing & record keeping:** The usage of big data with cloud computing Machine data may now be stored quickly and simply, making it accessible to everybody. It allows for the examination of any form of data from any machine at any place. This digital record-keeping will improve traceability while lowering liability, warranty costs, and recalls.

Despite these benefits, the transition is still in its infancy. However, it is obvious that Industry 4.0 and its technical advancements will be implemented by all organisations and industries globally in the near future. Below is the figure to have an overlook towards the supply chain sustainability.

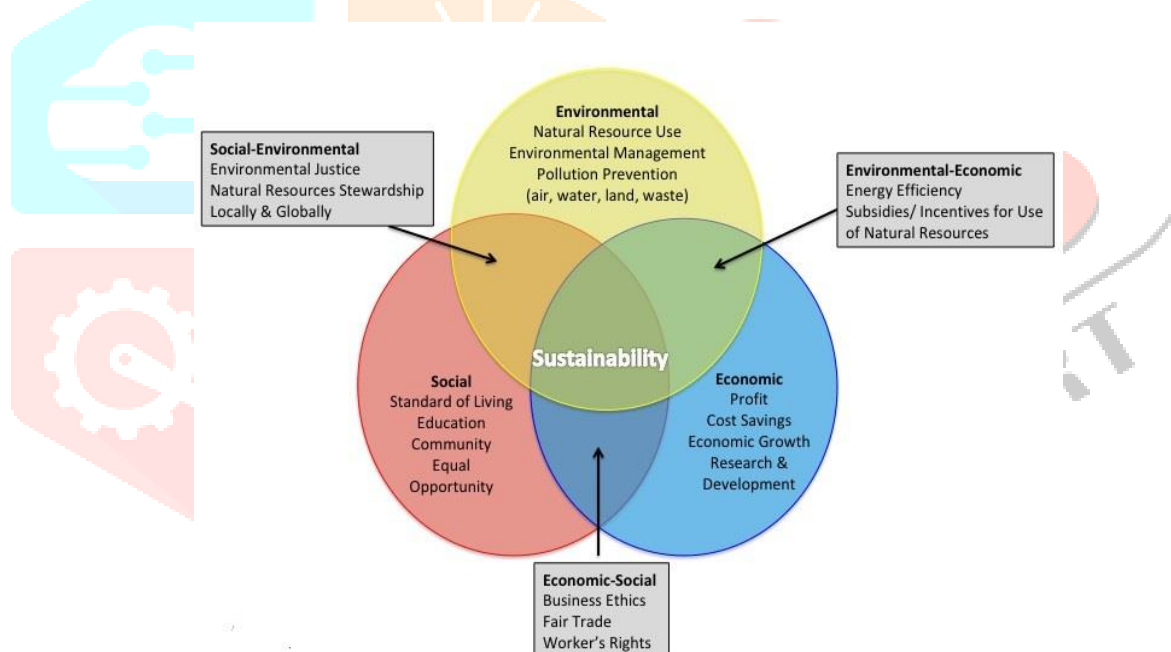


Figure 1 Supply chain sustainability

### 3.1 Opportunities of sustainability from macro perceptive

#### 3.1.1 Manufacturing Business Models

In the era of Industry 4.0, the new business model is strongly driven by the use of Intelligent Data to deliver new services. It is important to use this development to establish a new sustainable business model. A

sustainable business model will significantly increase or mitigate the negative impact of on the environment and society. Or you can do that fundamentally. Contributes to the solution of ecological or social problems. In addition, sustainable business models inevitably feature long-term competitiveness. In this context, the main concept is not only to sell the tangible product, but also to sell the features and accessibility of the product.

### 3.1.2 Networking value creation

Networking of the Industry 4.0 Value Creation Network offers new possibilities for the life cycle of closed products and the symbiosis of industry. This allows you to efficiently adjust products, materials, energy, and water. Flows throughout the product life cycle, and flows between different factories. The closed product lifecycle helps keep a product into a multi-use phase lifecycle with refurbishment or reuse. Industrial Symbiosis describes the (inter-company) cooperation of various factories to achieve a competitive advantage through the trading and exchange of products, materials, energy, water, and intelligent data at the local level.

## 3.2 Opportunities of sustainability from micro perceptive

### 3.2.1 Improvement in Equipment

Factory production equipment is often a long-lived capital good of up to 20 years or more. Modifications provide an easy and cost-effective way to upgrade an existing production system with sensors and actuators and associated control logic to overcome system inhomogeneities in the factory. Therefore, retrofitting can be used as an approach for implementing CPS on value-added modules such as factories with existing production equipment. This can extend the stage of use or facilitate the use of means of production in the new stage of use, which can make a significant contribution to the economic and ecological aspects of sustainability. This is especially suitable for small businesses as it is a cost-effective alternative to buying new production equipment.

### 3.2.2 Human Management

In Industry 4.0, people will also be the organizers of value creation. Three different sustainable approaches can be pursued to address the social challenges of Industry 4.0.

- (1) Increase the training efficiency of workers by combining new ICT technologies. Virtual reality head-mounted display with learning tools.
- (2) Increase essential motivation and promote creativity by establishing a new CPS-based approach to work organization and design. B. Implement the concept of flow theory or use new ICT technology to implement the concept of gamification to support decentralized decision making.
- (3) Improving external motivation by introducing individual incentive systems to employees. It takes into account smart data within the product lifecycle and provides individual feedback mechanisms.

### 3.2.3 Improvement in Organisation

A sustainable-orientated decentralized business enterprise in a clever manufacturing unit specializes in the green allocation of merchandise, materials, energy, and water via way of means of deliberating the dynamic constraints of the CPS, e.g., of clever logistics, the clever grid, the self-enough supply, or the customer. This idea of holistic aid performance is being defined as one of the important blessings of Industry 4.0.

**Process Improvement:** The sustainable layout of approaches addresses the holistic aid performance method of Industry 4.0 via way of means of designing suitable production technique chains or via way of means of the usage of new technology inclusive of internally cooled tools.

**Product Improvement:** The method for the sustainable layout of merchandise in Industry 4.0 specializes in the belief of closed-loop existence cycles for merchandise via way of means of allowing the reuse and remanufacturing of the precise product or via way of means of making use of cradle-to-cradle principles.

Different techniques additionally cognizance on designing for the health of the consumer. These standards may be supported via way of means of the software of identity systems, e.g., for convalescing the cores for

remanufacturing, or making use of new extra offerings to the product for attaining a better degree of wellness for the customer.

#### 4. Discussion

As per the reviews on the relationship between Industry 4.0 and sustainability provides the determined area for future research. According to the previous researches there is a lack of empirical study most of the descriptions and contributions are conceptual or qualitative. Study related to empirical quantitative approach is missing; theory building oriented research is also rare. Muller et al., 2018 said that only one study empirically surveys the relationship between Industry 4.0 and three dimensions of sustainability which focuses on opportunities and challenges of industry 4.0 whether it has positive or negative impact on manufacturer to implement industry 4.0. The research paper is giving greater attention on positive aspects of Industry 4.0 (profitability of Industry 4.0 technologies) and forgetting its weakness (high implementation cost). This study points out the technologies lead to variety of environmental and social benefits (such as health and safety gains or resource) but focus on negative effects.

There are many studies focussing on impact of Industry 4.0 on supply chain sustainability but very few researches done on sustainability as a driver for Industry 4.0 implementation.

#### 5. Conclusion

The main objective of the research is to identify the impact of industry 4.0 on sustainability in supply chain. This study explores various parameters for implementing Industry 4.0 in industry to attain sustainability. Industry 4.0 is still in development. The implementation of Industry 4.0 connects people, machines and objects to self-fulfilling real-time systems, creating a value chain between companies that impacts the entire supply chain.

Industry 4.0 adds some benefits to the supply chain. All suppliers, manufacturers, logistics, warehouses and fulfilment are more transparent and accurate, and unnecessary costs are overcome. Progress engines help to predict the demand for various products with high accuracy. High connection and cooperation between all supply chain levers to take the next level of supply chain, the sensor tracks the flow of the product and supplies the relevant information in real time, so increasing the bearing function such as the sensor. It also enhances agility by using integrated procurement-to-consumer data in the “Supply Chain Cloud” to enable all shareholders to make decisions with all factors in mind.

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