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The Role of Industry 4.0 as a Driver to Sustainable Development Goals - A Critical Review

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ABSTRACT

Due to the ever-increasing challenges associated with escalating environmental damages, resource depletion, poverty and inequality, the importance of the concept of sustainable development and its applications becomes necessary in the manufacturing sector. The industry 4.0 is a revolutionary concept which encompasses the continued progression of technology leading to human-free production processes and intelligent machines. The Sustainable Development Goals set out by the UN are adopted as 2030 agenda for sustainable development. The objective of this paper is to identify the applicability of the technologies under industry 4.0 to achieve the global goals (or SDG's) particularly in Indian context. The initiatives like 'SAMARTH – Udyog Bharat 4.0' have been initiated in India to make manufacturing companies aware about industry 4.0 and adopt it, to help make the companies and India as a whole, to achieve the development goals. This paper is a part of the literature review which is carried out as a preliminary phase, which aims to bring out the various variables and their role in establishing a relationship between industry 4.0 and adoption of SDGs. The paper will also bring out the challenges faced by the manufacturing sectors in India and how industry 4.0 can help to overcome them, thus, contributing to achieve the SDG's.

Keywords: Sustainability, SDG's, Industry 4.0

INTRODUCTION

Industry 4.0

The 18th century marked the beginning of the industrial revolution as the Industry 1.0 which led to increase in production and urbanization. Since then ideas and innovation have led to technological advancements.

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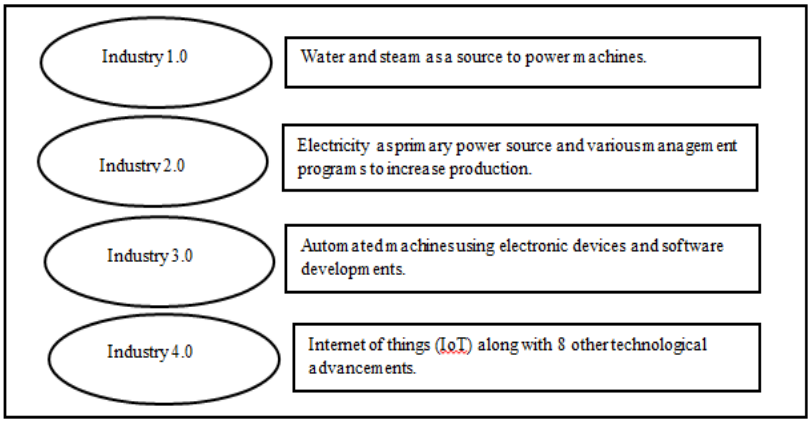

Figure 1: Industrial Revolution advancement

The figure 1 illustration on the different advancement stages in industrial revolution. The fourth industrial revolution or industry 4.0 is a technological revolution that that brought smart factories which has the flexible mass production capacity along with customized product feature. According to R. Tsvetkova, there are nine technological advancements that have created the fourth revolution or Industry 4.0. Figure 2 represents the advancements leading to industry 4.0. Apart from the nine technologies, artificial intelligence and blockchain eventually became a part of industry 4.0.

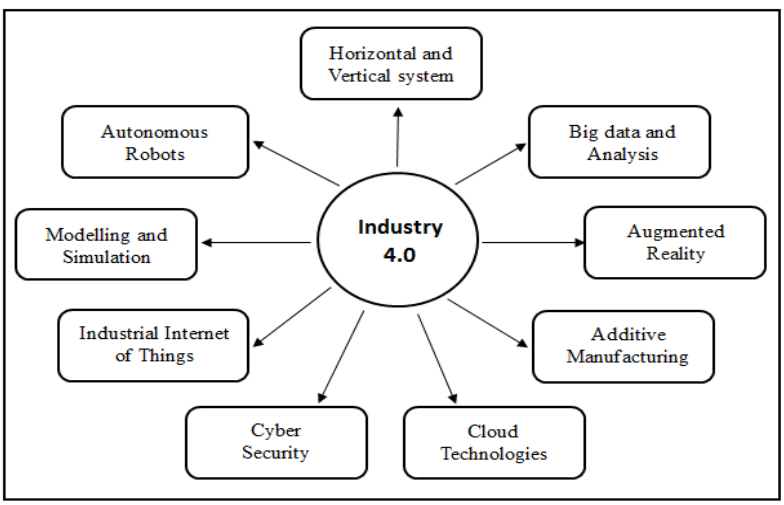

Figure 2: The nine technological advancements leading to Industry 4.0 [1]

INDUSTRY 4.0: AN INDIAN PERSPECTIVE

The mid of 1960's saw many manufacturing companies automating the process with the introduction of industry 3.0, however the manufacturing companies in India preferred to remain in industry 2.5 due to low cost labor availability. In 2011, with the introduction of industry 4.0, the Indian companies are still reluctant to adopt the technology advancements of the fourth industrial revolution. Lack of awareness and skill set, systematic approach towards updating technology, lack of investment is some of the reasons for the non-acceptance of Industry 4.0 [9]. The government has to play a critical role to overcome the problem. As per the statistics of 2018-19, the contribution of agriculture and allied sector, industry sector and service sector to the Indian economy where 17%, 29.6% and 54.3% respectively [5]. The Indian government has undertaken initiatives like 'Make in India' to make India a manufacturing hub. Digitization will play a key aspect to fulfill the goal. The programs like 'Digital India' launched by Government of India and 'Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH) Udyog Bharat – 4.0' an initiative of Department of Heavy Industry aims to educate the manufacturing companies about industry 4.0 and the way it will make the current process run in a Smart and Intelligent manner by decreasing maintenance cost, inventory or product wastage, machine downtime and increasing productivity and product quality[6]. The Aadhaar is seen as one of the world's largest digital identification program undertaken by the Unique Identification Authority of India. As per a report by McKinsey states that India is has a fast-growing market for digital consumers with 90% growth in country's digital adoption between 2014-17. Digitalization has to potential to create 65 million job by 2025 [24].

SUSTAINABLE DEVELOPMENT GOALS

The world population is growing day-by-day and the world population is predicted to reach 10 million inhabitants which means that the demand for the basic human needs (that is., water, shelter, food and clothing) will also

increase [2]. In order to match the demand with supply more resources from the earth will be exploited resulting in consequences like climate change and earth overshoot day. As the GAIA theory states that, "All the elements (living and non-living) in the nature are interconnected", thus, a sustainable balance needs to be maintained with the use of resources. Sustainable development means doing more with less that is use of recycled and reused raw materials and products instead of virgin material.

The Sustainable development goal (or SDG's) are the global convention which is adopted as the 2030 agenda for sustainable development by the 193 UN members in the year 2015. Each of the 17 goals have targets and to measure the progress of each target there are indicators. In total there are 169 targets and 230 indicators [3].

SUSTAINABLE DEVELOPMENT GOALS: AN INDIAN PERSPECTIVE

The second most populated country in the world, India is facing unprecedented problems like drought, reducing water and air quality, solid waste management and poverty due to unsustainable practices in various sectors. According to a report by Global Footprint Network and the Confederation of Indian Industry, the country's ecological footprint has doubled since 1961 and it demands two India's to full-fill the bio-capacity of the consumption and absorb the waste [7]. According to Sustainable Development Report 2019, India has an SDG global rank of 115 [8]. The recent assessment shows the performance of India as per the indicators of the 17 SDG's. The assessment shows that 9 among the 17 goals have major challenge.

INDUSTRY 4.0: A TOOL TO FULL-FILL SDG'S IN INDIA

1. Sustainable Agriculture

Agricultural sector is a primary source of employment for almost 58% of the population and it contributes 17% of the Indian GDP. India is the largest producer of pulses, dairy products, jute and spices, and second largest producer of rice, wheat, sugarcane, groundnut, vegetables, fruit and cotton [11]. But the sector is has seen a decline in production due to unsustainable and unscientific ways of agricultural practices like use of chemical fertilizers and pesticides on plants, inadequate storage and transportation facilities, lack of connection between market and the farmer. The climate change is also posing a major problem for the agricultural sector which results in flooding due to heavy rains, drought due to heat waves and soil erosion.

Among the industry 4.0 technologies, IoT and big data and analysis emerges to improve the current agriculture to sustainable agriculture thus increasing the productivity and bring a positive impact on the environmental by optimizing the resource use. The concept of agriculture 4.0 has evolved from industry 4.0 which integrates the technology of industry 4.0 with the agricultural practices. The IoT technology connects the agricultural equipment over a network to achieve a connected value chain [9]. The technology uses sensors to get the real-time data from the field like humidity, temperature, soil structure, moisture content in soil and fertilizer amount. This data is sent to decision making system which compares it with the data in cloud and the weather conditions. After comparison, the farm equipment's controlled by actuators perform the necessary tasks. Thus, saving on fertilizer and pesticide run-off, energy and water [10]. Cloud computing can also be used to store the data like location of agriculture, soil type, amount of inputs like fertilizer and water used for the production, etc. These can data can be made available in the public domain from where consumers can know about the produce using blockchain technology. The data can also be used the IoT sensors in the field to compare and vary the amount of inputs for the production. Thus, IoT technology can help build a sustainable agriculture with which SDG 1, SDG 2, SDG 6, SDG 7 SDG 8, SDG 12, SDG 13 and SDG 15 could be achieved.

2. Sustainable Supply Chain Management

The supply chain is network which begins from the raw material acquisition and ends at the consumers table. Along with the acquisition, manufacturing and processing, storage and distribution and sales being a part of the supply chain makes it complex and difficult to manage. The industry 4.0 technologies integrated with the supply chain management could help overcome this problem and led the way to make the chain sustainable. Digitization in supply chain management can provide transparency and aid to improve decision making process.

In food supply chain, the current practices have led to food wastage, food spoilage and intermixing that occur mainly during the transient of the processed food. The farmers also lack the information about the market availability and requirements which results in demand-supply gap and a lot of wastage. These wastages also have led to increasing greenhouse gas emissions especially methane. A group of researchers have identified IoT, Automation and Robotics, Cyber-Physical system, Big data, and Cloud computing as five technologies that can help make the food supply chain sustainable [13]. Apart from these blockchain technology can be used to increase the transparency of the supply chain by making the consumers aware of the source of food, way of production, inputs during the production, etc. It can help reduce food wastage by connecting the source where food is abundant to those with scarce/no food supply. It can be also help trace back the spoiled food back to the source thus preventing health related issues [22]. The blockchain technology can play a major role of connecting the farmer to the consumers. The farmers can know the market (or consumer's) demand though a common digital platform and accordingly fulfill the gap [22]. The platform can also be used to sell disrupted (not in expected shape) vegetable and fruits can be to juice companies instead of them being wasted at the market place due to lack of buyer.

In construction supply chain, with each project being unique and customized look, faces problems like raw material acquisition, internal

communication issues due to involvement of various services (namely, electrical, mechanical, civil, labor supply, etc.), wastage and debris issue [12]. Industry 4.0 technologies can help the supply chain to become sustainable. Big data and analytics can better organize the data hence helping the higher officials to accurate decisions [26]. Blockchain technology can increase the traceability of the raw material (RM) supply and keep a check on the RM stock availability. Argument reality (AR) can be used to give the consumer or the client a experience of the final product thus eliminating the chances of dissatisfaction or wastage [26]. The demonized waste debris being the greatest problem, autonomous robots can help in analyzing the quality of the debris and blockchain can be used to connect the source of debris with those required.

3. Sustainable fishery

Seafood is an integral part of nutritional value and its demand for it is increasing day-by-day. India with the coastline length of 7516.6 km, fishery is an emerging sector. It is the second largest producer of fish and accounts up to 5.23% share in agricultural GDP [23]. The sector has provided employment for over thousands of people. The marine life also plays a vital role in keeping a balance in the ecosystem and sustaining life. But the increasing demand has led to unregulated, illegal and unreported fishing. Overfishing along with problems like marine litter, global warming and climate change the fish population has been decreasing over years. To overcome the problem of over and unregulated fishing, traditional practices of putting up observers and depending on log book records are followed in order to get information regarding the landings, catches, location of fishing and discards due to bycatch. With the increasing concerned, initiatives like protective marine areas have been taken up for the fish to regenerate. But not all area could be kept under check thus technologies like Artificial intelligence (AI) combined with big data and analytics could emerge as a solution for sustainable fishing. The AI could analyze the market demand and according advice the fisherman

about the catch for a day. An AI system can track the location of fishing, amount of catch, types of catch and discards. These data could be analyzed and combined in a meaningful form by big data technology. This data could be made available in a public platform enabling the government, consumer and retailers know about the catch. The systems could improve the traceability in seafood by helping the consumers know about the catch [25]. Thus, the Al along with big data and analytics could aid in maintaining an electronic log book in which all the activities could recorded and managed automatically without any alterations. The poaching of fishes could also be tracked by using AI as a tool.

The fisherman needs to be primarily educated about the need for this integration and also trained for an optimal use of the technology. On the other hand, the consumers must be educated and motivated to change the fish-eating behavior, since each type of fish has its own breeding season (or month) which help recover and maintain the fish population.

4. Creating a Circular Economy

The world has started to witness the challenges that is being created by the current linear economy of 'Take-make-dispose' principle and it has slowly started to move towards a circular economy. India is no behind with this regard. The country is currently generating 62 million tonnes of waste per year. The circular economy is still an early stage India and people believe it to be only recycling. But it is much beyond that. It is about not generating any waste and keeping the material, component or a product in the loop. The Ellen Macarthur foundation defines circular economy as "a principle of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems" [14]. In circular economy waste is seen as a resource. It has two cycles namely, technical cycle and biological cycle. The biological cycle takes in organic waste which is processed by cascading, anerobic digestion, biochemical extraction process whereas the technical cycle processes non-organic waste by processes like maintenance, reuse, refurbish and recycling. The

cycles fed the material at appropriate level after necessary processing. The materials that does not fit into either of these cycles are used for energy recovery by incineration. Digitalization could be an opening way for India to build its path towards circular economy. It could help business increase resource and energy efficiency, reduce wastage and increasing the production by better monitoring the process and the logistics route could be efficiently designed ensuring that the loop is closed [19]. For the waste to be converted to a resource to be fed back into the loop, it much be primarily identified, segregated and sent to appropriate industry for being processed into a new product. The segregation system in India is poor with mostly manual sorting system. This creates a gap resulting in the resource going to the landfill. Robotics and artificial intelligence (AI) could emerge as a solution to the problem which compares the object's characteristics with the standard characteristic data stored using cloud technologies. With the primary principle of circular economy being designing the products for being returned back in the loop, modelling and simulation plays a major role to fulfill this. Optimizing can also be conducted using simulation as a tool thus preventing on wastage. Reverse logistics remains a major challenge in India due to lack of proper supply chain management. Blockchain evolves as a solution to the problem. The technology can help track the material, component or product from the sourcing till back to the source thus completing the loop of circular economy. The predictive manufacturing is becoming a requirement in manufacturing sectors. This has the potential to make the industry safe, energy efficient, cost efficient and resource efficient by extending the machine's lifetime. Cloud computing, industrial big data and smart factory (or IoT) has the ability to make it possible [20]. A group of researchers have also analysied the potential of Industrial Internet of Things, Cloud Computing, Cyber-Physical Systems and Machine learning as an means in predictive maintenance [21]. Additive manufacturing (or 3D printing) can play a major role in utilizing the waste to produce useful products after the waste collection, sorting and treatment processes [15]. Another group of researchers have adopted the ReSolve framework (Regenerate, Share, Optimize, Loop, Virtualize and Exchange) and the industry 4.0

technologies (namely, Cyber-Physical Systems, Cloud Manufacturing, Internet of Things and Additive manufacturing) to develop a matrix of relationship between them in the three stages of product loop (that is., design, production and reverse logistics) to achieve a sustainable operation management [16]. India being an emerging economy with businesses beginning to adopt circular economy, decision making is an important aspect of the business. But with abundance of data available from finance, production and logistics department, big data and analytics plays a major role as a facilitator assist in decision making process [17]. Song B., et al., also explores the use of Big data and analytics in the emerging field of industrial symbiosis [18]. Thus, combining circular economy with the industry 4.0 technologies can help increase the product life cycle and closing of the loop. The sustainable development goal 1, 2, 11 and 14 can be achieved by practicing circular economy with a support of industry 4.0.

ANALYSIS AND DISCUSSION

Digitization being one of the key factors towards a countries' economic development but India lags behind in technology acceptance primarily due to lack of financial investment and lack of awareness. Indian agricultural and fishery sectors are the once that lack behind with respect to technological advancement. The supply chain having various aspects, it becomes complex and critical to manage it. The industry 4.0 technologies mainly, blockchain, IoT, clod computing, big data and analytics can help make supply chain sustainable by reducing the amount of waste and tracing the movement of raw material, intermediate and product during the transportation. Industry 4.0 technologies has a broader applicability in the field of circular economy. Technology like IoT and autonomous robots has the ability to explore the waste stream to get the type and amount of each raw material present. They can aid in accurate dismantling and increase the recovery rates. Thus, Industry 4.0 has the ability to accurately measure and analyze the data to help in decision making process. This

makes the process efficient in terms of energy and resource. It paves the way towards sustainability and achieve the sustainable development goals.

CONCLUSION

This paper explored the industry 4.0 and sustainable development goals in an Indian perspective. It also discusses the applicability of the industry 4.0 technologies to overcome the various challenges from various sectors mainly, agricultural sector, fishery sector and supply chain management in manufacturing sector to achieve sustainable development goals. The field of industry 4.0 has many job opportunities but requirement of skilled labor is high. Hence, getting quality education along with collaboration with the industry can help get the required skill set for the sector. The role of the industry 4.0 to create a circular economy was also explored. The farmers and fisher man need to be educated regarding the advantages of technology in the respective sectors. In India, industry 4.0 and circular economy are new and emerging sectors and more research must be encouraged in the field. This paper is an initial review process and further study will be done on the applicability of industry 4.0 in other sectors like waste management, tourism, education sector etc. and the way it will help to achieve SDG's.

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