INDUSTRY 4.0 FOR SUSTAINABLE DEVELOPMENT

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Abstract: *The paper focuses on the critical issues related to the Industrial Revolution and its consequences on human life and the environment. Despite being the catchphrase of Sustainable Development, it seemed to be an ambiguous topic as people fail to understand, follow, and adopt its practice. The paper aims to contribute significantly to the technological advancements and further explains its implication on human life and environment. It studies how technological innovation can achieve and promote sustainable development, particularly in developing countries.*

There are three dimensional but interconnected pillars of SD, namely environment, economy, and society as a whole. The decision and policymakers need to be always alert for mitigating the effects of business and its activities on these pillars and ensure a better place for the future generation. The fourth industrial Revolution is a significant leap towards taking responsible human action and behavior at the international, national, community, and individual levels.

Index Terms: Sustainable Development, Industrial Revolution, Industry 4.0, Socio-economic development.

I.　INTRODUCTION

Over the years Sustainable Development (SD) has become a ubiquitous development paradigm, the catchphrase for international aid agencies, the jargon of development planners and the theme of conferences and academic papers, as well as the slogan of development and environmental activists (Ukaga, Maser, & Reichenbach, 2011). The concept has gained much attention and became a buzzword. However, notwithstanding its pervasiveness and popularity, murmurs of disenchantment about the concept are rife as people continue to ask questions about its meaning or definition and what it entails as well as implies for development theory and practice, without clear answers forthcoming (Montaldo, 2013; Shahzalal & Hassan, 2019; Tolba, 1984). SD is at the risk of becoming a platitude and meaningless, which practitioners and academics would surely acknowledge, but nobody would define precisely.

A clear and concise definition of the concept and explanation of its dimensions are prerequisites for moving beyond the sustainability rhetoric and achieving the desired agenda for sustainable development. Both practitioners and academics have advocated that these prerequisites are needed to encourage sustainable development. While we cannot argue that literature available on SD proliferates, issues relating to the definition, history, evolution, pillars, principles, and the present implications of these on the development of humans remain ambiguous to many people. Despite the presence of an abundance of literature, succinct clarification of the ambiguous issues about SD is significant as policy and decision-makers depend not only on data and information for the associations among pillars and the principles of SD. Instead, they also tend to enhance the understanding of such associations and their actual implications in the interest of the development of humans. The purpose of this paper is to contribute to the discourse on SD by providing more concise information on its meaning, evolution, associated key concepts, dimensions, and the relationships with technological advancement taking place in the global scenario. This is very significant as this would provide researchers, development practitioners, and students information about the various industrial revolution and SD shifted paradigm for policy and decision making.

II. WORLD POPULATION GROWTH AND DEMOGRAPHIC TRENDS

Overconsumption, ozone layer depletion, acid rain, unemployment, scarcity of water, education, growing population are the significant concerns prevailing worldwide. One of the major concerns being witnessed by the world is the rapid growth of the population, particularly in developing and underdeveloped countries. Today the population is growing by about 900 million per decade. It has been observed that nearly all of this growth occurs in developing countries like India, Latin America, and East Asia, which witnessed population growth of 1.5 percent per year. The population of China is growing at a rate of 1.1 percent, and Africa is growing much faster at a rate of 2.8 percent per year. In addition to the population burst, developing countries are also experiencing a shift of rural population to the urban areas. However, the developed countries have a stable growth or decline in population numbers. One the other hand, the United States is facing an increase in population due to migration. One of the primary reasons for population growth is the increase in life expectancy attributed to good health care and advancements in the pharmaceutical sectors.

From the last few years, it has been observed that there is a shift in the increasing population density from the lands like China, rest of Asia and Europe towards developing and underdeveloped countries of the world. This increase in the number of headcounts is a matter of great concern as it poses a significant challenge in meeting the basic requirements of each individual. The vast population

density reduces the quality of life and slows down the country's economic and infrastructural development. With its fixed resources, the planet now supports 5.5 billion people, who were approximately 2.5 billion in 1950. This shows that we have precisely doubled ourselves in number in the last 70 years. It can be understood the way the population is exerting pressure on earth and its resources.

III. SUSTAINABLE DEVELOPMENT & ITS GOAL

Environment, defined as a system of systems, creates the medium necessary for all forms of life. In contrast, sustainability is related to the environment as it drives all resources for the existence of all life forms. The official definition of sustainable development appeared for the first time in 1987 in the Brundtland Report, titled 'Our Common Future.' The report was produced by Brundtland Commission chaired by Doctor Gro Harlem Brundtland, ex-Prime Minister of Norway. Sustainable development was defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs'. This gave a clear concept and meaning for the first time to the term that the world is not as limitless as everyone thought it to be, and human life for its existence and maintenance requires limited available resources.

Later in 2005, during the World Summit on Social Development, three interdependent pillars of sustainability were identified - economic development, social development, and environmental protection. At the core, local and global efforts, tandem to each other, are trying to meet basic human requirements without degrading the social and natural environment. Sustainable development focuses on enhancing the quality of human life, along with its surrounding ecosystems.

Perceiving the success of the Millennium Development Goals, the Sustainable Development Goals titled "Transforming our world: the 2030 Agenda for Sustainable Development" with a fifteen-year plan was adopted in September 2015 in the UN summit to eradicate poverty, inequality, and combat environmental degradation. The 17 Goals of development were adopted by the global leaders to mitigate the effect of poverty and hunger, counter all sorts of inequalities prevailing in the society, promote peace and justice and tackle environmental changes while creating equal opportunities for all. The countries took ownership and developed their guideline and framework to comply with the 17 SDG.

The Sustainable Development Goals (SDG) comprises 17 goals and one hundred and sixty-nine targets in contrast to MDG's with eight goals and twenty targets. The SDG is to be achieved by the individual nation based on its existing problems, severity, and priorities. The goals are: No Poverty, Zero Hunger, Quality education to all, Clean drinking water and sanitation, Good Health, Gender equality, Clean and Affordable Energy, Employment Opportunities and Economic Growth, Life on Land, Conservation of fresh and marine life, Industry, Innovation, and Infrastructure, Reducing Inequality, Developing Sustainable Cities and Communities, Sustainable Consumption and Production, Prevent Climate Change, Peace, Justice, and Strong Institutions, Partnerships for the attainment of these goals. All these 17 Goals are interconnected and cannot be achieved unless all goals are equally accomplished.

IV. THE ROLE OF TECHNOLOGY IN SUSTAINABLE DEVELOPMENT

Technology is the scientific application of tools and techniques for the accomplishment of social objectives. Technology plays its role in the development process of any society, and according to the level of use and interaction with nature, impacts relatively on the environment and life. Technological advancement has led to industrialization activities on a large scale, contributing to higher living standards. On the other hand, it has also affected the environment adversely because of the uncontrolled and unethical practices involved in the utilization of resources and management of industrial waste. The current climate and environmental challenges faced globally are the results of uncontrolled technological advancements and its unchecked utilization, especially where it directly affects the quality of air, land, and water. These environmental violations resulting from technological advancements have posed a threat to life's existence from time to time. This unchecked technological advancement needs to be curbed and should be utilized for preserving nature in its natural state as far as possible.

Environmental pollution, Environmental degradation, Global warming, depletion of natural resources, and ecological imbalances are the significant negative impacts of technological advancements on the environment, which is of growing concern. Through SDG, the steps taken up by the nations are to mitigate the adverse effect of technology and industrialization by adopting sustainable technology for growth. Technology has positive, sustainable effects by minimizing the waste produced and by maximizing the effectiveness and efficiency through uncovering all the possible alternatives for scant resources. Environmental benefits can be observed by small changes in technical support, which leads to the attainment of sustainable development goals. The pertinence of scale and employing local resources for personal and industrial purposes and equity are significant for sustainable development. Great steps have been taken in the past few decades for reducing pollution through innovation and the adoption of cleaner technologies for production. These involve both inputs of materials as well as processing equipment. Few approaches such as recycling, low-input agricultural production systems have been utilized merely to reduce waste. Several other technologies exist to minimize the extraction and utilization of natural resources and maximize efficiency in the process adopted. Technology innovation is still far behind in various areas like food processing and fiber production, industrial processes, energy production, and waste management.

V. THE EXISTING TECHNOLOGIES IN SUSTAINABLE DEVELOPMENT

Sustainable development is the factor of technologies as well as opportunities available for the enterprise to exploit for its growth and development. The technologies which privileged people economically were the ones that flourished. Several innovative developments have taken place in the area of science and technology over the past few decades. Relentless efforts of scientists and engineers contributed to some of the most impressive technological developments in society, which improved the quality of life. However, the consequences on society and the environment, in the long run, were utterly ignored. The unregulated and massive production and use of triggered industrial operations are manifold. Subsequently, it has created an adverse effect on nature as the

increased industrial activities demanded more natural resources leading to environmental depletion and hostile climate.

The industrial and technological Revolution triggered by both the World War impacted the social-cultural as well as environmental structures prevailing on the planet. It opened new ways of communication, transportation, commerce, and trade stripping off the natural forest, grassland, and converting the natural canvas into man-created structures. The agrarian society gradually transitioned towards industrialization and has adopted the new inventions for better yield and production to make human life more comfortable. Although, these inventions later proved to be detrimental to nature as well as for life on earth. The Revolution in transportation with the use of natural resources increased speed and capacity. However, the natural resources as fossil fuels with high calorific value created natural catastrophes from time to time of different capacities.

One of the significant coalfields in India is Jharia coalfield in Jharkhand, which is the largest reserve of bituminous coal with 23 underground mines and nine open cast mines. This coal belt meets the country's most of the coal requirement, and with it comes, one of the most polluted towns in the country with PM 10 level at approx 295 μg/m (the permissible limit is 100 μg/m3). The mining activities and the transportation of coal have made the town live in a bubble of dust. The black diamond, as referred due to its economic value, has supported various economies in the country. However, the living condition of the miners and the people in the vicinity cannot be appreciated.

Similarly, oil and the natural gas requirement is fulfilled by the process comprising activities like drilling, exploration, extraction, storage, transportation, and refining. Although all these stages are carried out through quiet advanced and mechanized processes under the supervision of experts, various incidents have proved that how humans strive for comfort can be detrimental to the environment and other forms of life.

Oil accidents like the Gulf of Mexico or the Deepwater Horizon oil spill, Exxon Valdez Oil Spill, ABT summer are considered to be few of the most massive oil spills in the petroleum industry's history. If we talk about a Deepwater Horizon oil spill, the accident led 53000 barrels of oil flowing into the Gulf of Mexico every day for three months, doing immeasurable damage to the marine ecosystem leading numerous species to the verge of extinction. Number of similar accidents occurred from time to time, affecting the environment irreversibly.

The other sectors of the economy, like communication, textile, electronics, manufacturing of household goods, energy, and agriculture, also witnessed similar technological advancements without considering its long term impact on the resources and life. For the growing food requirement, agriculture had to be leveraged with chemical fertilizers and pesticides, which deteriorated the natural composition of earth soil. The uncontrolled production led by the mechanized process and to meet the escalating consumption of the exploding population disturbed the equilibrium of nature. The technological advancements made during the past century lacked concern for the environment and were not able to mitigate the environmental damage done.

VI. GLOBAL PERCEPTION OF THE FUTURE WORLD   & INDUSTRY 4.0

The depleting resources, catastrophes of nature, species getting extinct, and the negative impact of the deteriorating environment on humans were the few main reasons for concern for the nation's worldwide. Continuous effort for the number of years taken by the United Nations brought up the ambitious 2030 Agenda for Sustainable Development 2015, which triggered a sense of concern to all to bring required change in the way of life and approach of socially inclusive and sustainable environments. Modern-day challenges for man were problems like rising sea level, extreme weather conditions, dangerous level of pollutants on land, water and air, etc. the list is exhaustive. However, the fulfillment of each individual's basic amenities was still like a dream mission, especially for the developing and the underdeveloped countries.

The industrial revolution has undergone three phases of transition and is presently undergoing through its fourth phase of the revolution, i.e., Industry 4.0. First industrial revolution witnessed transferring of muscle power to steam power, which was followed by the second industrial revolution of electrical energy, which leveraged bulk production through an assembly line. The adoption of computers and automation was the third revolution in the industrial world. This got further enhanced in the fourth level with automated real-time data in the manufacturing process to make it more agile and foster economic, social growth with more concern for the environment. However, many companies are still struggling with the third industrialization level; several others geared themselves adopting most innovative technologies for their businesses.

The massive budget enterprises are adopting one or more of these technologies like autonomous robotics, artificial intelligence, big data analytics, cloud computing, etc. for autonomous manufacturing and efficient utilization of resources. The actual impact and implication of industry 4.0 technological features can be measured only after two to three decades when its repercussions will be realized on society and the environment.

Industry 4.0 revolves around the concept of the complete digitalized and autonomous manufacturing process, smart factories with sensor aided production systemssystem, the security of information, zero-waste production, cloud-based computing, artificial intelligence—the internet of things and many more to be added to this innovative platform. The objective behind adopting this smart way of business is the concern for human well being and improving sustainable capabilities and global environmental factors. The concept of adopting Industry 4.0 for sustainable development is based on nine pillars of knowledge. One of the pillars of Industry 4.0 is a**ugmented   reality**, referred to as the digital environment created by the computer to showcase the contents of the real world digitally through various devices. This is very useful for the manufacturing industry to display showcase new products and processes which can be otherwise impossible to replicate. This also provided real-time data about operating machines and tools about its services and maintenance, thus avoiding any wear and tear or breakdown, which will interrupt the manufacturing, thus incurring heavy losses to the company. **Additive Manufacturing** incorporates 3D printing technology with its flexibility, economic advantage, and quick and easy handling is a boon for manufacturers with creativity and innovative ideas. **Internet of Things** is referred to as the connectivity and networking of electronic devices like smartphones, laptops, tablets, refrigerators, television, lights, fans, or any other gadgets which can enable transmission of data. This technology is used in industries to collect real-time data from different

areas and machines to know the present situation for effective and efficient decision making. Subsequently, another advancement in the IT industry was Big Data analysis, which is now incorporated in the analysis of supply chain data for manufacturing enterprises. Different patterns created by consumers' buying behavior or any product market is subsequently evaluated to make better decisions regarding productions and logistics. **Cloud Computing** as the advancement over data sharing is in tremendous demand as it provides immense data storage capacity with enhanced accessibility and integrity. **Simulation** of product and its processes through models in the virtual environment with real-time data helps conceptualize different stags and related disruptions. This helps reduce costs many times as it is nearly impossible to reverse the actual product or process if created with any flaws in it. As businesses are becoming freer from human interference, it is replacing humans with robots. This is because of more pressure on production and to minimize the wastage of resources. This **automation** can prove to be a double-sided coin in the future as it provides sustainable and smart products but by replacing man with the machine, which might snatch away the workers' employment. At the core of industry 4.0 lies **system integration**, i.e., to enhance organizational connectivity both internally and externally. The different units/systems all need o to be synchronized to have a cohesive work environment and efficient productivity. The advanced technological environment can be thriving only if it has a secured connectivity environment and data transmission. **Cybersecurity** protects the business from any kind of cyber attack or data threat or and maintains data integrity for the proper functioning of different units.

VII INDUSTRY 4.0 AFFECTING SOCIAL, FINANCIAL AND ENVIRONMENTAL SUSTAINABILITY

Organizations are on a toss, identifying and encouraging technology, apt for the environmental, political, and socio-economic situations for a specific operation or geographical area. Technology is agile due to the substantial cost and time involved in its research and development. Enforcing the adoption of the expensive and latest technology in the developing and the underdeveloped countries would lead to several economic and social problems. These problems are expected to be catered to by advanced methodologies. However, at times, investing in traditional technologies and methodologies to enhance productivity and efficiency may prove beneficial for local site situations. For a successful technology, execution suitability of scale is a primary characteristic. For sectors like education, health care, and small- scale light industry, enhanced or low- impact technology are suitable for systems like solid-state communications and renewable energy technology.

The nations attained the MDG poverty target quite ahead of the 2015 deadline. It was recorded that nearly 700 million people were brought above the level of extreme poverty in 2020 as compared to 1990 data. In developing countries, 47% of the people lay below the income level of $1.25 per day. This figure was reduced to 22% in 2010, showing considerable achievement due to the nation's efforts worldwide. However, these are a minute fraction of changes in the international community from which it is expected to take bold decisions and collaborative actions to achieve targeted sustainable development goals.

VIII. CONCLUSION

Over the years, the global community has managed to achieve sustainable development progress to some extent by impacting the life of a large segment of the poor and vulnerable in different parts of the continent. However, this achievement is not of much worth as the degradation of the environment, and climate is posing a severe threat to life on earth. The major challenge for sustainable goals arises from the unsustainable production and uncontrollable consumption pattern adopted by the developed countries, followed by the developing countries with undeveloped countries following suit. A development approach that amalgamates suitable technology with sustainable development has been described by Leapfrogging. The objective of Leapfrogging is for developing nations to avoid the environmental and social ills that result from the development styles and patterns incorporated by the industrial nations.

The doubling of the global population in the last few decades, coupled with significant technological advancements, leveraged the economic activities worldwide. This sprawling industrial activity worldwide provided job opportunities at different levels, subsequently raising the living standard. This encouraged the buying capacity and fulfilled the people's demands boosting the country's economic growth. All these activities took place completely, ignoring its impact on nature and the environment. Nature was perceived as an unperturbed and infinite pool of resources which can replenish itself limitlessly. This concept and notion damaged the natural system of the green planet to such an extent that it started posing a threat to human life and its existence. The blend of technological advancement with concern for the environment is bound to change the world irreversibly. Past innovations have made disastrous impact on life and nature which can be restored by orienting innovation and research in the direction of new technology and its better handling so that natural equilibrium can be maintained.

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