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ASSESSING TRIPLE BOTTOM LINE ASSESSMENT FRAMEWORK: A SYSTEMATIC APPROACH FOR THE MANUFACTURING INDUSTRIES

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Abstract

In industrial development, sustainability evaluation is vital. A structured framework is required to develop sustainable policies within an organisation. A company's sustainability framework includes elements or performance measures to ensure appropriate development in policies, people, products, procedures, and overall performance. The study examined these frameworks and related factors in the manufacturing industry from 2007 to 2020. Any industry, including manufacturing, must use a sustainability evaluation framework and apply it. However, manufacturing industries lack methodological frameworks for assessing sustainability. The paper examined the problems and opportunities that sustainable frameworks present to the manufacturing business. This sustainable assessment framework focuses on the triple bottom line concept such as economic, social and environmental aspects of an industry. Employee engagement, continuous learning, supply chain management, and many other factors are essential elements of this framework. A secondary data analysis process has been followed for this research article to go through a wide range of data regarding this topic from different journal articles and websites. An exploratory study design has been included in this research for in-depth analysis of collected data. As per findings, the sustainable development framework has identified different internal and external drivers that are essential for the manufacturing industry.

Keywords: Value stream mapping (VSM) approach, Key Performance Indicator, Continuous learning, Employee engagement, Supply chain management, Conceptual Framework, Triple Bottom Line, Green Practices.

1. Introduction

New technical prowess is introduced by merging technological advancement and robotics that interface with one other to achieve optimal performance in the manufacturing Industry 4.0. (Queiroz and Telles, 2018). Sustainability framework refers to a specific way under which a company or business firm can organize various thoughts about sustainability measures. It has been found that there is a difference between the necessities of sustainable development within manufacturing sectors of India in current situations and in earlier situations, whether for environmental aspects or social aspects. The current level of industrialization within India has created many challenges (Jayashree et al., 2021). This has introduced the increasing demand for assessment of the sustainable scenario of the Indian manufacturing industry. The conceptual framework for engaging environmental, economic and social dimensions is essential to build sustainable planning (Bhanot et al., 2015).

The research article will focus on the Indian manufacturing industry and their approach to develop a sustainability assessment framework in the modern era. The research article will emphasize on different aspects of the manufacturing system within India, which considers computer technology as a part of their sustainable development prospects. Green Manufacturing practices, Industry 4.0 and its sustainable scenario is an essential part of this research that will focus on the current sustainable framework within the manufacturing process of India, which differs from the previous system. The issues necessitate a re-examination of sustainability practises, standards, measuring methodologies, and emerging technology (Wood et al., 2015). As a result of such concerns, businesses are scrambling to find new production processes and consumption that are more environmentally friendly. On the basis of both financial and environmental performance, the organisations are being evaluated (Furstenau et al., 2020). Companies can attain long-term viability in this aspect thanks to the advent of Industry 4.0. (Stock and Seliger, 2016). There are many opportunities as well as problems in this futuristic and complex procedure (Zhou et al., 2016). In addition to improving the system's able to adjust in a changing situation, it also allows organisations to self-organize, diagnose problems, and take immediate action on those issues (Yang et al., 2018). The result is that businesses are quickly adapt to the new technology and manufacturing procedures developing to transform, gather, distribute, and understand data from production equipment and other automated vehicles (Sarvari et al., 2018). Because of the digital revolution, businesses are able to increase their productivity by implementing cutting-edge

manufacturing methods. By creating high-quality products at lower costs and making sure that non-renewable resources are used effectively, the Industry 4.0 approach creates a competitive advantage.
There have been recent studies looking at the importance of strategic flexibility in implementing Processes to achieve sustainability (Gupta et al., 2020). Daz-Chao et al. (2020) illustrate the need of taking action in order to improve capacity. The efficient deployment of Industry 4.0 necessitates that organisations have certain competences. Despite this, there has been little discussion in the literature on the major determinants of Industry 4.0 that operate as capacities and increase sustainability (Akhtar et al., 2020). Besides, even though it is clear that determinants are important, there have been little empirical research on their significance in Industry 4.0 and sustainability practises implementation (Daz-Cháo et al., 2020). There is a paucity of research in this field, especially for developing countries. Consequently, the focus of this research was on the role of the most important factors in the implementation of Industry 4.0 for sustainability manufacturing operations in Indian manufacturing industries. Taking into account the aforesaid research questions, this study investigates how Industry 4.0 variables affect manufacturing industries' Triple Bottom Line (TBL) sustainability. They are hardly connected into the global trading system and focused on the local farmers' market. This study focuses on management engagement, skills, organizational behaviours, IT infrastructure, innovation processes and supply chain integration and their effects on industry 4.0 for the development of environmental, economic and social sustainability. The report identifies key variables for conducting manufacturing practices in a sustainable manner. The study shows that the factors influence Indian manufacturing industries' adoption of Industry 4.0. In this way, the sustainable determinants help firms grasp the difficulties and concerns around technology and strengthen the development of Industry 4.0. Therefore, the study defines the research objectives as:
(1) to understand sustainability assessment in the Indian manufacturing industry, focusing on social and technical aspects from 2007 to 2020, and (2) to understand the role of Industry 4.0 on the sustainability of the Indian manufacturing Industry.

2. Literature Review

2.1. Effect of Sustainability Indicators on Social Sustainability Framework of Indian Manufacturing Industry and Its Evolution from 2007 to 2020

Manufacturing Industry plays an essential role within a country for its overall development process. As per various studies, it has been found that work conditions such as the location of the organization, leaves offered to employees are essential factors; which define sustainability measures of any industry or organization in previous and current times both. Moreover, it has been found that workers desire higher leaves, location and Work environment from their organization to maintain their skills and well-

being (Digalwar et al., 2020). Majority of the workers have agreed with the fact that there is a decline in their health and safety measures due to the use of toxic chemicals within their manufacturing process.

Fig. 2*: Social Sustainability Indicators within Indian Manufacturing Industry (Digalwar et al., 2020)*

Social sustainability indicator obtained from survey results.

SN		Criteria	Survey Result	% Contribution	Group Weight
1	Work Condition (WC)	How important is the convenient and well accessible of work location.	0.71407	0.07773	**0.4162**
2		Importance of number of paid Leave and sick leave offered per year.	0.71852	0.07821	
3		How important is the interest of organization in welfare and satisfaction.	0.77333	0.08418	
4		How important is the job security in organization for elevated performance and satisfaction.	0.84593	0.09208	
5		How important are the appreciation and rewards for performing well.	0.77185	0.08402	
6	Work Environment (WE)	How important is the comfort at workplace (Lighting/Ventilation etc.).	0.79852	0.08692	**0.2800**
7		Rate the Effect of coolant/Oil used during manufacturing on health and performance.	0.52889	0.05757	
8		Rate the effect of level of emissions and waste from manufacturing operations in organization on performance and satisfaction.	0.54815	0.05967	
9		How important is the level Noise generated from manufacturing operations in organization on performance and satisfaction.	0.69630	0.07579	
10	Work Safety (WS)	Rate the effect of exposure to toxic chemicals during manufacturing operations on performance and satisfaction.	0.54815	0.05967	**0.1519**
11		Rate the operational risk level during manufacturing operations.	0.52444	0.05709	
12		Frequency of occupational accidents during manufacturing operations.	0.32296	0.03516	
13	Skill Development (SD)	How important is the training provided by organization (In house and at other organization) for skill development and work satisfaction.	0.67407	0.07338	**0.1519**
14		How important is involvement in decision making in job satisfaction.	0.72148	0.07854	

According to the above figure, apart from work conditions and work safety, there are many aspects of inductors that affect the social sustainability prospects of the Indian Manufacturing industry. The work environment is also an effective indicator that can be considered as an important aspect of a sustainable assessment framework of the industry. Additional research work has been developed to identify specific challenges and prospects of the Triple Bottom line concept within the sustainability assessment framework of Indian manufacturing firms. Computer technology within industry 4.0 is now the additional aspect that helps to enhance the work environment and employees' skills. In 2007, 2009 and 2010, sustainability mainly focused on IT and electronic structure under industry 3.0 and later it has engaged big data science, cloud computing to enhance employees' skills.

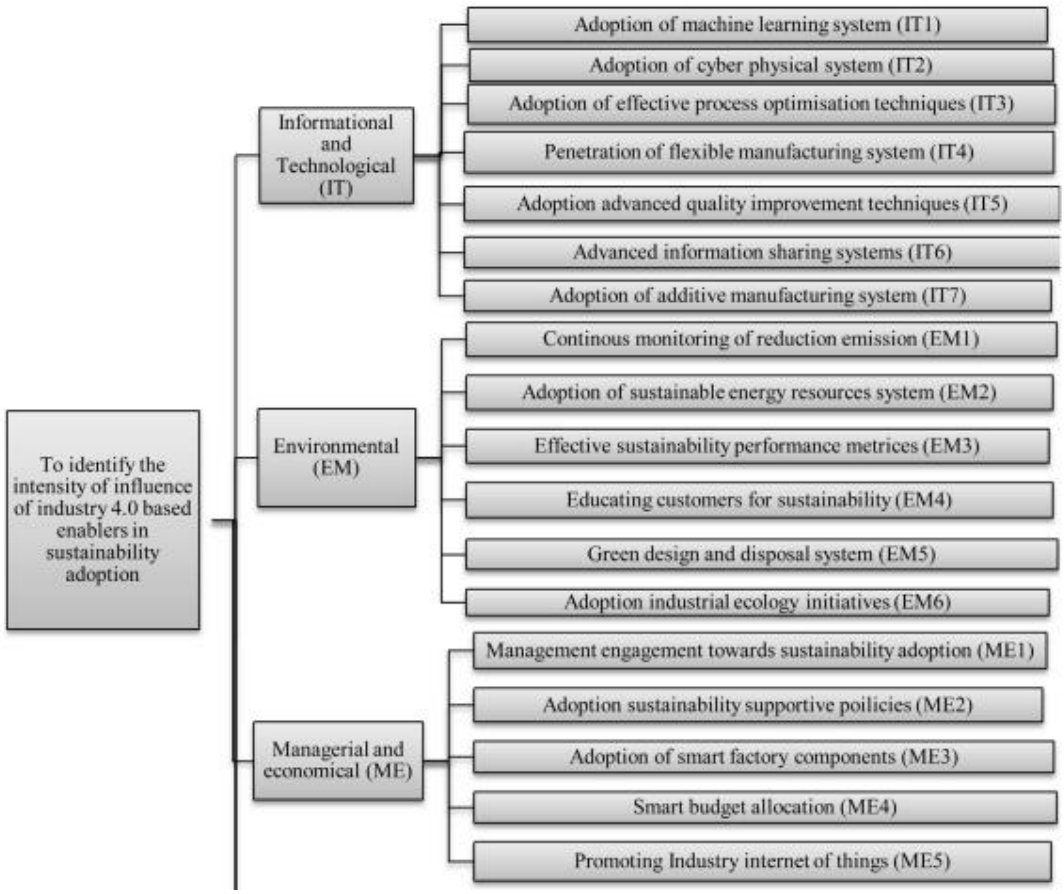
2.2. Journey from 2007 to 2020 by introducing the effect of Industry 4.0 within Sustainable Assessment Framework of Indian Manufacturing Industry

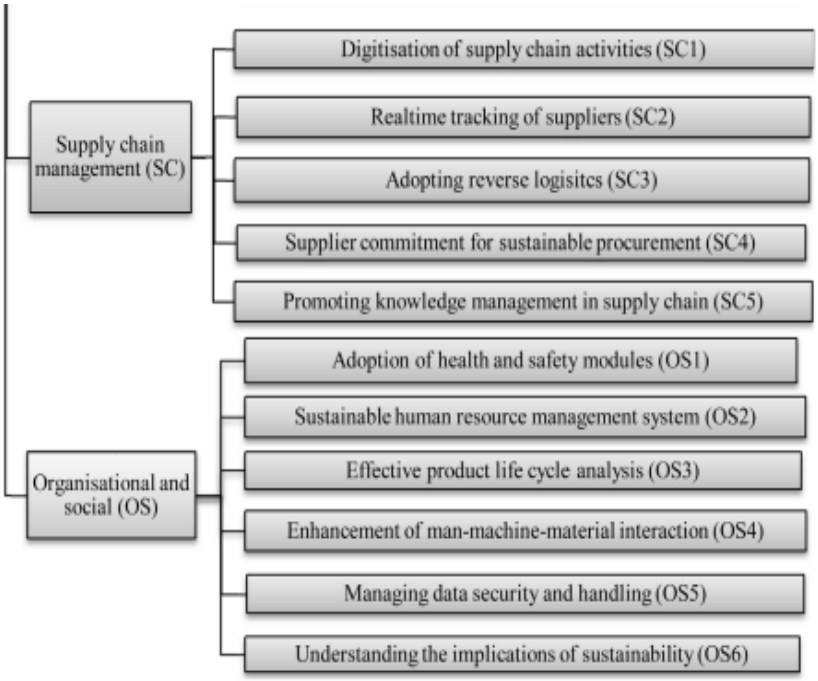
As a part of Industry 4.0, an interconnection among computer technology, smart materials, and intelligent machines to act together with the environmental aspect of the industry and make effective decisions with a nominal human association (Pasi et al., 2020). Whether it is in 2007 or in 2020, the triple bottom line concept is considered as a constant term within the manufacturing sector and its suitable framework to enhance its future possibilities. Cloud-based business intelligence solutions, Management as a service, maintain as a service is essential perspective of sustainable development framework within India to enhance and maintain sustainable measures. Before 2011, when the actual

concept of Industry 4.0 comes under focus, manufacturing industries focus on IT and electronic elements to exacerbate its triple bottom line concept.

In the year 2012, many of the manufacturing firms of this country used 3D printing; as it is considered as the best solution for any manufacturing problems. In 2013, resource optimisation for maintaining economical aspects of the triple bottom line concept has been a major area of sustainability assessment. In 2014, companies also enabled different computing systems such as cloud computing elements to the manufacturing process of India that can be helpful to increase its suitability measures (Pasi et al., 2020). As per results, robot arms and smart sensors are associated with high suitability within Indian manufacturing firms; which is a major discovery of Industry 4.0. However, there are some challenges within the Indian manufacturing industry due to job loss fear among employees. As a result, proper training to train employees regarding the computer system and digital process of Industry 4.0 is essential for them; that are developed through continuous learning in current manufacturing aspects.

Fig. 1. *Framework for Enhancing Sustainability (Yadav et al., 2020)*





A development framework shown in the above figure, with the help of the Robust Best-Worst Method can be introduced within a manufacturing firm to identify the intensity of industry 4.0 enabler in the sustainability adaptation process. "Information and Technology", "Environment", "Managerial and economic", "Supply Chain Management" and "Organisational and Social" are the Industry 4.0 enablers, which are included within this sustainability adaptation framework. Adaptation of the machine learning process, "Sustainable Energy resource system", and promotion of Industry-based "Internet of Things (IoT)", all relies on smart computer technology. This framework shows a significant change in the sustainable framework within the manufacturing industry compared to the last 10 years.

2.3. Triple Bottom Line and Sustainability

Following the Brundtland Report (UN, 1987), the community has become more cognizant of the manufacturing company's environmental effect (Kiel et al., 2020). Aside from earnings, consumers and their concerns were given significant consideration (McWilliams et al., 2016), culminating in many corporate responsibilities in the manufacturing industries (Paz et al., 2021). By designing the triple bottom line assessment, sustainability has captivated the world's attention due to its relevant ideas and suggestions about the environment and climate change (Khan et al., 2021). Industrial sustainability seeks profit (Schulz and Flanigan, 2016), while social and environmental sustainability seeks to promote humans and community (Bai et al., 2020). Furthermore, the TBL expects a progressive relationship between all three to avoid conflict. Sustainability requires consideration of all 3 components (Schulz and Flanigan, 2016). So, it may have predicted that the sustainability development

of Indian manufacturing industries may be enhanced through three dimensions of sustainable assessment framework.

2.4. TBL sustainability and Industrial technologies

These are essential organisational trends for boosting sustainable output (Bai et al., 2020). Industry 4.0 technologies help to overcome obstacles such as fierce competition, changing market needs, modifications, and product life cycles (Telukdarie et al., 2018) while also contributing to current societal sustainable growth (Reza et al., 2020). Besides, Industry revolution 4.0 contributes significantly to organisational and societal sustainability (Stock and Seliger, 2016). Reduced set-up times, labour costs and lead times increase organisational profit (Bai et al., 2020). Such solutions reduce waste, boost energy efficiency (Zhu et al., 2008), and promote reuse and recycling (Kumar et al., 2020). Employees' safety measures are protected by digital and intelligent technology, which reduce monotony and repetitive duties, hence motivating employees and greater job satisfaction (Müller et al., 2018). Companies should develop eco-friendly Industry 4.0 technology for sustainable production methods to efficiently use resources (Ghobakhloo, 2020). Thus, adopting and implementing Industry 4.0 will help Indian manufacturing industries stay competitive and contributing to the country's sustainable development.

3. Research Methodology

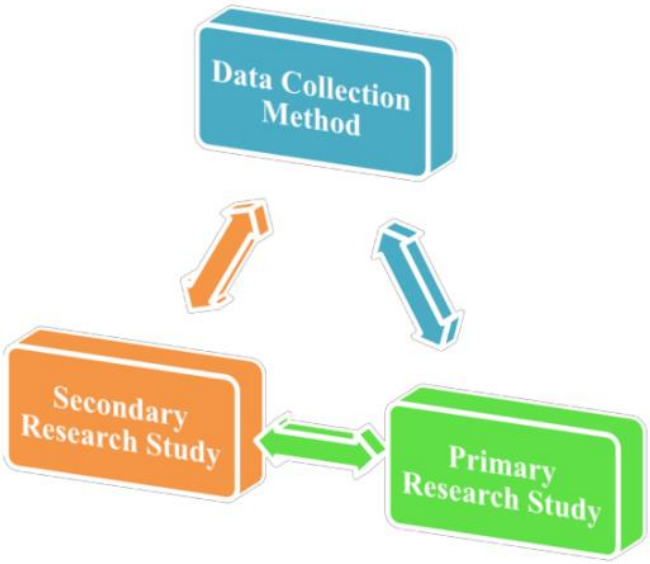
3.1. Research Philosophy, Approach and Study Design

Research philosophy and its proper implication within a research article is the most essential tool for getting the best possible result. Interpretivism philosophy mainly emphasizes developing an in-depth analysis of variables of different factors related to the research topic such as industry 4.0, social factors, economical factors, employee engagement factors and others for this particular research. This factor has been considered as the main aspect of the research analysis process in various contexts under interpretivism philosophy (Alharahsheh & Pius, 2020). Exploratory study design has been considered in this research article to conduct an in-depth analysis of collected data after finding quality responses throughout the research work (Omair, 2015). An inductive research approach has been developed to advance knowledge and new theories regarding the sustainable framework, suitable for the Indian manufacturing industry (Woiceshyn & Daellenbach, 2018). Any article published in any other language than English is excluded from the research and all the article should link to the research topic directly or indirectly.

3.2. Data Collection Method and Data Analysis

Data collection methods can be developed in two different processes: one is primary data collection and another is secondary data collection. The particular research article has considered a secondary data collection method to collect a wide range of data from different journal articles and websites regarding the research topic (Heap & Waters, 2019). Secondary data collection method is effective for proper utilization of collected data and shaping those data for analysis in a flexible way. Moreover, the secondary data collection method is essential for the research study; as it takes less time for conducting the research work (Johnston, 2017). Moreover, a thematic data analysis princess has been conducted within the research article to gather all collected data into some effective and concise workplace themes (Joffe, 2012).

Fig. 3. *Data Collection Process*



3.3. Ethical Consideration

Ethical consideration of the research work relies on the fact that all the journal articles and websites used for data collection must be published within the last 10 years and authentic as well.

4. Result and Discussion

4.1. Theme 1: Six areas of Reforms during 2020 are the Turning Point for India for Establishing Sustainable Assessment Framework

As per reports, after many years of sustainability approach and transformation, reforms established within the six areas such as sector-specific policies for sustainable development, creating a flexible labour market, unlocking supply chain management concepts, enabling efficient power distribution, privatizing state-owned enterprises and reducing the cost of doing business are considered as a turning point for India. It has been found that in recent times after the 2020 COVID-19 outbreak, the key step for India to move forward towards global manufacturing will be dependent on a holistic policy framework to meet all the needs and priorities of different sectors. This holistic policy approach can have three dynamic factors such as stable tariff regimes, well-functioning, and proper incentives (Mckinsey, 2021). These all aspects are essential for maintaining a sustainable framework within a manufacturing sector after considering different social, environmental and economic elements.

4.2. Theme 2: Green Manufacturing and Integrated Sustainability Assessment Framework affects Indian Manufacturing Industry Positively

Green manufacturing is a major aspect of the sustainability framework within Indian manufacturing firms; as it focuses on designing, manufacturing, delivering and disposing of products by generating the least harm to the surrounding environment. A framework for prioritising GM drivers is implanted for linguistic ratings, associating three decision-maker groups, who are working in GM for more than 5 years (Mittal & Sangwan, 2014). These group members decide which are the main drivers of GM such as environmentally conscious manufacturing, energy and resource-efficient manufacturing and many others.

As per article findings, an integrated sustainable framework has been introduced within the machine manufacturing industry of India based on wet and dry machining. In terms of economic indicators for the sustainability assessment framework, some radar plots are presented.

Fig. 4. *Radar Plot for Economic Indicators (Bhanot et al., 2016)*

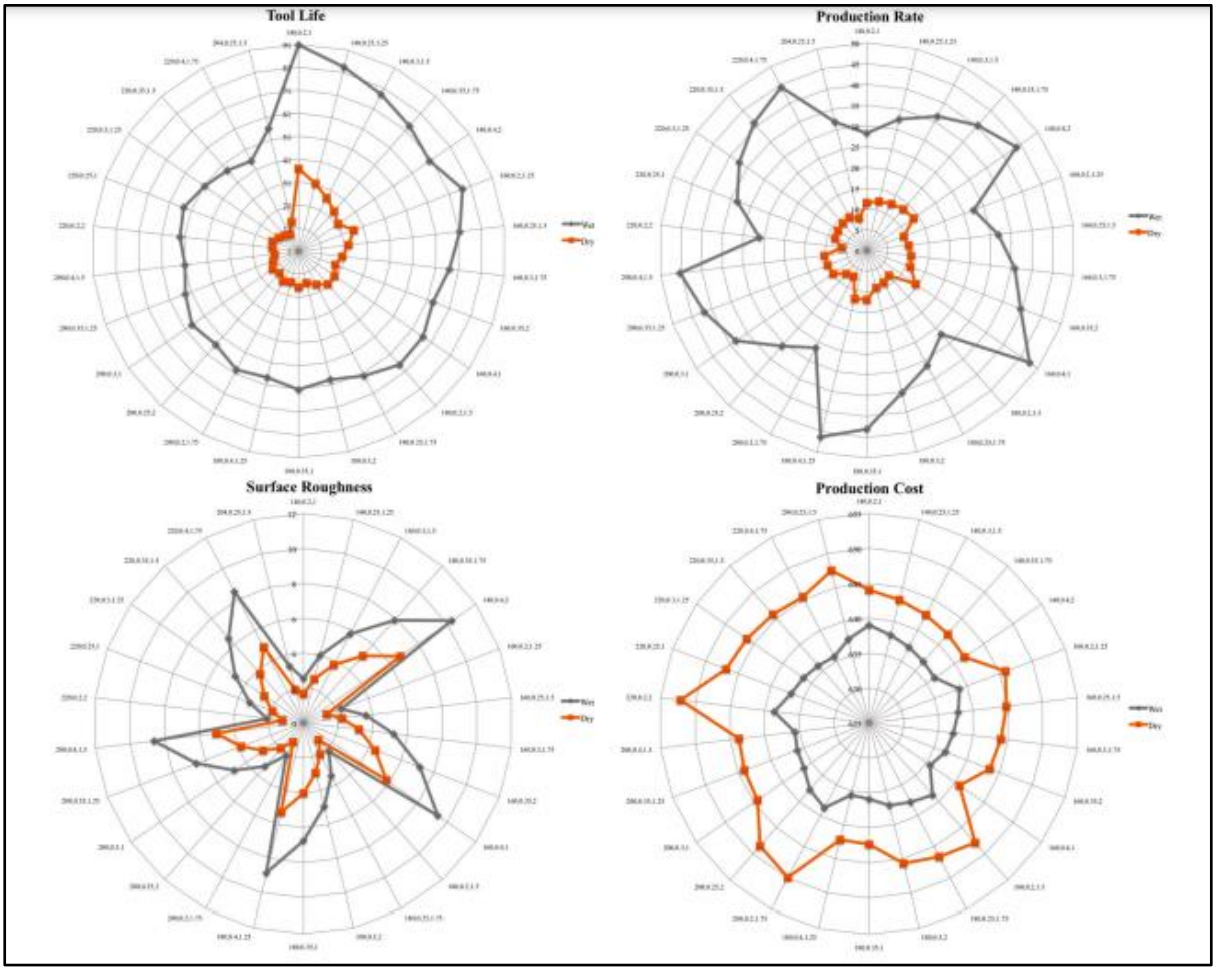
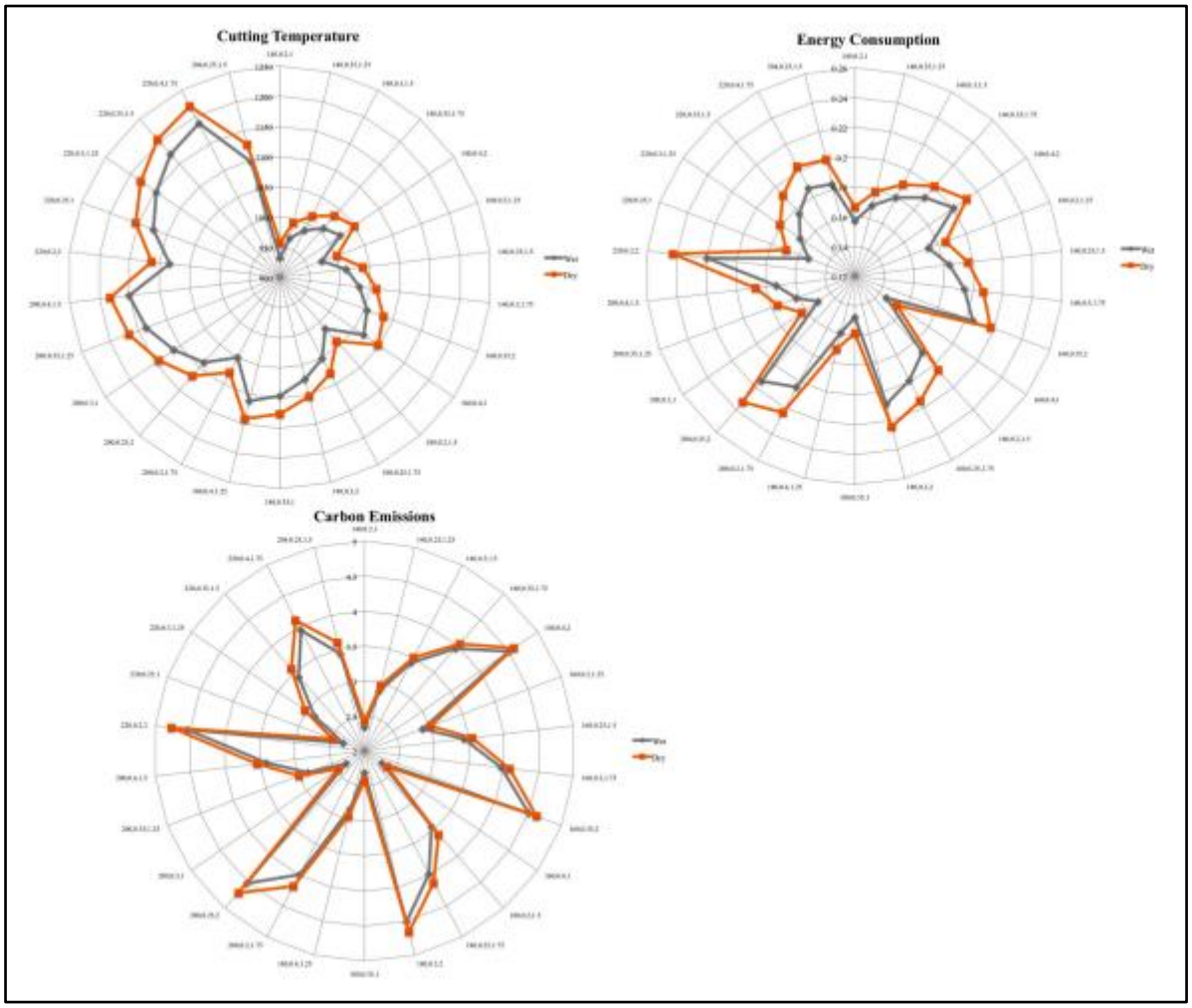


Fig. 5. *Radar Plot for Environmental Indicators (Bhanot et al., 2016)*



The above figures (fig.4, 5, 6) illustrate that wet machining is better and preferable than dry machining, in terms of tool life, production rate, production costs, cutting temperature, energy consumption and carbon emission. However, the cutting quality of dry machining is preferable over wet machining.

Fig. 6. *Social Indicators for Sustainability (Bhanot et al., 2016)*

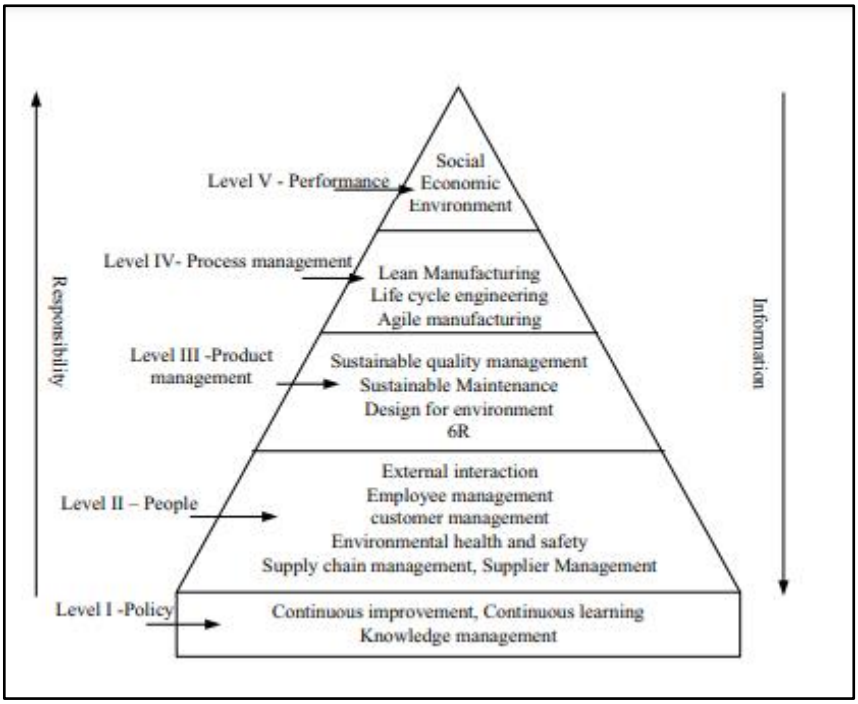
S. no.	Social indicators	W_1	W_2	W_3	W_4	W_5	W_6	GRG
1	Productivity of Worker (i.e. how efficiently and quickly products are manufactured by workers)	0.667	0.5	0.667	1	0.5	0.5	0.639
2	Cordial relations with other workers	0.5	0.667	0.667	1	0.667	0.5	0.667
3	Skill level of worker	0.5	0.5	0.667	1	0.5	0.5	0.611
4	Flexibility to job rotation	0.5	0.4	0.667	0.667	0.5	0.5	0.539
5	Punctuality to work	0.5	0.4	0.5	0.667	0.5	0.5	0.511
6	Top management support in various issues	0.5	0.4	0.5	0.667	0.5	0.5	0.511
7	Job satisfaction level (salary, incentives and workload)	0.5	0.5	0.667	0.667	0.667	0.5	0.583
8	Conducive working environment (suitable working conditions and ergonomic design of workspace)	0.5	0.4	0.5	0.667	0.5	0.5	0.511
9.1	Awareness on sustainable manufacturing initiatives	0.333	0.333	0.4	0.4	0.333	0.333	0.356
9.2	Technological upgradation through training centers	0.333	0.333	0.333	0.4	0.333	0.333	0.344
9.3	Financial support (in form of loans, tax incentives, ESI benefits)	0.4	0.5	0.4	0.5	0.4	0.4	0.433
10.1	Products quality and functionality requirements	0.667	0.5	1	1	0.667	0.5	0.722
10.2	Waste management practices	0.5	0.4	0.667	0.667	0.5	0.5	0.539
10.3	Energy conservation practices	0.5	0.5	0.667	0.667	0.5	0.5	0.556
10.4	Operational safety	0.5	0.5	0.667	1	0.667	0.5	0.639
10.5	Personnel health and hygiene (including practices followed by workers and impact of coolants and lubricants)	0.5	0.4	0.5	0.667	0.5	0.5	0.511
	Social sustainability index (based on mean of social indicators)							0.542

Above fig.6 shows the grade values of different social indicators; which reflect the Key Performance Indicators of many manufacturing firms in India. The top three social indicators are “Products quality and functionality requirements”, “Cordial relations with other workers” and “Productivity of worker and operational safety”. All these three aspects are essential for any manufacturing industry like this machine industry of India to maintain their sustainable measures. Moreover, the flexibility of job rotation, punctuality to work is the less important indicators within the manufacturing industry and its development. Operational safety and productivity will also enhance workers to engage in green practice within the manufacturing industry. The cordial relation of a worker with another is essential to maintain the workplace environment and to develop suitable works within the manufacturing process. As a result, it can be stated that the triple bottom line concept is essential for any manufacturing sector whether in the current technical age or in the traditional approach. The use of high-tech solutions under the 4th industrial revolution was not still under consideration (Bhanot et al., 2016). IT, electronics were mostly used in the manufacturing sector. In the current area, the development of a “Lean, Green, and Six Sigma (LGSS)” based strategy for an integrated framework within the sustainable assessment of the Indian manufacturing sector can be addressed for continuous learning or improvement within manufacturing firms. The use of AI, Cyber-physical systems within Lean and green practices, which are related to suppliers and customers of manufacturing sectors, accelerates value stream mapping of the organization (Yang et al., 2018). Green practice also eliminates environmental waste, and six-sigma practice improves the quality of items. As a result, this framework will be an effective one to embrace sustainability measures within environmental and social aspects.

4.3. Theme 3: A Five Hierarchical Conceptual Framework enhances Sustainable Assessment within Manufacturing Industry

As per research findings, it can be stated that sustainability assessment was considered as a complex problem within the Indian manufacturing industry in previous times and many dimensions or elements must be covered within their planning process to enhance the sustainability of this industry by a greater margin.

Fig. 7. *Hierarchical Sustainability Assessments Framework (Bhakar et al., 2018)*



According to the above figure, it can be stated that Policy, People, Product management, Process management and Performance management of the manufacturing industry are the major aspects of a sustainable development framework. In this context, it is clear that, Performance of a firm relies on the triple bottom line concept of the sustainability framework of a manufacturing firm in India, which includes social, environmental and economic perspectives. Engaging policies regarding the use of renewable energy, water consumption and green manufacturing enhance environmental sustainability (Schulz and Flanigan, 2016). Process management with lean manufacturing, Product Management within the sustainable quality assessment is the major criteria of this framework. Employee management considering their work culture needs to become under level II with a continuous learning process of business policies in Level I. In 2018, the centre developed by World Economic Forum has reshaped the collaboration of industry 4.0 within Indian manufacturing firms and it accelerates the use of cyber computing systems within the triple bottom line concept.

5. Discussion

The study conceptually scrutinizes the secondary research method by critically examining the literature studies. The study employed an inductive research design by following the study's exploratory nature. This study particularly introduces a sustainable assessment framework for the manufacturing industries in India. The study identified several internal and external organizational factors that highly contribute to the sustainable environment of the Indian manufacturing industries between 2007-2020. The study targeted triple bottom line components i.e., economic, social and environmental factors for the sustainability of Indian manufacturing industries. The investigation began by looking at six areas considered pivotal for Indian policies for sustainable development, generating a flexible labour market, accessing supply chain management notions, empowering efficient power allocation, and minimizing the cost of the materials. All factors are based on a holistic policy of Indian manufacturing industries that ensure organizational sustainability even during the coronavirus (COVID-19) pandemic.

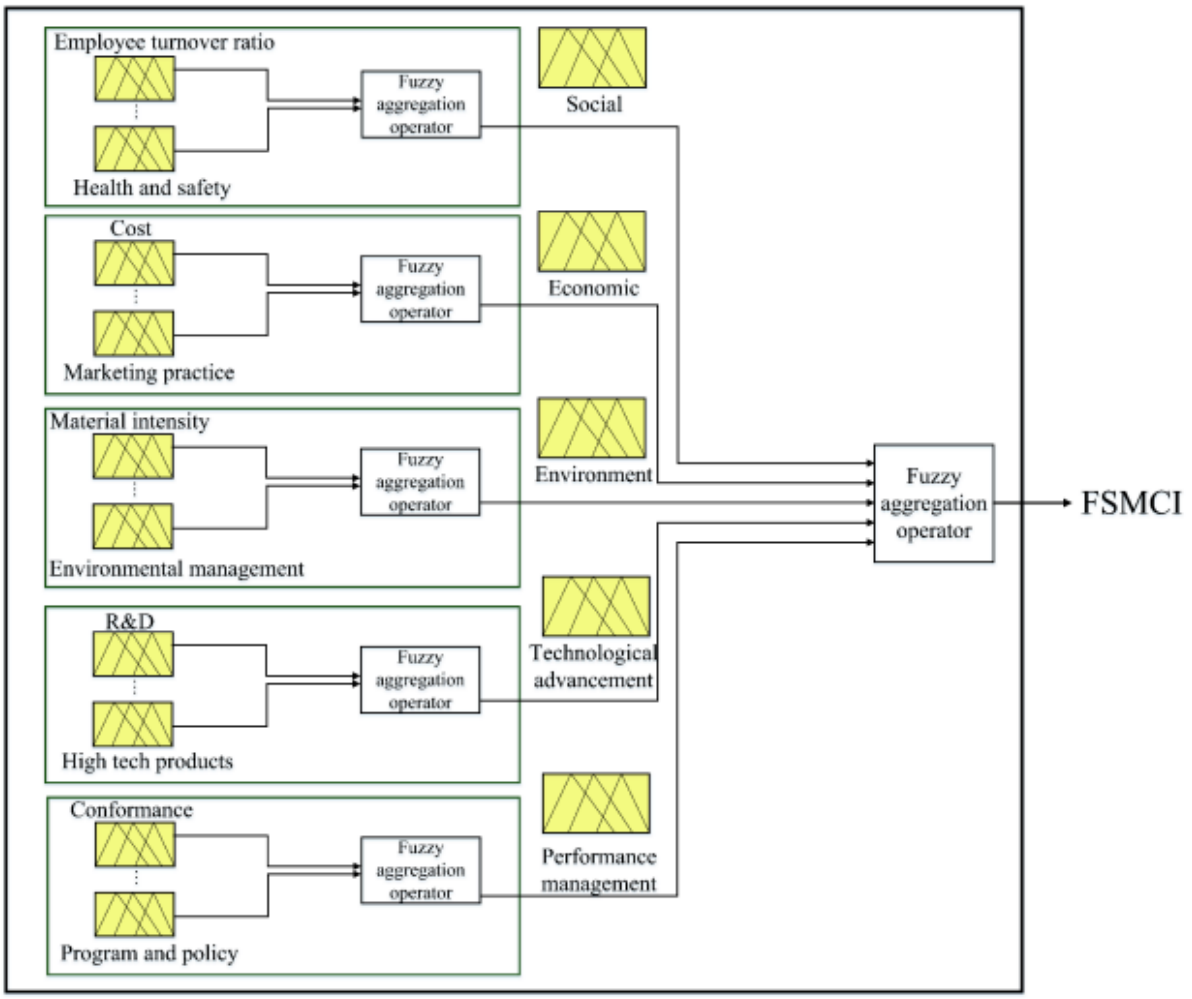
The study identifies green manufacturing as the second most important factor for a better sustainable environment. Green practices always keep innovating organisational sustainability. It depends on developing novel and new ideas, particularly green practices that ultimately summarise manufacturing industries' results. In this way, the consumption of energy resources, raw materials, labour, and capital resources should be minimised (Mittal & Sangwan, 2014) to ensure higher productivity and performance. Furthermore, the sustainable environment is derived from two concepts i.e., wet machining and dry machining. Finally, the study elaborated with literature pieces of evidence that wet machining has better infrastructures than dry machining in terms of tool life, production rate, production costs, cutting temperature, energy consumption and carbon emission. The only thing that distinguishes dry machining from wet machining is cutting quality.

The study also prioritized social factors considered the performance-based measures for Indian manufacturing industries. The study found three significant social factors (i.e., product quality and functionality requirements; cordial relations with other workers; and productivity of workers and operational safety.) These three fundamental factors highly contribute to the sustainable environment of the Indian manufacturing industries. Unfortunately, job flexibility and work punctuality were the least important factors for sustainable development. Surprisingly, if Indian industries provide operational safety measures, the employees will highly engage and increase productivity at the workplace.

The study also reported that the Lean, Green and Six Sigma (LDSS) approach might be effective for the development of a green sustainable environment (Bhanot et al., 2016). Additionally, blockchain, AI and ML systems can improve the sustainable environment for the Indian manufacturing industries. Last, the study stated that policy, people, product management, process management, and performance management are the major contributors to the manufacturing industry's sustainable assessment (Daz-

Cháo et al., 2020). The results show that the triple bottom line components are useful and effective for ensuring a sustainable framework. These economic, social and environmental factors can reduce the waste of resources, gas emission, labour cutting and increase renewable energy resources, green practices, green novel and new ideas, and intellectual resources that significantly help create a sustainable environment for Indian manufacturing industries. In this way, they will enhance employee engagement, safety measures, commitment, productivity and intellectual stimulation.

Fig. 8. *Fuzzy Model for Sustainable Assessment (Hendiani et al., 2020)*



According to the above figure, Performance Management, Technological Advancement, Environmental, Economic and Social aspects are the main factors of the model to measure sustainability criteria.

5.1 Practical Implications

The concept of Industry 4.0, along with its drivers, has emerged as a critical concept for SMEs in order to achieve TBL sustainability in recent years, prompting numerous types of study to be done across fields. The number of studies on Industry 4.0 incorporated the Advanced technologies (TOE) theory and the Diffusion of Innovation (DOI) framework (Lin et al., 2018), and only a few experiments evaluated Industry 4.0 predictors from the resources and capabilities perspective (Daz-Chao et al., 2020; Gupta et al., 2020). In view of the fact that Industry 4.0 comprises a challenging environment, and that resources must be structured in order to gain competitive advantage, investigating the drivers from the innovation diffusion perspective provides significant perspectives into existing information. Thus, using the DCV, this study demonstrates that the predictors serve as the foundational principles for Industry 4.0 technologies and have a significant impact on its success. This allows Indian manufacturing industries to achieve a competitive edge while remaining self-sustaining from a financial, physical, and social standpoint. The study has several implications for properly implementing a sustainable assessment framework for Indian manufacturing industries. The results ensure that industrial managers focus on economic, social and environmental factors that are the backbone of maintaining a sustainable environment. The managers should develop a sense of green practices system that highly generates a positive environment for the employees working at the workplace. In this way, they would like to adopt green practices, and there will be a highly sustainable environment.

Moreover, TBL's long-term viability, according to the findings of the study, is dependent on the successful implementation of Industry 4.0, which increases profit through increased production effectiveness, enhances the ecological environment consumption of resources, and providing people with a healthy, safe workplace (Yang et al., 2018). Additionally, the long - term learning has been empirically confirmed, demonstrating its importance in terms of long-term sustainability. Besides, many scholars will be encouraged by the findings of this study to investigate more paths of Industry 4.0 deployment and long-term sustainability however, top management dedication and IT infrastructures have yielded extremely positive results, demonstrating achieve great things acumen in the process, particularly in Indian context, according to the report. Such manufacturing sectors may need to rethink their strategy in order to maximise on the advantages associated with the deployment of Industry 4.0 in process of reaching sustainability (Akhtar et al., 2020). The results of this study would be extremely valuable for professionals and scholars who want to examine other variables that can contribute to victory in India, where Industry 4.0 implementation still in its inception.

5.2. Limitations and Future directions

Every study has some limitations and future directions, and so does this study. The study only used secondary data based on published reports, articles and books between 2007-2020. The study targeted only Indian manufacturing industries with a small landscape area. However, future studies should be

based on mixed-method research, which will be helpful to understand what are the factors that quantitatively and qualitatively help the industries to create a sustainable assessment framework in manufacturing industries, the primary data collection might provide accurate and contemporary results for the manufacturing industries to know "how are the practices being rated?" and "what are the actual contributors of maintaining a sustainable environment?" Future studies may also focus on measuring employee psychological factors (i.e., work engagement, organizational commitment, turnover intention) that provide intellectual resources for developing a sustainable environmental framework (Zhou et al., 2016).

5.3. Conclusion

According to the assessment criteria under the hierarchical sustainability assessment framework (Stock and Seliger, 2016), it can be seen that social, environmental and economic factors are the key aspects to measure and plan suitability framework and take effective actions. As per the findings, India got its turning point towards a most sustainable approach after the reformation of six areas of concern, which is essential for developing a holistic policy framework within the manufacturing industry. After the COVID-19 pandemic, it has been helpful for the country to move forward to global sustainable hubs after considering stable tariff regimes, well-functioning, and proper incentives.

Green Practices and Integrated sustainability framework has a huge effect on manufacturing firms in terms of all the three elements of triple bottom line concepts. LGSS strategy is considered to be an effective approach within an integrated sustainability framework to continuous learning. The overall research article identifies that focusing on the triple bottom line concept is the main aspect within the sustainability assessment framework to achieve all the other related criteria of sustainability within Indian manufacturing firms. However, it can be concluded that from 2007 to 2020, the use of technical advancement is the main developing factor within the manufacturing industry to enhance their sustainable planning.

It can be recommended that Sustainable assessment within an organization or industry has several steps to follow. One of the most essential steps of these is to define the sustainability scenario of that particular area and then identify the elements of the sustainability framework that are important to improve this scenario (Queiroz and Telles, 2018). Measuring the value of each element of the sustainability framework is another step of this sustainable assessment process along with proper planning (Cedarscenter, 2021).

As discussed by the fuzzy model of sustainable assessment (Hendiani et al., 2020; Wood et al., 2015), Performance Management, Technological Advancement, Environmental, Economic and Social aspects are the main factors of this model. It can be suggested that, Research and Development (R&D) with

high-tech products, Employee turnover ratios can be assessed in Indian manufacturing firms to measure their sustainability criteria.

References

Akhtar, P., Ullah, S., Amin, S.H., Kabra, G., Shaw, S., 2020. Dynamic capabilities and environmental sustainability for emerging economies' multinational enterprises. Int. Stud. Manag. Organ. 50 (1), 27–42.

Alharahsheh, H.H. & Pius, A. 2020. A review of key paradigms: Positivism VS interpretivism. *Global Academic Journal of Humanities and Social Sciences*, 2 (3), 39-43.

Bai, C., Dallasega, P., Orzes, G., Sarkis, J., 2020. Industry 4.0 technologies assessment: a sustainability perspective. Int. J. Prod. Econ. 229, 107776.

Bhakar, V., Digalwar, A.K. & Sangwan, K.S. 2018. Sustainability assessment framework for manufacturing sector–a conceptual model. *Procedia Cirp*, 69, 248-253. Retrieved from: https://www.sciencedirect.com/science/article/pii/S2212827117308818

Bhanot, N., Rao, P.V. & Deshmukh, S.G. 2015. Sustainability assessment framework for a manufacturing firm: an exploratory study. *Journal of Practice Management*, 39 (2), 36-46.

Bhanot, N., Rao, P.V. & Deshmukh, S.G. 2016. An integrated sustainability assessment framework: a case of turning process. *Clean Technologies and Environmental Policy*, 18 (5), 1475-1513.

Cedarscenter, 2021. *Overview*. Retrieved on: 8 January 2021 from: http://cedarscenter.com/sfoverview.cfm

Díaz-Chao, _A., Ficapal-Cusí, P., Torrent-Sellens, J., 2020. Environmental assets, industry 4.0 technologies and firm performance in Spain: a dynamic capabilities path to reward sustainability. J. Clean. Prod. 281 (xxxx), 125264, 125264.

Digalwar, A.K., Dambhare, S. & Saraswat, S. 2020. Social sustainability assessment framework for Indian manufacturing industry. *Materials Today: Proceedings*, 28, 591-598. Retrieved from: https://www.sciencedirect.com/science/article/pii/S2214785319342567

Furstenau, L.B., Sott, M.K., Kipper, L.M., MacHado, E.L., Lopez-Robles, J.R., Dohan, M.S., Imran, M.A., 2020. Link between sustainability and industry 4.0: trends, challenges and new perspectives. IEEE Access 8, 140079–140096.

Gaikwad, L. & Sunnapwar, V. 2020. Development of an integrated framework of LGSS strategies for Indian manufacturing firms to improve business performance: an empirical study. *The TQM Journal*, 33 (1), 257-291. Retrieved from: https://www.emerald.com/insight/content/doi/10.1108/TQM-05-2020-0110/full/html

Ghobakhloo, M., 2020. Industry 4.0, digitization, and opportunities for sustainability. J. Clean. Prod. 252, 119869.

Gupta, S., Modgil, S., Gunasekaran, A., Bag, S., 2020. Dynamic capabilities and institutional theories for Industry 4.0 and digital supply chain. Supply Chain Forum 21 (3), 139–157.

Heap, V., & Waters, J. 2019. Data collection methods. In *Mixed Methods in Criminology* (pp. 141-176). Routledge. Retrieved from: https://www.taylorfrancis.com/chapters/edit/10.4324/9781315143354-8/data-collection-methods-vicky-heap-jaime-waters

Hendiani, S., Liao, H., Bagherpour, M., Tvaronavičienė, M., Banaitis, A. & Antucheviciene, J. 2020. Analyzing the status of sustainable development in the manufacturing sector using multi-expert multi-criteria fuzzy decision-making and integrated triple bottom lines. *International journal of environmental research and public health*, 17 (11), 3800. Retrieved from: https://www.mdpi.com/727082

Jayashree, S., Reza, M.N.H., Malarvizhi, C.A.N. & Mohiuddin, M. 2021. Industry 4.0 implementation and Triple Bottom Line sustainability: An empirical study on small and medium manufacturing firms. *Heliyon*, 7 (8), e07753. Retrieved from: https://www.sciencedirect.com/science/article/pii/S2405844021018569

Joffe, H. 2012. Thematic analysis. *Qualitative research methods in mental health and psychotherapy: A guide for students and practitioners*, 1, 210-223. Retrieved from: https://www.researchgate.net/profile/Helene_Joffe/publication/230000572_Thematic_Analysis/links/00b7d53bd6edd1aee3000000

Johnston, M.P. 2017. Secondary data analysis: A method of which the time has come. *Qualitative and quantitative methods in libraries*, 3 (3), 619-626. Retrieved from: http://www.qqml-journal.net/index.php/qqml/article/view/169

Kiel, D., Müller, J.M., Arnold, C., Voigt, K.-I., 2020. Sustainable industrial value creation: benefits and challenges of industry 4.0. In: Digital Disruptive Innovation. World Scientific, pp. 231–270.

Kumar, R., Singh, R.K., Dwivedi, Y.K., 2020. Application of industry 4.0 technologies in SMEs for ethical and sustainable operations: analysis of challenges. J. Clean. Prod. 275, 124063.

Lin, D., Lee, C.K.M., Lau, H., Yang, Y., 2018. Strategic response to Industry 4.0: an empirical investigation on the Chinese automotive industry. Ind. Manag. Data Syst. 118 (3), 589–605.

Mckinsey, 2021. *India's turning point*. Retrieved on: 8 January 2021 from: https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/India/Indias%20turning%20point%20An%20economic%20agenda%20to%20spur%20growth%20and%20jobs/MGI-Indias-turning-point-Report-August-2020-vFinal.pdf

McWilliams, A., Parhankangas, A., Coupet, J., Welch, E., Barnum, D.T., 2016. Strategic decision making for the triple bottom line. BSE 25 (3), 193–204.

Mittal, V. K., & Sangwan, K. S. 2014. Prioritizing drivers for green manufacturing: environmental, social and economic perspectives. *Procedia Cirp*, 15, 135-140. Retrieved from: https://www.sciencedirect.com/science/article/pii/S2212827114004612

Müller, J.M., Kiel, D., Voigt, K.I., 2018. What drives the implementation of Industry 4.0? The role of opportunities and challenges in the context of sustainability. Sustainability 10 (1).

Omair, A. 2015. Selecting the appropriate study design for your research: Descriptive study designs. *Journal of Health Specialties*, 3 (3), 153.

Pasi, B.N., Mahajan, S.K. & Rane, S.B. 2020. The current sustainability scenario of Industry 4.0 enabling technologies in Indian manufacturing industries. *International Journal of Productivity and Performance Management*. Retrieved from: https://www.emerald.com/insight/content/doi/10.1108/IJPPM-04-2020-0196/full/html

Paz, T.d.S.R., Caiado, R.G.G., Quelhas, O.L.G., Gavi~ao, L.O., Lima, G.B.A., 2021. Assessment of sustainable development through a multi-criteria approach: application in brazilian municipalities. J. Environ. Manag. 282, 111954.

Queiroz, M.M., Telles, R., 2018. Big data analytics in supply chain and logistics: an empirical approach. Int. J. Logist. Manag. 29 (2), 767–783, 2018 May 14.

Research Boundaries, 3. Association for Information Systems (Malaysia Chapter), Malaysia, pp. 91–104. https://www.researchgate.net/publication/348704345_Industry_40_and_Sustainability_-A_study_on_Malaysian_MSC_Status_Companies.

Reza, M.N.H., Jayashree, S., Malarvizhi, C.A., 2020. Industry 4.0 and sustainability-A study on Malaysian MSC status companies. In: Exploring Information System

Sarvari, P.A., Ustundag, A., Cevikcan, E., Kaya, I., Cebi, S., 2018. Technology roadmap for industry 4.0. Industry 4.0: Managing the Digital Transformation. Springer, pp. 95–103.

Schulz, S.A., Flanigan, R.L., 2016. Developing competitive advantage using the triple bottom line: a conceptual framework. JBIM 31 (4), 449–458.

Stock, T., Seliger, G., 2016. Opportunities of sustainable manufacturing in industry 4.0. Procedia CIRP 40, 536–541.

Telukdarie, A., Buhulaiga, E., Bag, S., Gupta, S., Luo, Z., 2018. Industry 4.0 implementation for multinationals. Process Saf. Environ. Protect. 118, 316–329.

UN, 1987. Report of the World Commission on Environment and Development. Vaidya, S., Ambad, P., Bhosle, S., 2018. Industry 4.0 – a glimpse. Procedia Manufacturing 20, 233–238.

Woiceshyn, J. & Daellenbach, U. 2018. Evaluating inductive vs deductive research in management studies: Implications for authors, editors, and reviewers. *Qualitative Research in Organizations and Management: An International Journal*, 13 (2), 183-195. Retrieved from: https://www.emerald.com/insight/content/doi/10.1108/QROM-06-2017-1538/full/html

Wood, R., Stadler, K., Bulavskaya, T., Lutter, S., Giljum, S., de Koning, A., Tukker, A., 2015. Global sustainability accounting-developing EXIOBASE for multi-regional footprint analysis. Sustainability 7 (1), 138–163.

Yadav, G., Kumar, A., Luthra, S., Garza-Reyes, J.A., Kumar, V. & Batista, L. 2020. A framework to achieve sustainability in manufacturing organisations of developing economies using industry 4.0 technologies' enablers. *Computers in industry*, 122, 103280.

Yang, S., Raghavendra, M.R.A., Kaminski, J., Pepin, H., 2018. Opportunities for industry 4.0 to support remanufacturing. Appl. Sci. 8 (7).

Zhou, K., Liu, T., Zhou, L., 2016. Industry 4.0: towards future industrial opportunities and challenges. In: 2015 12th International Conference on Fuzzy Systems and Knowledge Discovery, FSKD 2015, pp. 2147–2152.

Zhu, Q., Sarkis, J., Lai, K.-h., 2008. Confirmation of a measurement model for green supply chain management practices implementation. Int. J. Prod. Econ. 111 (2), 261–273.