A REVIEW OF LITERATURE ON ADOPTION OF SUSTAINABLE MANUFACTURING PRACTICES AT MSMES, KARNATAKA.

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Abstract:

Industrialization throughout history has been one of the main contributors to pollution, disregard for environmental issues, resulting in an unsustainable production model. A change from this context, the imminent new industry model called the Fourth Industrial Revolution or Industry 4.0, aims for a manufacturing system that is both viable and sustainable. The main forms of collaboration of Industry 4.0 in relation to sustainability are an essential concept to be studied. Scientific works point out the advantages provided by the new industry model such as improved product life cycles, manufacturing works in an integrated way with the use of cyber-physical systems allied to the principles of this industry, such as decentralization, virtualization, interoperability among others which lead to more adaptability to natural resources and environmental costs. The proposed study aims at conducting detailed examination regarding adoption/ contemplation/ potential for sustainable manufacturing in Micro Small & Medium Enterprises (MSMEs) located in select districts/ industrial clusters of Karnataka, India.

Keywords: Industry 4.0, Sustainable manufacturing, MSMEs, Industrial Revolution, and Operations strategy.

Introduction:

A growing number of companies are treating "sustainability" as an important objective in their strategy and operations to increase growth and global competitiveness. This trend has reached well beyond the small niche of those who traditionally positioned themselves as "green," and now includes many prominent businesses across many different industry sectors. In many cases, these efforts are having significant results.

There are a number of reasons why companies are pursuing sustainability:

- Increase operational efficiency by reducing costs and waste
- Respond to or reach new customers and increase competitive advantage
- Protect and strengthen brand and reputation and build public trust
- Build long-term business viability and success
- Respond to regulatory constraints and opportunities

It is a well-acknowledged fact that the major environmental concerns have arisen because of the pollution and consumption of natural resources. Thus, the implementation of sustainable systems is an essential requirement in modern manufacturing to address these concerns and to present effective solutions.

Each sustainable aspect has specific objectives that should be achieved in order to create and implement the efficient term of sustainability. The main objectives of social sustainability are focused on health improvement, safety, quality of life enhancement, and ethics. When looking at the environmental sustainability, clean air, water, soil, regulations implementation, and eco-balance efficiency support this goal. With respect to economic sustainability, the main pillars are product and process development, new employment, and large-scale new business opportunities. The concept of sustainable manufacturing is identified and analyzed through three main levels, namely: product, process, and system levels. The interaction among these levels provides the required sustainable target. With regard to the product level, the perspective of sustainable manufacturing focuses on the new 6R approachs (i.e., re-duce, re-design, re-use, re-cover, re-manufacture, and re-cycle) instead of the 3R approach (i.e., reduce, reuse, and recycle), as it theoretically achieves a closed loop and multiple life-cycle paradigms.

At the process level, reducing energy consumption, hazards, and toxic waste is accomplished through using an optimized technological process associated with an effective process planning methodology, while using an efficient supply chain system considering all life-cycle stages (i.e., pre-manufacturing, manufacturing, use, and post-use) provides an effective sustainable system. The expectations of a sustainable manufacturing are as follows:

- consumption reduction.
- Energy Waste elimination/reduction.
- Product durability improvement.
- Health hazards and toxic dispersion elimination.
- Higher quality of manufacturing.
- Recycling, reuse, and remanufacturing enhancement.
- Development of renewable energy resources.

Review of Literature

The proposed research aims to conduct a detailed study of the current literature in the area of sustainable manufacturing, identify broad themes & research gaps and identify the future research areas. The conceptual model for the study is depicted in Figure 1. Searched for relevant papers in the domain of Sustainable Manufacturing using key words like " Sustainable manufacturing", " Industry 4.0" , "Smart factory" , " Barriers for Sustainable manufacturing" "MSMEs" etc. , in mostly A* and A rated journals.

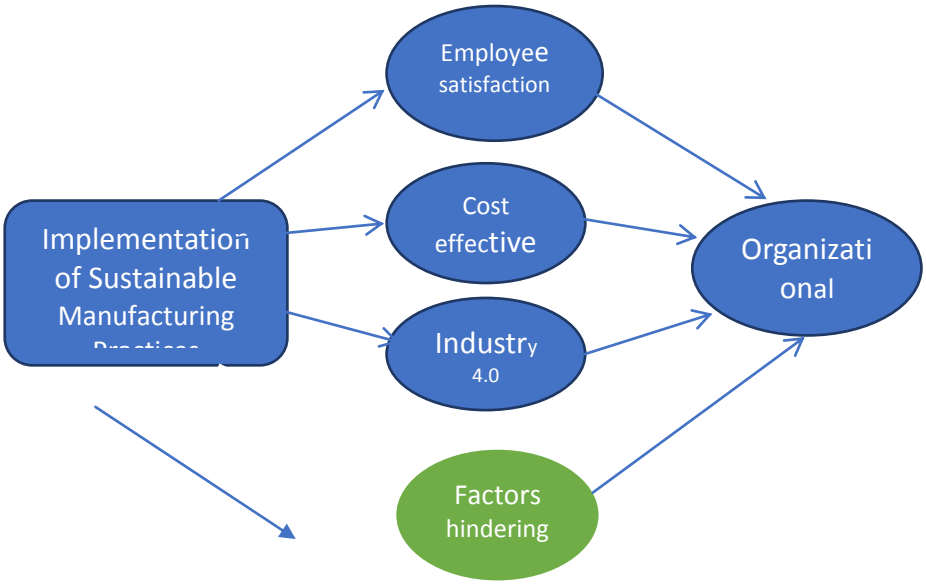

Figure 1: Conceptual model for the study

Development of Sustainable manufacturing themes

A detailed analysis of contents of the reviewed papers lead to the following themes which will be discussed more in detail in this report

1. Concept and evolution of sustainable manufacturing
2. Industry 4.0
3. Industry 4.0 and Sustainable manufacturing
4. Adoption of Industry 4.0 and sustainable manufacturing by MSMEs
5. Key drivers/ factors contributing to sustainable manufacturing
6. Barriers/ challenges of sustainable manufacturing

1. Concept and evolution of sustainable manufacturing

The evolution of sustainable manufacturing is shown in the Figure 3. It can be seen that sustainable manufacturing evolves through several generations, namely: traditional manufacturing; lean manufacturing; green manufacturing; and, in its most developed phase, sustainable manufacturing.

There is no universal definition for the term sustainability; however, the most acceptable illustration of this term was proposed by Norway's Ex-Prime Minister and Director-General of the World Health Organization (WHO), Gro Harlem Bruntland, who expressed it as "meeting the needs of the present without compromising the ability of future generations to meet their own needs".

Figure 2: Sustainability: Triple Bottom line

Jawahir and Wanigarathne showed that the main aspects of sustainability are focused on the triple bottom line (TBL) environmental, economic, and social directions shown in the figure 2, in order to achieve better requirements through effectively utilizing available resources.

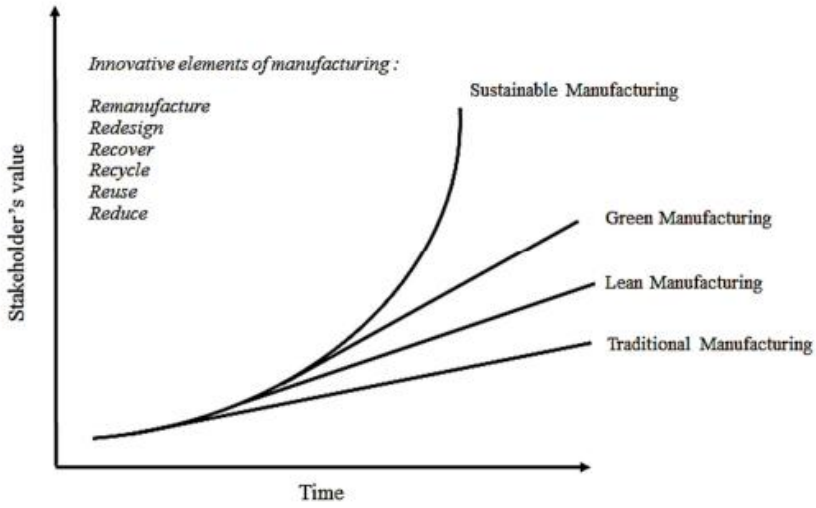

Figure 3: Evolution of Sustainable manufacturing

It is a well-proven fact that due to globalization, concerns about pollution and environmental concerns need to be taken care-off (Kishawy et al., 2018). To tackle these problems and conserve natural resources, it is essential to focus on sustainable manufacturing (Kishawy et al., 2018). Sustainable manufacturing has emerged as a pivotal concept in each and every sphere of science like mechanical, chemical, environmental, energy and material (Lee et al., 2019). Various researchers like Elkington (1994), Hediger (1999), O'Brien (1999), Aaronson (2005), Bansal (2005) and Abdul-Rashid et al. (2017) have defined the concept of sustainability. According to Elkington (1994) and Gupta et al. (2018), sustainability can be defined by a triple bottom line, which bifurcates into social, economic and environmental aspects. Other than the definition, Kishawy et al. (2018) explained numerous advantages of implementing sustainable practices include reduced energy consumed, reduced wastages, enhanced product life, reduced environmental degradation, a better quality of life. Abdul-Rashid et al. (2017) opine SMPs deal with adopting greener technologies of production, waste reduction, optimizing resource utilization and using greener recycling waste methods.

The 6R approach adds three new elements to modify the classic approach (3R); these elements are recover, redesign, and remanufacture. The recover stage deals with collecting end-of-life products through post-use activities.

2. Industry 4.0

The developed countries of the world are moving on the path of fourth stage of industrialization nowadays which is known as Industry 4.0. It is followed by third stage of industrial revolution which was based on automation powered by information technologies started in the early 1970s (Madhab C. Jena, 2019). By the mid-eighteenth century, the initial movement in terms of industry began in England.

Following the US and European countries such as Germany began a shift from agricultural society to industrial society (V. Koch et al, 2014). The phenomenon of Industry 4.0 was mentioned in the German language for the first time in 2011 in Germany, during the "Hannover Fair" event as a proposal for the development of a new concept of German economic policy based on high technology strategies, symbolizing the beginning of Fourth Industrial Revolution. Passive machines and robots have replaced the workforce, which means that they are controlled by a human being without consciousness. Already in 2012, the number of industrial robots was about 273 per 1000 workers in Germany.

Industry 4.0 has a huge advantage on accelerating the manufacturing with lower cost and higher output. It creates an environment of smart factory with smart manufacturing, smart Engineering, smart energy, and smart logistics. Industry 4.0 aims to upgrade the manufacturing technologies by integrating the physical systems of the factory with the Internet of Things (IoT), cyber-physical systems (CPSs) and cloud computing. The integrated platform helps to monitor the parameters and operations, such as man, machine, material movement and so on through real-time communication and enables to take smart decisions.

3. Industry 4.0 and Sustainable manufacturing

A paradigm Industry 4.0 will be a step forward towards more sustainable industrial value creation. In current literature, this step is mainly characterized as contribution to the environmental dimension of sustainability. The allocation of resources, i.e. products, materials, energy and water, can be realized in a more efficient way on the basis of intelligent cross-linked value creation modules.

This new industrial system is run by advanced manufacturing technologies. The set of 'pillars of technological advancement' identified by Rüßmann et al. (2015) are listed below:

- Autonomous Robots – the use of robots in the production is evolving in their utility, increasing autonomy, flexibility, and interaction with humans and other robots.
- Simulation – besides the use for simulating products, materials and production processes, simulation models can be used to improve plant operations creating a virtual model of the factory including all elements (machines, products and humans), also called digital twins.
- Horizontal and Vertical systems integration – IT systems integration in the entire supply chain creating data-integration networks and internal cross-functions integration as well.
- Industrial IoT – devices with embedded computing communicating and interacting in real-time.
- Cybersecurity – integrated networks demanding protection for critical industrial systems, manufacturing lines, and also to secure reliable communication and information flows.
- Cloud – data-driven services and data sharing across different sites will be deployed in the cloud.
- Additive Manufacturing (AM) – AM will enable small batch production of customised and lighter products, also reducing logistics costs and stocks.
- Augmented Reality (AR) – beside various applications, AR can be used to improve work and maintenance procedures and promote virtual trainings.

4. Adoption of Industry 4.0 and sustainable manufacturing by MSMEs

MSMEs are the backbone of economic growth for India. Also, 120 million people find employment in such MSMEs, and 80% of these entities are based in rural areas (Confederation of Indian Industry Report, 2019). The rural population and the location of the MSMEs underscore the importance of the MSME sector in the Indian economy. Indian manufacturing MSMEs are classified based on investment in plant & machinery. The classification bracket of expenditure towards plant & machinery is not comparable with the global standards of SME classification.

Indian MSMEs, thus, are not only small in size but also small in terms of their pockets. Hence, it is natural for such an entrepreneur to focus only on the 'bottom line' of the financials. It puts the onus of achieving sustainability goals onto consumers, in other words, 'sustainable consumption'. Growing awareness and the need for sustainable practices at all levels across the value chain pushes the budding entrepreneurs towards adopting sustainable practices in their manufacturing processes (Akshay G Khanzode, 2020).

Globalisation has necessitated smaller firms to target on Sustainable Oriented Innovation (SOI) practices, as an essential parameter for achieving competitive advantage. However, transforming MSMEs towards the incorporation of SOI practices is not an easy task for a developing country like India. For this, MSMEs will have to focus on significant innovation factors that would help them sustain global competition.

5. Key drivers/ factors contributing to sustainable manufacturing

Once the models, elements, and needs of sustainable manufacturing are defined, it is necessary to understand and obtain the required methodologies to implement an effective sustainable manufacturing system. In this section, the practice and recommendations for the implementation of sustainable manufacturing concepts are discussed. To achieve a sustainable manufacturing system, defining and implementing some practical aspects through the product, process, and system levels are required. Some of these aspects are summarized as follows (Hossam A. Kishawy and et al., 2018): -

- Applying principles of utilized materials and inputs, which are non-hazardous and recyclable;
- Developing and planning of production processes to reduce the consumption of energy, materials, and water;
- Using renewable energy that does not affect the natural environment;
- Developing product design to be reusable, re-manufacturable, or recyclable;
- Expanding the design concepts of using fewer resources and applying easy-to-repair techniques;
- Using efficient transportation and logistics systems.

The implementation steps to achieve the sustainable manufacturing approach are varied based on the implementation difficulty level. These steps are provided, as shown in Figure **4. The summary of these steps along with their descriptions are summarized as follows**

1. Developing work practice and maintenance: This step is called the housekeeping step, and it is considered as a simple action to accomplish effective monitoring, inventory management, and scheduling in all production operations (e.g., reducing loss from leaks, keep equipment's maintaining properly, sustainable training programs).

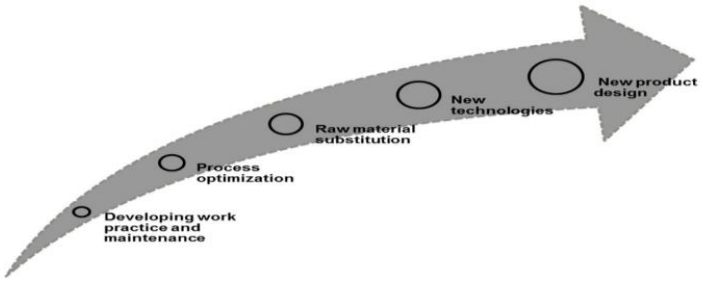

Figure 4: The implementation of steps of the sustainable manufacturing approach

(Hossam A. Kishawy and et al., 2018)

2. Process optimization: In this step, development in manufacturing processes is required to minimize waste, conserve raw materials, and reuse waste materials.
3. Raw material substitution: The main objective of this step is to replace hazardous materials and chemicals (high environmental impact) with sustainable materials (low health and environmental impact).

4. New technologies: This step depends on using more energy-efficient systems that enhance the environmental impact performance, as they have effective capabilities of saving heat and energy.
5. New product design: This is considered the most difficult implementation step as it needs to transfer the whole system from the ground up to be greener (more sustainable).
6. **Barriers/ challenges of sustainable manufacturing**
Naveen Virmani and et al., 2020 provides valuable insights on what are the 22 different barriers to sustainable manufacturing and its relevance to the MSMEs working in the automobile industry.

The 22 different barriers were categorized into four categories,

1. Production and operations related barrier (POM): POM barrier includes lack of advance manufacturing facilities, lack of research and development facilities, lack of skilled manpower, lack of standard operating procedures, lack of continuous improvement culture, employee resistance to change, communication gap, and lack of information and technology facilities.
2. Organization-related barrier (ORB): It is the second most important barrier in the manufacturing context from a sustainability point of view. This is in line with other research findings related to MSME, including automotive component suppliers (Gupta and Barua, 2016a), wherein TMT commitment was found to be an essential enabler of green supply chain management practices.
3. Collaboration-related barrier (CRB): The study findings suggest that the lack of supplier integration is having a high impact on collaboration-related barrier. For security reasons, industries typically do not involve suppliers at each stage of production. But supplier involvement results in better alternatives and improved design of the product.
4. Government rules and regulations (GRR): GRRs have a profound impact on achieving sustainability in a manufacturing organization. This aligns with Cuerva et al. (2014), who suggested that enforcement strategy from government departments contributes to keeping the industries intact with the standardized tools and procedures at every stage of production.

Conclusion:

This work created a framework for understanding the sustainable Manufacturing in the era of Industry 4.0 using the concepts taken from the literature, which are categorized into different themes. This has made easy for future classification of papers according to the above themes.

Future Research

This literature on sustainable manufacturing in the era of Industry 4.0, has recommended a number of future research directions. Majority of the studies focused on manufacturing processes, other types of business process in the supply chain according to the SCOR (Supply Chain Operations Reference) model were not considered (John Gerhard Olsson, 2018). The papers reviewed for this study involve production and IT as independent departments, challenges across these departments, such as communication, were not considered in most of the studies. Even though Industry 4.0 was introduced in 2011, there are very less empirical studies related to sustainable manufacturing in the era of Industry 4.0. The other factors like leadership, regulatory pressure, supplier relationship management, employee involvement, lean production and agile manufacturing can be considered as all are equally important for achieving superior economic performance, environmental performance and social performance. People from different departments such as supply chain, finance or marketing could have been interviewed to generate a more holistic view on sustainability in manufacturing. Majority of the studies focuses only on few countries like Germany, Italy, Scandinavian countries and Malaysia, more studies to be conducted on Indian manufacturing sector. Automobile sector, heavy industries sector, cement industries are the major focus for the study(Bonilla et al. (2018) and Brozzi et al. (2020). Limited study has been done on sustainable manufacturing at MSMEs of Karnataka.

The VUCA (Volatile, Uncertainity, Complex, Ambiguous) world of increased customer demands, bio-war leading to regional recession in various segments of manufacturing and high-attrition rate post pandemic has created a demand to study the sustainable manufacturing practices in the era of Industry 4.0 in the Micro small medium enterprises of Karnataka.

References

- Hossam A. Kishawy, Hussien Hegab, and Elsadig Saad(2018). Design for Sustainable Manufacturing: Approach, Implementation, and Assessment.
- Carla Gonçalves Machado, Mats Peter Winroth & Elias Hans Dener Ribeiro da Silva(2019). Sustainable manufacturing in Industry 4.0: an emerging research agenda. International Journal of Production Research.
- Maria Holgado , Marco Macchi & Stephen Evans(2020). Exploring the impacts and contributions of maintenance function for sustainable manufacturing. International Journal of Production Research.
- Naveen Virmani, Sasadhar Bera and Rohit Kumar. Identification and testing of barriers to sustainable manufacturing in the automobile industry: a focus on Indian MSMEs. Benchmarking: An International Journal.
- Nubia Carvalho., Omar Chaim, Edson Cazarini, Mateus Gerolamo(2018). Manufacturing in the fourth industrial revolution: A positive prospect in Sustainable Manufacturing. Elsevier.
- Rohit Sharma (2020). Sustainable manufacturing and industry 4.0: what we know and what we don't. Journal of Enterprise Information Management.
- T. Stock, G. Seliger (2019). Opportunities of Sustainable Manufacturing in Industry 4.0.International Scientific Committee of the 13th Global Conference on Sustainable Manufacturing
- Surajit Bag, Jan Ham Christiaan Pretorius, Shivam Gupta, Yogesh K. Dwivedi (2020). Role of institutional pressures and resources in the adoption of big data analytics powered artificial intelligence, sustainable manufacturing practices and circular economy capabilities. Technological Forecasting & Social Change – Elsevier
- Muhammad Imran Qureshi, Nohman Khan, Shazia Qayyum, Subha Malik, Sanil S Hishan and Thurasamy Ramayah (2020). Classifications of Sustainable Manufacturing Practices in ASEAN Region: A Systematic Review and Bibliometric Analysis of the Past Decade of Research. Sustainability – MDPI
- Christian Enyoghasi, Fazleena Badurdeen (2020). Industry 4.0 for sustainable manufacturing: Opportunities at the product, process, and system levels mentions that Quality and Business Excellence awards have become major force for driving competitiveness of Indian Organisations, to compete globally. Resources, Conservation & Recycling – Elsevier
- Javed Malek Tushar N.Desai (2019). Prioritization of sustainable manufacturing barriers using Best Worst Method. Journal of Cleaner Production.