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Sustainable Inventory Management: A Bibliometric study

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Abstract
This paper presents a bibliometric analysis on Sustainable inventory models. The methodology applied is review on previous research and the performance evaluation based on identified attributes, using MS Excel. The data set was obtained from *Library Genesis (Libgen)* using the search criteria *Sustainable Inventory*. A total of 78 papers became available based on the search criteria and were included for our analysis. Based on the analysis of the attributes, it has been observed that the most notable authors were Mr Umakanta Mishra, Mr Jei-Zheng Wu, and Biswajit Sarkar. The notable countries were USA, India and Taiwan. The most noted Universities were Vellore Institute of Technology, University of Tehran, Soochow University, Polytechnic University of Bari, Lund University, Hajee Mohammad Danesh Science and Technology University and Fu Jen Catholic University. Among the Journals, Journal of Cleaner Production, Sustainability and IEEE are the notable ones. Among the Publishers, Elsevier, Springer and MDPI are the best contributors. There has been an increase in number of the publications during the years 2016-2020. Many significant topics pertaining to Sustainable Supply Chain, Inventory Models, Life Cycle Analysis, Environmental issues, Carbon Cap and Trade, etc have been thoroughly analysed in these papers. Solutions and the way forward have been suggested. Data on some of the practical case studies have also been provided. Such type of Bibliometric Analysis helps us to review the present state of research on the chosen topic and identify the key areas in which further research can be made.

Keywords: bibliometric analysis, sustainable inventory, attributes, authors, universities, countries, journals, publishers

Introduction

Wang B et al and have applied Statistical Methods for conducting Bibliometric analysis to examine the research papers. [1]. Katherinne et al has adopted a detailed methodology for conducting the Bibliometric Analysis for Inventory Models in a Sustainable Supply Chain. This methodology includes statistical analysis of some of the attributes like Year of publication, Authors, Journals, Publishers, Universities, Countries, etc. [2]. In recent years, there has been a significant rise in research focused on the influence of eco-friendly products on the economy. In their study, Taleizadeh et al explored the optimal strategy for determining both the selling price and replenishment frequency in an inventory model for manufacturing green products.[3]. Khatua and Maity also examined the influence. relationship between the demand for environmentally-friendly products and the connection between financial gains and environmental harm in an imperfect situation inventory system for production.[4]. Saxena et al. elaborated a fuzzy logic-based

eco-friendly green inventory model.[5]. Nikolopoulou et al explained that an eco-friendly supply chain merges the management of the environment with the management of the supply chain, with the goal of minimizing and lessening the harm to the environment, the use of natural resources, waste, etc.[6]. The impact of the deterioration process on inventory models was investigated by Pahl et al, taking into account planning functions as recycling, disposal, replenishment, aggregate production, and inventory reflow.[7]. Ashby and Leat informed that there is a requirement for researchers to develop more practical tools for implementing Sustainable Supply Chain Management (SSCM)[8]. Barbosa-Póvoa and da Silva explained as to how sustainability practices are treated through operation research methods.[9]. Sustainability, as described by Emamisaleh and Rahmani (2017), is a development process that takes care of all present requirements without jeopardizing the ability of future generations to take care of themselves.[10]. A sustainable location-allocation model was created by Shaw et al taking into account how consumer behaviour affects the environment and influences the demand for low-carbon items.[11]. Salehi et al enumerated the global initiatives to reduce environmental impacts which have prompted companies to adjust their operations, improving efficiency and minimizing negative externalities. This shift has resulted in greater emphasis on sustainable practices like recycling and waste management. [12]. Torabi et al. introduced a comprehensive model for a sustainable wine manufacturer-distribution network, incorporating economic, environmental, and social objectives.[13].

Ko and Evans proposed a network design model for a third-party logistics company, examining both forward and reverse logistics flows while considering dynamic parameters.[14]. Mallidis et al. introduced a green supply chain network design model for the first time, incorporating input ports, distribution centres, and transportation modes. The model also addressed decisions regarding the dedicated or shared use of warehouses.[15]. The trends and problems associated with factors such as increasing population, reduced availability of precious natural resources has resulted in a new concept called Sustainable Logistic Management, as per Soysal et al.[16]. Faulty production processes and improper handling can result in defective products, as per Rosenblatt et al [17]. According to Vishkaei , in every batch of products, some items may have imperfections. The inspection process helps by sorting the products, ensuring that only high-quality items reach customers. Some models assume that retailers either return defective products to the supplier or sell them immediately at a discounted price [18].

In payment policies, various strategies can be employed, with one of the most widely accepted being the trade-credit policy. Trade credit serves as a short-term external financing option for retailers and can also reduce per-unit purchasing costs. During the entire trade-credit period, no interest is charged by the supplier to the retailer; however, equivalent costs may be offset through specific terms and conditions agreed upon with the retailer. Teng (2002) was the first to illustrate two distinct advantages of trade-credit periods.[19]. The concept of trade credit was first explored by Goyal, who developed an Economic Order Quantity (EOQ) inventory model that factored in allowable payment delays. In this model, interest is applied to the purchasing cost of goods traded during the permitted delay period.[20]. Lashgari et al. proposed a three-layer supply chain inventory model that incorporates a partial upstream and partial downstream credit policy.[21].

According to Benjaafar et al, rising carbon emissions have significantly affected human life and contributed to global warming, prompting governments to implement regulations aimed at reducing these emissions. Reducing carbon emissions is essential for human survival and is achieved through various policies, including carbon caps, carbon taxes, cap-and-trade systems, and carbon offset initiatives [22]. Mangan et al. stated that freight transportation is vital in modern manufacturing industries.[23].

Nagi et al have stressed the importance of making inventory and operational transportation decisions alongside the strategic facility location.[24]. Ben et al have informed that advancing towards sustainable development is a key strategic objective for supply chains, and achieving a greater degree of integration in supply chain design can significantly support this objective.[25].

The main objective of this research is to analyse the academic and scientific literature related to Sustainable Inventory Management as well as to find answers related to most representative articles, authors, journals, universities and countries. It also seeks to identify the potential areas of present trends and the future outlook of the same.

The manuscript is organized as follows: **Section 2** gives the details of the Methodology (source data and the search criteria) adopted in extracting the required data. **Section 3** presents the results of the Bibliometric analysis. The analysis includes the most representative articles, authors, journals, universities and countries. **Section 4** includes a detailed discussion on the various aspects of research, analysis and future trends. **Section 5** provides the conclusions, limitations and future research.

1. Methodology (Source data and search criteria).

The research articles have been sourced from **Library Genesis (libgen)** for which access rights are available. The key words used as search criteria are **Sustainable Inventory**. Based on the search criteria, **78 articles** could be accessed.

2. Results

2.1 Publications by year

The number of publications by year is shown in Figure 1 given below.

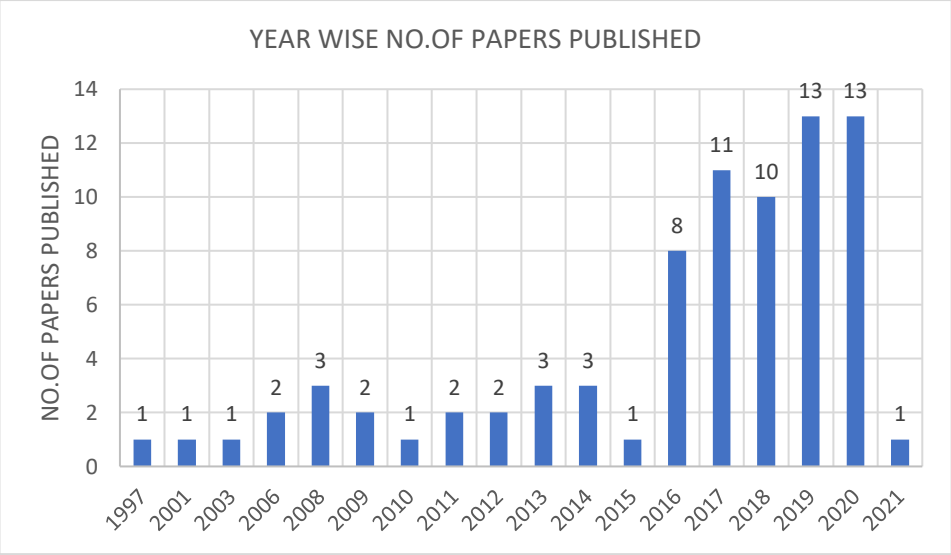

Figure 1. Year wise number of papers published.

From the figure, it is evident that there seems to be an increasing trend from the year 2016.

2.2 Publications by Journals

The number of publications by Journals is shown in Figure 2.

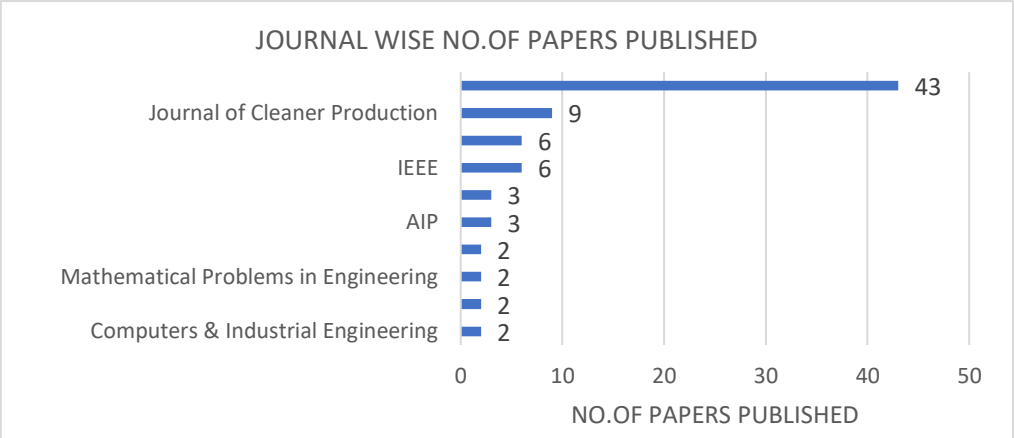

Figure 2. Journal wise number of papers published.

Journal of Cleaner Production is a peer-reviewed academic journal covering transdisciplinary research on cleaner production. It is published by Elsevier. It tops the list with 9 papers. Institute of Electrical and Electronics (IEEE) publishes the leading journals, transactions, letters, and magazines in electrical engineering, computing, biotechnology, telecommunications, power and energy, and dozens of other technologies. In our study, 6 papers have been included in IEEE. Sustainability is a peer-reviewed open-access academic journal published by MDPI. It covers all aspects of sustainability studies. In September 2021 the journal was among the initial 13 journals included in the official Norwegian list of possibly predatory journals, known as level X. In our study, 6 papers have been included by Sustainability. Further, ASME and AIP published 3 papers each, whereas 4 publishers had 2 papers each. A total of 43 journals published only 1 paper each.

2.3 Publications by Publishers

The number of publications by Publishers is shown in Figure 3.

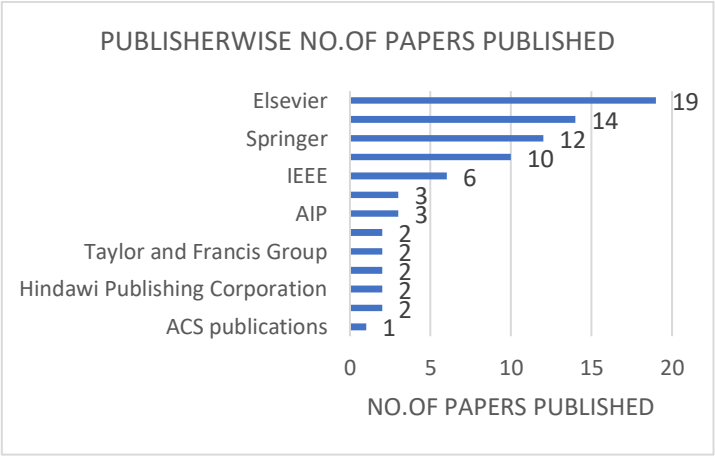

Figure 3. Publisher wise number of papers published

Elsevier, who has got 19 publications in our study, are the world's leading scientific publisher and data analytics company and have been serving the global research and healthcare communities for more than 140 years. Springer, who has got 12 publications, is an American publishing company of academic journals and books, focusing on the fields of nursing, gerontology, psychology, social work, counselling, public health, and rehabilitation. MDPI who has 10 publications, a pioneer in scholarly, open access publishing, MDPI has supported academic communities since 1996. Based in Basel, Switzerland, MDPI has the

mission to foster open scientific exchange in all forms, across all disciplines. IEEE has 6 publications. Out of the balance, ASME and AIP has 3 publications each.

2.4 Publications by Universities

The number of publications by universities is shown in Figure 4.

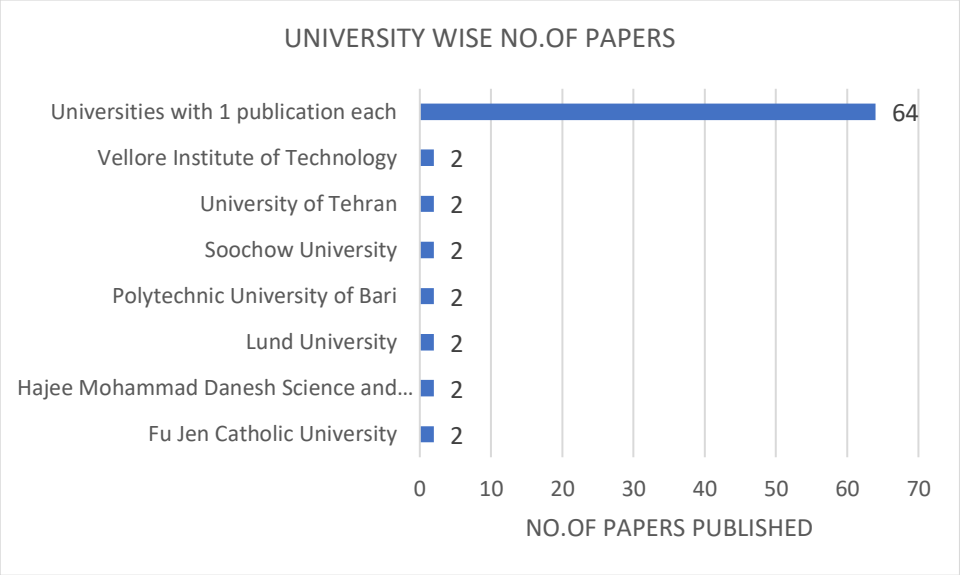

Figure 4. University wise number of papers published

Vellore Institute of Technology, University of Tehran, Soochow University, Polytechnic University of Bari, Lund University, Hajee Mohammad Danesh Science and Technology University and Fu Jen Catholic University have contributed with 2 papers each. 64 Universities have contributed with 1 paper each.

2.5 Publications by Countries

The number of publications by Country is shown in Figure 5.

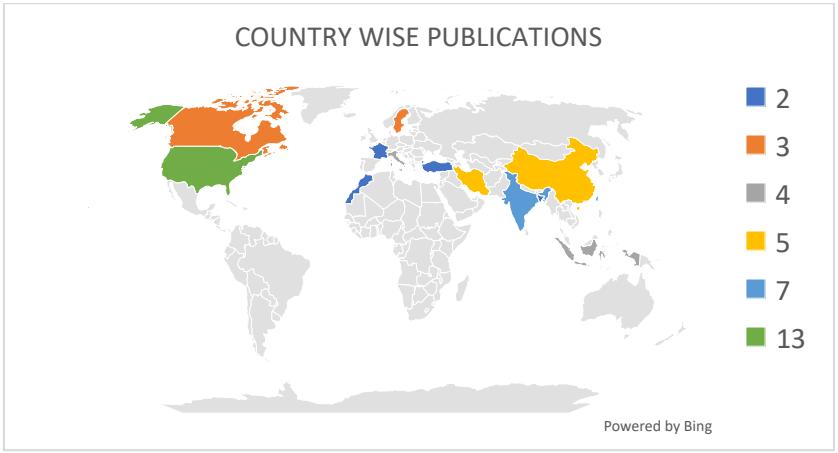

Figure 5. Country wise number of papers published

USA (13), India (7), Taiwan (7), Iran (5), China (5), Italy (4), Indonesia (4), Sweden (3), Canada (3), Turkey, Morocco, Korea, France & Bangladesh (2 each) are the major countries in which a majority of papers have been published.

2.6 Publications by No. of Authors in each paper

The number of authors contributing in each paper is shown in Figure 6.

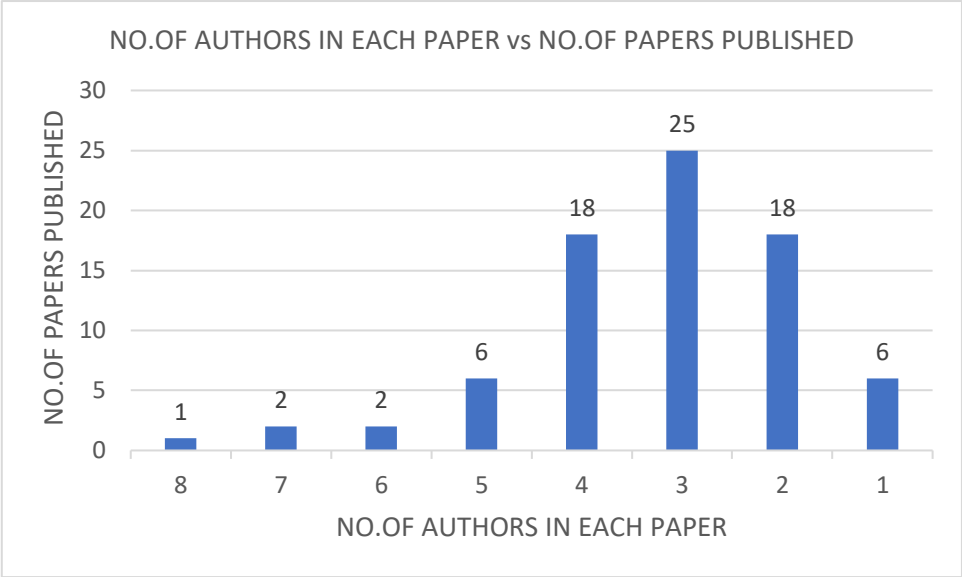

Figure 6. No. of Authors in each paper

This statistic is very interesting. 8 authors had contributed in 1 paper, 7 authors and 6 authors on 2 each. But, the most common observation is that 3 authors in a single paper had contributed in 25 papers. 4 authors as well as 2 authors have contributed in 18 papers each.

2.7 Author wise Publications.

The details of major author wise publications are shown in Figure 7.

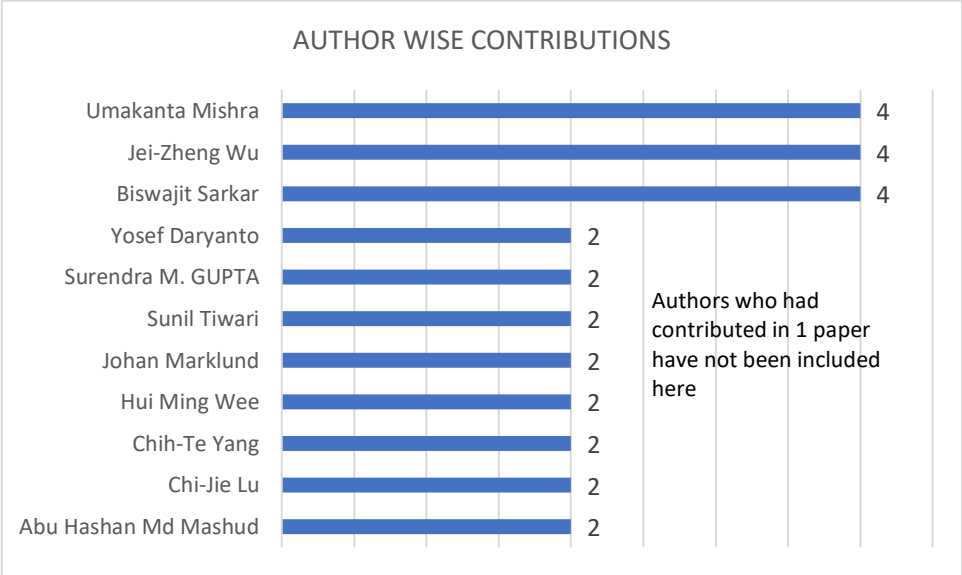

Figure 7. Author wise contributions

Mr Umakanta Mishra, Mr Jei-Zheng Wu, and Biswajit Sarkar have contributed in 4 papers each. 8 authors have contributed in 2 papers each and the rest in 1 paper each.

2.8 Key word wise grouping.

The details of the major key word wise grouping are shown in Figure 8.

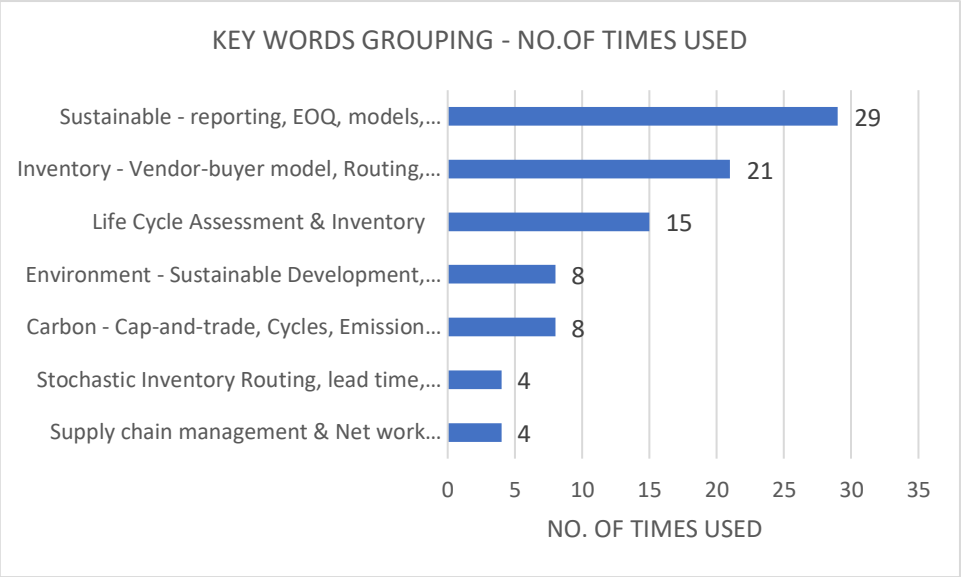

Figure 8. Key word wise grouping

Three key words were selected for each paper and were sorted and grouped and presented in the form of a bar chart above. From the chart the major key word groups are Sustainable (29 times), Inventory (21), Life Cycle Assessment (15), Environment (8), Carbon (8), Stochastic (4) and Supply Chain Management (4).

3. Discussions

The details of each attribute along with the notable contributions have been discussed in the earlier section. The summarized data is presented below.

No.	Attribute	Major Contribution
1.	Year	2016, 2017, 2018, 2019
2.	Journals	Journal of Cleaner Production, IEEE, Sustainability, AIP, ASME
3.	Publishers	Elsevier, Springer, MDPI, IEEE, ASME, AIP
4.	Universities	Fu Jen Catholic, Hajee Mohammad Danesh S&T, Lund, Polytechnic University of Bari, Soochow, University of Tehran, VIT.
5.	Countries	USA, India, Taiwan, China, Iran
6.	Authors	Biswajit Sarkar, Jei-Zheng Wu, Umakanta Mishra
7.	Key words (times used)	Sustainability, Inventory, Life cycle, Carbon related, Environment

The above data has given a lot of insight in the way the research is progressing with respect to the various attributes. Key issues under the different groups are discussed below.

Under **Sustainability,** Abu Hashan Md Mashud et al deliberated on a Sustainable Inventory model taking into account imperfection in products, deterioration and controllable emissions. An optimization model of the selling price was examined along with investment and replenishment planning to maximize profit.[26]. Pamel C et al discussed the issue of a design of a new collection system for infectious medical waste,

which are produced by patients in self-treatment, stored at pharmacies and picked upby local authorities for disposal.[27]. Fangfang Wang et al proposed calculation of estimates of exhaust emissions from a container vessel during its voyages. The estimates are done for both GHGs and air pollutants based on power-based and fuel-based approaches.[28]. B Kenter et al explored the potential of using remotely sensed data from Landsat 5 and 7 to characterize and monitor forest habitats at a landscape scale over an 11-year period, spanning from 1989 to 2000. It was found that the habitat model is a useful approach to qualify potential habitats for umbrella species at the landscape level.[29]. According to Mehmet A. ILGIN et al, the purpose of this study is to jointly optimize the spare parts inventory and transportation policies in a reverse logistic network (RL) designed for end-of-life (EOL) television recycling. With the help of Arena OptQuest, optimum number and size of trucks with optimum reorder and order qty levels for the spare PCBS for minimum cost has been proposed.[30].

Under **Life Cycle Assessment**, Forbes R. McDougall proposed for the use of Integrated Waste Management (IWM) approach along with the application of Life Cycle models for effective waste management.[31]. Beverly Saur has suggested for the use of Life Cycle Inventory (LCI) analysis, which is required for impact assessment and interpretation stages of Life Cycle Analysis (LCA). Water use and carbon tracking studies are also encouraged.[32]. According to Mary Ann Curran, the collection and validation of quality life cycle inventory (LCI) data can be the very difficult aspect of developing a life cycle assessment (LCA). The author has suggested the best sources from which LCI data can be obtained.[33]. V.Baharwani et al has suggested to examine the environmental impact of photovoltaic (PV) power generation systems throughout their life cycle, focusing on energy payback time (EPT) and greenhouse gas emissions. The analysis is conducted through a life cycle assessment (LCA) to reflect the current advancements in photovoltaic technologies.[34]. According to Antonino Marvuglia, the paper discusses the use of an iterative algorithm, known as GeTLS, for implementing Total Least Squares (TLS) regression to solve over-determined systems directly in their rectangular form, which is required for processes giving more than one output.[35].

Under **Inventory Control**, Olof Stenius et al has provided an analysis of a model for sustainable control of a one warehouse N-retailer inventory system. This also includes shipment consolidation, which is time based. In order to minimize total expected costs, the reorder levels, shipment intervals and capacity reservation quantities are jointly optimized. [36]. Secil Ercan et al has worked on a multiproduct multi-vehicle inventory routing problem. This problem has been modelled cost of fuel consumption as an environmental objective. Demand and inventory costs are considered as un-certainty. The computational results are promising.[37]. According to Tiena Gustina Amran et al , an inventory problem considering perishable raw material with warehouse capacity constraints required to be solved. Lagrange multiplier approach was used for optimizing the EOQ. It was also observed that the total inventory cost decreased by about 2.42% based on an actual case study. [38]. Marwane Benhadou et al has informed that the air quality in urban cities is getting badly affected due to the emissions of the vehicles. In his paper, he has developed a methodology to estimate traffic flows and estimate the inventory emission in the centre of the city.[39]. According to M. Rahimi et al, the management of expired perishable products is getting more difficult due to the costs associated with rework and environmental pollution. In his paper, he has advocated a new bi-objective mathematical model considering economic and environmental/social issues. Concept of reverse logistic is applied. The Torabi-Hassini method is used to solve the problem.[40].

Under **Carbon Inventory**, P. Tomkins et al, has pointed out that due to the burning of fossil fuels, the concentration of CO_2, in the atmosphere has been increasing rapidly. He has attempted to provide an

overview of the carbon inventory on earth with analysis of fluxes of carbon among the geo-habitats with a view to establish anthropogenic carbon cycles.[41]. According to Kai Kang et al, of late, business enterprises continue to focus only on economic activities and not on the impact of these activities on the society. In his paper, he has suggested a new sustainable inventory allocation planning model with carbon emissions and defective item disposal. The environment considered is of fuzzy type with the consideration of multiple periods. Dynamic Programming based GLNPSO, and a fuzzy random simulation method are deployed for the solution. [42]. Umakanta Mishra et al, in their paper had suggested for the development of a sustainable electric supply chain mathematical model wherein the demand of electricity is price-dependent and is a decision variable under setup cost and carbon emission. [43]. Hua-Yueh Liu has proposed a system to monitor the carbon foot print of a reused military facility during its renovation. The LCBA-Neuma system, a local carbon survey software developed by the Low Carbon Building Alliance (LCBA) and National Cheng Kung University in Taiwan, was used in this project. Installation of a solar cell system on the roof top has resulted in the reduction of total life-cycle carbon emissions.[44]. According to Umakanta Mishra et al, Carbon tax and cap policies are key strategies employed by many countries to address the issue of reducing carbon emission. With this in mind, a sustainable economic production quantity (SEPQ) carbon tax and cap model has been proposed to regulate carbon emissions through investment in green technology (GT) under various scenarios, both with and without shortages. This study presents three models: a) a sustainable economic production quantity carbon tax and cap model without shortages; b) a sustainable economic production quantity carbon tax and cap model with partial backordering; and c) a sustainable economic production quantity carbon tax and cap model with full backordering, with and without green technology investment.[45].

Under **Environmental issues**, according to Jinhuan Tang et al, the goal is to develop a sustainable supply chain (SSC) network that accounts for consumer environmental behaviours (CEBs). CEBs not only influence consumer demand for low-carbon products but also affect their willingness to pay premium prices for such products. CEBs are integrated into the SSC network model, which encompasses location, routing, and inventory decisions. Initially, a multi-objective optimization model that balances both costs and carbon emissions in a combined location-routing-inventory framework is proposed. This model is solved using a multi-objective particle swarm optimization (MOPSO) algorithm. Next, a revenue function that incorporates CEBs, based on a Pareto set representing the trade-off between costs and carbon emissions is added.[46]. Mohadeseh Alsadat Zadjafar et al has proposed a mathematical model for sustainable inventory. The effects of environmental factors on social issues have been studied. A green economic order quantity model (GEOQ) has been added. This has been done by including income from waste sales and sulphur oxides (SOx), nitrogen oxides (NOx) gases, Biochemical Oxygen Demand (BOD) and chemical oxygen demand (COD) indicators in waste water. Using a non-linear constrained solution method, the problem was solved. Using a real case study in paper and pulp mill, the effectiveness of the model was validated.[47]. According to Miguel Jaller et al, this study examines the direct effects of environmental policies on logistics practices. The paper focusses on estimating potential changes in inventory and fleet purchase decisions under policies aimed at enhancing the environmental efficiency of transport activities by reducing overall transportation emissions. These policies include requirements for fleets to incorporate zero and near-zero emission vehicle technologies, or to meet minimum vehicle type share mandates. The results provide insights for both private and public stakeholders as they consider the logistics challenges and opportunities generated by these sustainability policies.[48]. Umakanta Mishra et al has informed that the Supply chain activities are significant contributors to environmental emissions,

raising concerns about controlling these emissions through the development of a supply chain inventory model. This study addresses a replenishment problem involving joint pricing, dynamic investment in environmental costs, order costs, preservation technology costs, and optimal replenishment times for a non-instantaneous deteriorating item, with the goal of maximizing retailer profit. The demand rate is influenced by both stock levels and selling prices. An algorithm is employed to determine the optimal solution for the supply chain inventory problem, identifying the ideal selling price, preservation technology investment, environmental emission cost, order cost, and replenishment cycle time. Numerical analysis is conducted to show the application of the model. The proposed model could be applied in real world situations too.[49]. Hosang Jung et al has informed that with the fast advancement of information and communication technologies, sharing inventory information between manufacturers and suppliers has become more accessible than ever. Following this trend, he focussed on the concept of a virtual warehouse, where only inventory data for all supplier-provided materials is stored and shared. Unlike traditional supplier management, the manufacturer sets up and runs this virtual warehouse to monitor the inventory levels of all necessary materials simultaneously, while each supplier can only view their own inventory data. This virtual warehouse approach strengthens the relationship between manufacturers and suppliers and allows the management of suppliers as a unified entity, without the need for significant investments in a physical warehouse. This method appears to be more economically sustainable. To explore the impact of inventory information sharing through the virtual warehouse, he developed and analysed a simulation model based on system dynamics.[50].

4. Conclusion

This research analysed the data base of **Library Genesis (libgen)** pertaining to Sustainable Inventory. The concepts explained in these papers can be applied to companies, organizations, research institutes to solve the different issues related to Supply Chain Management with special focus on Sustainability. The findings of this study establish the growing interest in the Sustainable Inventory in different areas. Moreover, the increase in the number of papers published is a welcome sign. The presence of many Journals, Publishers, Authors, Universities and Countries across a wide spectrum shows great promise on the subject research in the years to come.

The limitations of the study are due to the availability of papers only from one data base, with the sample size not being very big. Bigger the sample size, better will be analysis of trend.

However, the Bibliometric analysis has clearly established the trend and pattern of the different attributes studied, based on which further research can be taken up.

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