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### **Published version**

SAAD, Sameh and KHAMKHAM, Mohamed (2022). The applications of AI in GSCM - a systematic literature review. In: SHAFIK, Mahmoud and CASE, Keith, (eds.) Advances in Manufacturing Technology XXXV. IOS, 348-353.

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# The Applications of AI in GSCM – A Systematic Literature Review

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**Abstract.** Due to the high demand for environmental sustainability and a green supply chain in recent years, industrial and service enterprises are striving to look for effective technologies and methodology to tackle the growing concerns and achieve environmental sustainability. Artificial Intelligence (AI) has emerged as one of the efficient techniques to enhance Green Supply Chain Management (GSCM) and achieve sustainable improvements. The study aims to explore and identify the main contribution of Artificial intelligence to GSCM growth and implementation through a systematic literature review. Five systematic processes are employed to evaluate and derive the latest published literature, using a set of inclusion and exclusion criteria to identify the papers in the GSCM field. The study addressed the research question and identified the most prominent AI technologies that contributed to GSCM. This paper provides insights through systematic analysis and synthesis through which researchers and practitioners will inspire to enhance GSCM growth.

**Keywords** GSCM, AI, Green materials, Green production. Green marketing and Green Consumption

## 1. Introduction

During the last of couple years, the world has been moving towards a digital era, Industry 4.0, and Artificial Intelligence (AI) has become the driving force for achieving advancement for both businesses and industry [13]. In addition, green supply chain management (GSCM) has been emerged as a critical organisational approach to enhance enterprises operational performance and to achieve sustainable improvements and competitive advantages [5]. However, organisations are increasingly demanding solutions and responses from companies that cause significant environmental impacts due to their production activities [4]. To defeat these challenges, companies need to adopt the most effective techniques and technologies to stay more competitive [13], one of the most crucial of these technologies is Artificial Intelligence which includes (IoT, cloud computing, Big Data Analysis (BDA). etc.) [24].

Dirican [8] defined AI as a machine's capability of communicating and imitating the actions of humans, using AI can lead to problem solving with higher accuracy, higher speed, and higher input. Therefore, De Oliveira et.al [5] mentioned that adopting AI along with other advanced technology can improve the cooperation between supply chain processes through the fast transfer and distribution of accurate information, the use

of information systems, increase the efficiency of the supply chain [24] and [18]. Therefore, Businesses embrace AI and invest in the application of AI to improve end to end supply chain operations [13] and [3]. However, technological developments have been shown that AI has a wider set of applications, including SCM, while other areas such as information technology are being decreased to a level of competitive necessity; thus, AI is emerging as a competitive Advantage [19]. Accordingly, there is a need to explore the contribution of AI to the field of GSCM, several studies have indicated this need such as [1], [11] and [26]. This paper attempts to address this gap through a systematic literature review and by answering the following research questions; How do Artificial Intelligence techniques contribute to GSM?

Green Supply chain management is a management method for environmental protection. It is introduced by the Industrial Research Association of Michigan State University in 1996 [18]. GSCM in terms of the product life cycle viewpoint, includes the following stages: raw materials, product design and manufacturing, product sales and transportation, product usage and recycling [18]. Integrating supply chain management and green technology enable enterprises to reduce the negative environmental impact and achieve optimal use of resources and energy [1]. Although GSCM is a concept that integrates SCM with environmental requirements at all stages, sustainable supply chain management constitutes an economic dimension, social and environmental sustainability. However, GSCM is part of sustainable supply chain management [20]. GSCM comprises five main components: green design, green materials, green production, green marketing, and green consumption [17]. As a result of the above review of the literature, five keywords are extracted to determine the results from each source of the research, including green design, green materials, green production, green marketing, and green consumption. The study is structured as follows; the methodology of the research outlines how the review was conducted [11]. The next stage is analyses and synthesis, including evaluating the individual studies based on its key contents and illustrating how they are related to each other. The paper concludes with a discussion and summarising the findings of the research.

## **2. Study Methodology**

This study adopted a systematic literature review to explore the main contributions of AI to enhancing GSCM, Denyer and Tranfield [6] stated that a Systematic Literature Review (SLR) is a research methodology that focuses on answering research questions based on the existing literature using five systematic processes. Thus, this study has followed the five processes outlined by [6] to answer the research question, which includes. 1) Establishing the literature review to gain a deeper understanding of the current knowledge, formulating the research question, identifying the research gap, and deriving the appropriate keywords for conducting SLR. 2) Locating the studies and identifying databases to collect a multitude of relevant literature for answering the research question. Hence, three databases have been determined to cover the reviewed literature related to the research question comprising Web of Science, Scouse, and ProQuest. 3) Selecting and evaluating the studies, five inclusion/exclusion criteria are used in this process to ensure the studies adopted are relevant to the research question; it focuses on the published literature between 2010 to 2021. Includes only the relevance and quality studies that contributed to GSCM, excluded all studies which are not written in English. Including all papers matching the research question (RQ) by focusing on the

Title, Aim, and Abstract, and then the article's contents, excluding all the studies repeated among databases. 4) Analysis and synthesis, the papers have been broken down into constituent parts based on GSCM field of study (green design, green materials, green production, green marketing, and green consumption). For synthesis, it has been attempted to identify the associated and different characteristics. (5) Reporting and findings, includes a summary of the data collected from the research and the results of the SLR. See Figure 1.

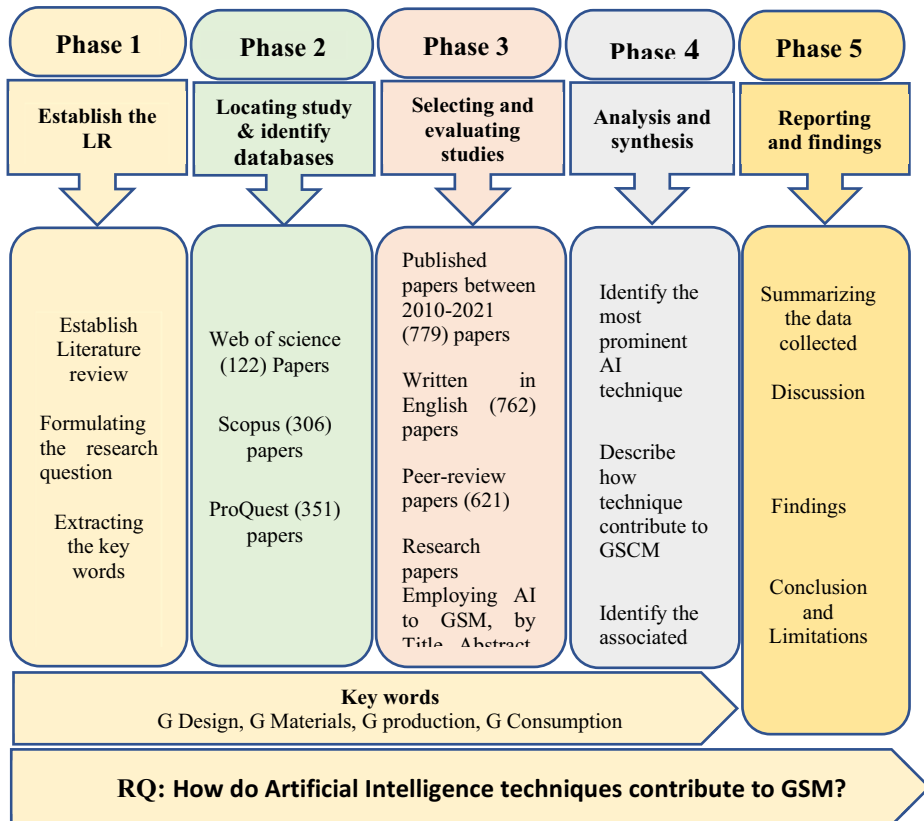


Figure 1. Research methodology

### 3. Bibliometric analysis

Twenty-three papers have been shortlisted to analyse and synthesise the collected literature and answer the RQ. A total of four papers were published in 2019 with regard to the application of AI in GSCM, and since then, the number of relevant papers has risen dramatically among the publication, which depicts the interest of the researchers and academicians in this area. The shortlisted articles were filtered in terms of the country region, the results showed that the UK had the highest contribution with nine papers, followed by the Netherlands with seven papers and Switzerland with four papers and US had two papers and Norway with one paper. Concerning analysing the results of the papers, five main AI techniques were discussed by the authors in research the results

show that AI and IoT techniques were employed by authors in 10 papers. AI and BDA techniques have been discussed in four papers, and Computing cloud, Data Environment Analysis–Artificial Neural Network DEA-ANN and Dual-channel Green Supply Chain DGSC appeared in the rest of the papers which is 9 papers.

#### **4. The contribution of AI in enhancing GSCM**

Due to the wide role and the vast application of AI techniques in SCM, and to provide a comprehensive answer for the main RQ, the study in this section strives to provide a valuable response through three main aspects: 1) Clarification of the mechanism of AI. 2) The most common AI techniques applied in GSCM. 3) How AI techniques contribute to enhancing GSCM development?

AI mechanism, this technology uses a set of tools and intelligent equipment such as RFIDs, wireless sensor networks, etc.. It utilises web-based software platforms which rely on cloud computing to facilitate the challenges of automated detection devices, which results in producing a large volume of data [8]. AI technology creates a virtual infrastructure in the Internet of Things and cloud computing. This integrates capability enables monitoring and storage processes, analytics tools, visualisation platforms, and customer delivery [18].

Therefore, IoT is one of the significant AI techniques used in the field of sustainability in GSCM by greater communication between individuals to increase their awareness and interaction with each other, which results in the development of effective communication. In addition, IoT is utilised in the transportation process to create the ability for different parts to interact in an interactive way, providing a convenient and practical intelligence transportation framework [18]. However, AI and IoT as integrated techniques (AIoT) have been used to create more transparency in the communication. It contributed to facilitating the planning process, tracking, and monitoring of goods, enabling managers and warehouse to track their shipment and inventory [20]. A IoT offers SC members a cohesive flow of real-time data about product location and shipping environment, and it gives vigilance if goods are transported in the wrong direction.

Cloud computing contributed significantly to GSCM, it helps the decision-makers to reduce the uncertainty in the most important management area of the supply chain particularly, supply uncertainty, demand uncertainty and process uncertainty [12]. This technology provides a service represented by infrastructure, platform, and software with the aid of the Internet. This service enables managers to monitor the flow of products and information in both forward and reverse flows, the technique employing a software called “Software As A Service” (SAAS), for managing uncertainty by providing on-demand information about product flow or information flow from the management of suppliers to the management of customers in both forward and reverse flows [19]. As a result, cloud computing associated with SAAS plays a vital role in managing supply chain functions such as forecasting, planning, warehouse management system, logistics system and procurement [17]

Big Data Analysis (BDA) plays a critical role in enhancing decision making in Green Supply Chain, the literature has proved that BDA improves visibility and integration in GSCs, and it also increases the availability of the valuable information [2]. In addition, BDA-AI as a hybrid technology offers help to SCM organisations by processing data needed to make internal and external green supply chain decisions to strengthen environmental performance [4]). Accordingly [21] stated that AI-BDA has

been applied for integrating environmental approaches in external and internal supply chains, resulting in reducing waste and air pollution. Benzidia et al. [2] mentioned that BDA-AI empowered internal GSC operations and collaboration with suppliers, which led to diminish the risk on the environment by reducing waste and carbon emissions.

Data Environment Analysis–Artificial Neural Network (DEA-ANN) as a combined technology used for supplier selection and green supplier selection, as selecting the right supplier in SCM has a significant impact on Supply Chain performance [14] and [15] stated that this hybrid technology is computational tools has been applied in GSCM to solve variety of problems in pattern recognition, prediction, and optimisation. This technology has an important role in predicting and calculating the suppliers' environmental performance [15].

Dual-channel green supply chain (DGSC) is a technique used in green manufacturing to selling green products through an online and offline channel [2]. DGSC technology provided a comprehensive decision support to determine important decisions, including pricing, differentiation price, and inventory in the presence of risk in a dual supply chain context. Kumar et al. [13] and Liu [14] stated that adopting DGCS is a better option for companies to reduce the cost, gain new customs, and protect the environment.

## 5. Conclusions

The paper discussed the main contribution of AI to GSCM based on a systematic literature review, twenty-one peer review articles identified and profoundly analysed through five phases. The study observed that among several different AI techniques available, some of them have been applied in a wider range in contrast to others. The paper observed that when AI is combined with other advanced technologies, it has significantly impacted the operational performance and enhanced GSCM growth. The results indicated that five AI techniques have been identified as the most prominent technology that contributed considerably to the development of GSCM and sustainability. These technologies not only improved the flow of materials and established continuous communication between supply chain members, but they also increased energy efficiency and reduced energy consumption. In addition, these technologies promoted supply chain operations with many advantages such as improving potential planning, monitoring inventory status during shipment, predicting goods movement and arrivals, tracking shipment, and locating in real-time. . These have resulted in eliminating waste, reduced environmental impact, and achieving considerable growth. It has also been noticed. The main contribution of AI technology in terms of enhancing GSCM growth and sustainability

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