Decision Support System Effects on Green Supply Chain Management: A Pathway Towards a more Sustainable Future

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Abstract. This study examines the impact of various factors on Decision Support Systems (DSS) and Green Supply Chain Management (GSCM) and their implications for sustainability. The analysis reveals that Circularity Design (CD), Sustainability Assesment (SA), Energy Optimization (EO), Green Innovation (GI), and Green Marketing (GM) significantly enhance the effectiveness of DSS and GSCM, underscoring their importance in fostering sustainable business practices. Conversely, Green Human Resources (GHR), Transportation Optimization (TO), Social Responsibility (SR), and Environmental Impact (EI) show non-significant effects, suggesting these areas may require further integration and strategic focus. This research is quantitative, involving a sample of 102 supply chain professionals from various business sectors. Structural equation modeling based on the SMART PLS approach was used to evaluate the hypothesis. The findings indicate that while certain elements are critical to driving sustainability, others need to be re-evaluated to better contribute to long-term environmental and operational goals. Future implications include the need for organizations to enhance collaborative and sustainability-focused decision-making processes, invest in green innovation and marketing, and strategically refine approaches to human resources, transportation, and social responsibility to achieve a more sustainable future.

Keywords: Green Supply Chain, Decision Support System, Sustainable Future

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1 Introduction

Managing supply chains more sustainably and efficiently is a challenge for businesses everywhere in this age of growing globalization [1]. Businesses are being encouraged to use Green Supply Chain Management (GSCM) techniques due to the growing consumer demand for eco-friendly products [2]. GSCM enhances operational effectiveness and business competitiveness in addition to minimizing the environmental impact of manufacturing and distribution operations [3]. The integration of sustainability concepts into supply chain management is known as "green supply chain management" (GSCM). This includes many different tasks, including choosing raw materials that are less harmful to the environment, streamlining production procedures to cut down on waste, and distributing goods in a way that lessens their carbon footprint [4].

However, there are certain difficulties in putting GSCM into practice. While making educated decisions on sustainability policies, businesses frequently encounter complexity and ambiguity. Decision Support Systems (DSS) play a critical role in this situation. A technique called DSS helps with complicated and unstructured decision-making by utilizing data, models, and information technology [5]. Multiple approaches for Decision Support Systems (DSS) have been created and evaluated through case studies in several fields of use, including sustainable assessment [6,7], circularity design [8,9], delivery optimization [10], energy optimization [11,12], transport optimization [13,14] and demand prediction [15].

Employing DSS enables businesses to efficiently evaluate data, forecast the effects of different choices, and choose the most effective tactics for achieving their GSCM objectives [16]. Determination support systems are frequently considered most helpful when interacting with suppliers, even though they address many other parts of GSCM. Organizing, selecting, evaluating, and selecting new suppliers are all included in this.

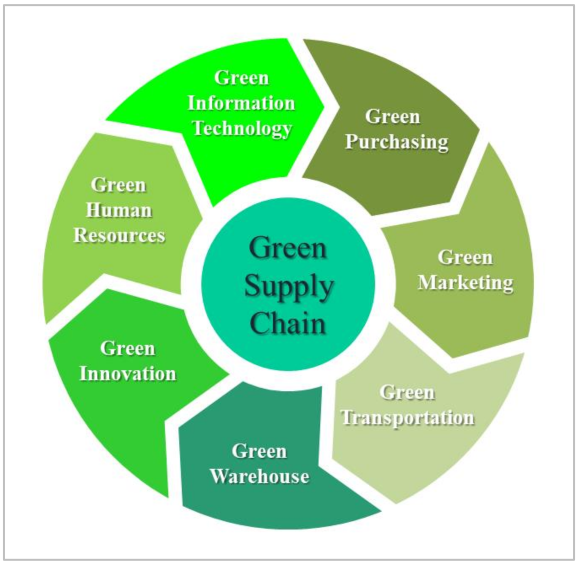

Fig. 1 Scope of activity green supply chain

According to Ninlawan et.al [17], GSCM has four activities, namely green procurement, green manufacturing, green distribution and reverse logistics. However, the GSCM's scope has expanded throughout time, as seen in Fig. 1, which includes green purchasing [18], green marketing [19], green transportation [20], green warehouse [21], green innovation [22], green human resources [23] and green information technology [24]. The green supply chain cooperation might be considerably more important. By encouraging environmentally friendly supply chain collaboration, the impact of this can be further enhanced. Building environmentally friendly products requires unique procedures and specialized equipment. A production or distribution process may encounter difficulties if essential information from partners, such as market demand, isn't easy to find. In such cases, the level of cooperation may need improvement unsatisfactory. This also leads to a decrease in the quality of eco-friendly items. However, the primary objective of businesses with green values and green supply chain is to achieve the greatest sustainability for the future [25].

The business aim of every organization should be supported by green supply chain goal. A corporation should look at its entire business goal and discover how green supply chain can help to reach its goals [26], like cost saving, environmental impact, social responsibility and sustainable practice [27]. Furthermore, the use of DSS in GSCM must be focused on issues related to the chain as a whole, which means it must be exhaustive from upstream to downstream and not only focus on certain chain elements [28]. To demonstrate how merging DSS and GSCM might help businesses advance towards a more sustainable future (SF), this article will examine key elements of each and assess their impact. Based on an investigation of previous studies conducted by researchers, it was revealed that there had been no research that explored variables affecting DSS, GSCM and SF simultaneously.

2 Methods

2.1 Conceptual Framework and Hypothesis Development

From the literature review, this research contributes to knowledge by providing conceptual and empirical insights into how environmentally friendly supply chain management is implemented among industrial sectors where companies and producers, clarify concepts related to future sustainability, by involving decision support systems as decision-makers. This research will explain how a decision support system (DSS) influences green supply chain management (GSCM) for sustainable future (SF). Here GSCM is the mediating variable, DSS is the independent variable and SF is the dependent variable.

Several literature studies on decision support systems are problem-solving tools. Labonnote et.al (2017) and Callychurn (2023) confirm that if the right strategies and decisions are taken, there is still hope for the industry's sustainability in the future [29,30]. Therefore we propose the following hypothesis,

H1: *DSS has a significant effect on SF*

Though it has progressed extremely quickly recently, there still needs to be more research on decision support systems in supply chains specifically related to green supply chains [31]. Therefore, we propose the following hypothesis,

H2: *DSS has a significant effect on GSCM*

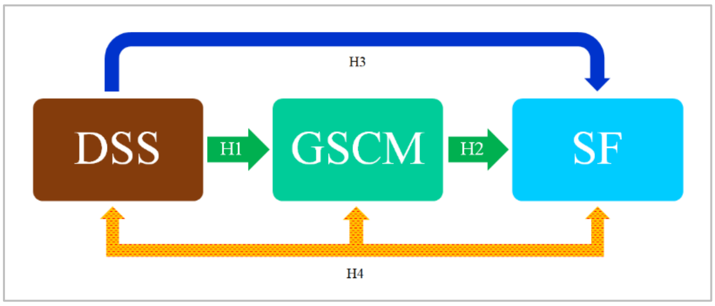

Fig. 2 Conceptual framework between decision support system (DSS), green supply chain management (GSCM) and sustainable future (SF)

While hurdles remain, the benefits of implementing green supply chain principles far surpass the initial expenditure, ultimately leading to a more sustainable future for all [32]. Therefore, we propose the following hypothesis,

H3: *GSCM has a significant effect on SF*

H4: *GSCM mediates the relationship between DSS and SF*

2.2 Research Approach and Sampling Method

Data analysis and collecting occur using a quantitative technique. This decision was made with the justification that, in attempting to explain correlations across research constructs, studies are both causal and predictive. The empirical portion of this study used a combination of correlational and survey research designs, using questionnaires for data collection, to maximize response rates [33]. The use of DSS in the green supply chain should be more focused on sectors that have significant and broad economic impacts such as agriculture, fisheries, animal husbandry and animal husbandry. This is important because attention to these sectors in the last decade has been limited. To ensure these conditions, questionnaires were given to companies in various sectors. A sample size of n=102 was considered adequate, based on recommendations from Memon et.al [34] that sample sizes are sufficient for multivariate research.

2.3 Statistical Analysis

Data were examined using descriptive and inferential statistics. The SMART partial least square (version 4.0) was applied as a method to achieve the entire analysis of data [35].

3 Results and Discussions

3.1 Respondent Characteristic

From 150 questionnaires sent, 102 were completed and deemed valid for analysis, resulting in an overall response rate of 68%. Several studies [36,37] recommend 60% as the minimum acceptable criterion for response rates in surveys.

In terms of gender, the sample consisted of 76.5% (n=78) men and 23.5% (n=24). The majority age group represents 41-50 years 60.8% (n=62). And most positions are in the manager group at 40.2% (n=41), while directors are at 9.8% (n=10) and the rest are supervisors at 16.7% (n=17), staff at 29.4% (n=30) and lecturers at 3.9% (n=4).

Regarding industrial classification, it is dominated by the energy industry at 39.2% (n=40), the manufacturing industry 13.7% (n=14), the chemical industry 2.9% (n=3), construction and developer 3.9% (n=4), consultant and services 9.8% (n=10), education and academic 7.8% (n=8), financial and general insurance 3.9% (n=4) others like ASN, hotel and hospitality, distributor, food and beverage, cosmetic, media & telecommunication, shipping) of 18.6% (n=19).

3.2 Analysis of Reliability and Validity

From the results obtained by smartPLS, there are several constructs whose composite reliability values are below 0.7, such as green purchasing, green transportation and green warehouse, this indicates that these constructs are not reliable, so the construct is removed. Table 1 explains that if the composite reliability (rho_c) value is > 0.7, this indicates that the construct asssesing has an acceptable level of reliability. Overall, the items measuring this construct are reliable in measurement design. The AVE value has a value of >0.5, meaning that the large variation in measurement items from each dimension meets the requirements for good convergent validity.

Table 1. Construct and measurement items

Construct	**Cronbach's alpha**	**rho_a**	**rho_c**	**AVE**
Circularity Design (CD)	0.808	0.808	0.912	0.839
Demand Prediction (DP)	0.849	0.854	0.930	0.869
Decision Support System (DSS)	0.937	0.939	0.946	0.639
Environmental Impact (EI)	0.824	0.824	0.919	0.850
Green Human Resources (GHR)	0.824	0.827	0.919	0.850
Green Innovation (GI)	0.789	0.789	0.905	0.826
Green Marketing (GM)	0.938	0.941	0.970	0.941
Green Supply Chain Management (GSCM)	0.912	0.913	0.930	0.654
Sustainable Assessment (SA)	0.808	0.808	0.913	0.839
Sustainable Future (SF)	0.911	0.914	0.931	0.693
Sustainable Practice (SP)	0.836	0.838	0.924	0.859
Transport Optimization (TO)	0.789	0.809	0.904	0.825

3.3 Path Analysis

The results from Figure 3 show the path coefficients range between 0.115 and 0.389, indicating there is a relationship between the constructs.

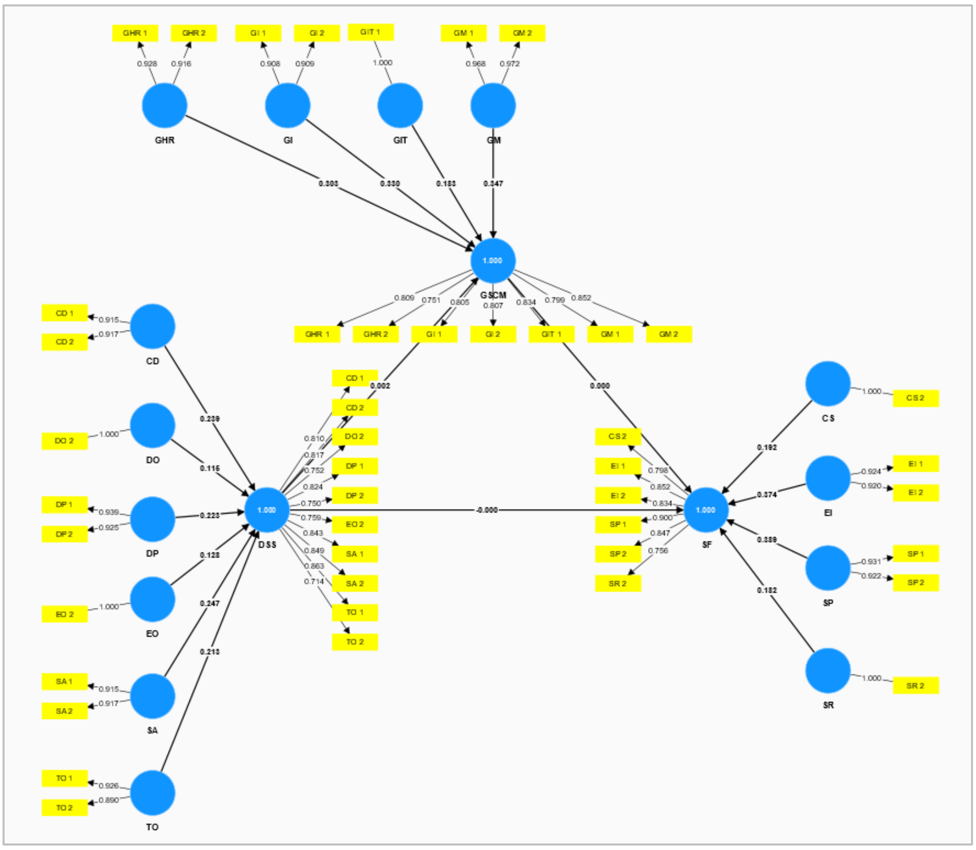

Fig. 3 Path coefficients one stage approach

3.3 Structural Evaluation Model

In this article, because the variables used are second order, the hypothesis test uses a two-stage approach, namely by connecting the variables according to the hypothesis. The intranet quality variable is measured by the latent variable score (LVS) formatively.

Table 2. Inner VIF

	VIF
Decision Support System -> Sustainable Future	3.471
Decision Support System-> Green Supply Chain Management	1.000
Green Supply Chain Management -> Sustainable Future	3.471

In Table 2, VIF (variance inflated factor) value is less than 5, so there is no multicollinearity between each variable.

Table 3. Results of outer weights

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Result
CD -> DSS	0.335	0.313	0.149	2.243	0.012	Supported
DO -> DSS	0.139	0.149	0.092	1.513	0.065	Not supported
DP -> DSS	0.069	0.09	0.122	0.567	0.285	Not supported
EO -> DSS	0.242	0.228	0.103	2.356	0.009	Supported
SA -> DSS	0.343	0.312	0.129	2.655	0.004	Supported
TO -> DSS	0.024	0.053	0.141	0.172	0.432	Not supported
GHR -> GSCM	0.06	0.084	0.139	0.428	0.334	Not supported
GI -> GSCM	0.563	0.531	0.142	3.96	0.000	Supported
GIT -> GSCM	0.239	0.23	0.17	1.407	0.080	Supported
GM -> GSCM	0.27	0.28	0.105	2.568	0.005	Supported
SP -> SF	0.737	0.721	0.1	7.402	0.000	Supported
SR -> SF	0.092	0.093	0.076	1.218	0.112	Not supported
CS -> SF	0.166	0.187	0.097	1.714	0.043	Supported
EI -> SF	0.091	0.086	0.09	1.02	0.154	Not supported

In table 3 it can be seen that delivery optimization, demand prediction and transport optimization do not have a direct influence on the decision support system. Then green human resources do not have a direct influence on green supply chain management. Sustainable practices and environmental impact also do not have a direct influence on a sustainable future.

Table 4. Results of PLS hypotheses testing analysis

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Result
DSS-> GSCM	0.844	0.866	0.029	28.994	0.000	**Supported**
DSS -> SF	0.886	0.897	0.025	35.926	0.000	**Supported**
GSCM -> SF	0.468	0.444	0.117	4.013	0.000	**Supported**

Decision support system has a significant influence on green supply chain management of 0.844 with t-statistics (28.994 > 1.96) or p-value (0.000 < 0.005), meaning that every change to the decision support system will significantly improve the green supply chain. Decision support system has a significant influence on sustainable future of 0.886 with t- statistics (35.926 > 1.96) or p-value (0.000 < 0.005), meaning that every change to the decision support system will significantly improve sustainable future.

Green supply chain management has a significant influence on sustainable future of 0.468 with t statistics (4.013 > 1.96) or p-value (0.000 < 0.005), meaning that every change to green supply chain management will significantly improve the sustainable future.

If the three hypotheses above are declared significant, then it can be stated that green supply chain management mediates the relationship between decision support system and sustainable future. In Figure 5 above, the green supply chain mediates between the decision support system and the sustainable future, but the decision support system also has a direct influence on the sustainable future. In this context, the author wants to illustrate that a decision support system can be applied for the sustainability of a company, namely by implementing green supply chain management.

Based on the eliminated mediating variable indicators, such as green purchasing, green marketing, and green warehouse, it may be concluded that numerous companies have yet to adopt these activities.

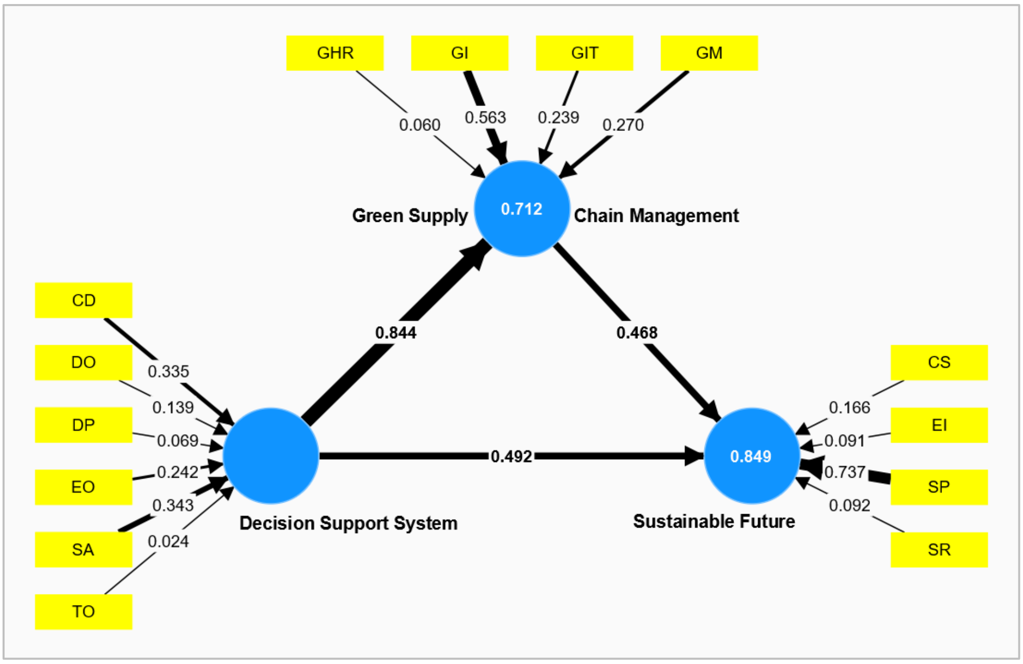

Fig. 4 Hypothesis testing

4 Conclusions

Based on the results of the discussion and research findings, several conclusions can be put forward. Green supply chain management has a significant impact on the sustainable future. This proves that the implementation of GSCM in several industries has gone well even though it has not been optimal. So it is hoped that there will be seriousness from the management and improvements in the implementation of green purchasing, green marketing and green warehouse.

Green supply chain management has a significant influence on the sustainable future. It is proven that the better the green supply chain management, the greater the company's sustainability. Decision support systems have a significant influence on the sustainable future.

The results prove that the stronger the company's system selection decisions, the better the company's sustainability will be maintained.

The findings show several significant ramifications for upcoming approaches. First, businesses should give priority to these areas in the construction of their Decision Support Systems (DSS) due to the substantial influence that both Circularity Design (CD) and Sustainability Assesment (SA) have on DSS. Businesses may improve the sustainability and collaborative aspects of their decision-making processes, which will improve environmental results and boost operational efficiency. Furthermore, the significance of fostering a strong environmental culture inside firms is highlighted by the significant impact of Energy Optimization (EO) on DSS. Businesses can make more sustainable and informed decisions if these ideals are aligned with DSS capabilities.

The important implications of Green Innovation (GI) and Green Marketing (GM) for Green Supply Chain Management (GSCM) underscore the necessity of ongoing investment in environmentally friendly products and sustainable marketing techniques. In addition to lessening the impact on the environment, these strategies guarantee that supply chains maintain their competitiveness and appeal to customers who are becoming more environmentally concerned. On the other hand, the non-significant results for Transportation Optimization (TO) and Green Human Resources (GHR) suggest that the way these sectors are currently approached may need to be reassessed. To improve the efficacy of GSCM, businesses should look for innovative ways to combine HR procedures and technology with their sustainability objectives. Lastly, the importance for businesses to deeply integrate sustainability into their operations is highlighted by the tremendous influence that Sustainable Practices (SP) have on a Sustainable Future (SF). Since SP is a major factor in achieving long-term sustainability objectives, businesses should keep improving and growing these methods. However, the limited influence of Environmental Impact (EI) and Social Responsibility (SR) raises the possibility that these elements need deeper strategic integration in order to effectively contribute to a sustainable future. Organizations can embrace a more all-encompassing strategy for sustainability that combines environmental care with commercial success by filling in these gaps.

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