Innovations

# Analytic Hierarchy Process Framework for Prioritizing Green Supply Chain Factors: A Case Study of Small-Scale Industries

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***Abstract:*** *This research paper delves into the application of the Analytic Hierarchy Process (AHP) framework for evaluating and prioritizing factors within the context of Green Supply Chain Management (GSCM). With a focus on small-scale industries in Jalgaon District, the paper aims to enhance understanding and implementation of GSCM principles. The AHP framework enables systematic comparison and weighting of different criteria, facilitating decision-makers to identify critical areas for improvement and resource allocation. The research emphasizes the significance of AHP in assessing and ranking factors critical to sustainable supply chain management, offering valuable insights for decision-makers in the pursuit of environmental responsibility and efficient operations. It presents the results of AHP analysis for GSCM practices, drivers, barriers, and pressures. Also highlights the relative significance of these factors, aiding in prioritizing efforts and resources towards sustainable and efficient supply chain practices.*

***Keywords:*** *AHP, Green Supply Chain, Decision-Making, GSCM Factors*

## 1. Introduction

In the context of modern business practices, the utilization of Green Supply Chain Management (GSCM) tools has garnered significant attention due to the increasing emphasis on sustainability and environmental consciousness. This research centers around a recent study conducted in the small-scale industries (SSIs) of the Jalgaon region, Maharashtra, focusing on GSCM criteria and their corresponding sub-criteria. The fundamental objective of this study was to meticulously assess the ramifications of implementing GSCM practices within this industrial sector. The research approach commenced at the foundational level, aiming to comprehensively grasp the performance dynamics of SSIs within the Jalgaon district. The AHP framework undergoes a critical analysis, aiming to prioritize the identified key Green Supply Chain Management (GSCM) factors. This prioritization provides valuable insights for decision-makers in their pursuit of environmentally responsible implementation.This research aims to explore the adoption of Green Supply Chain Management (GSCM) practices in Small Scale Industries (SSIs) located in Jalgaon, Maharashtra, India. The primary objective is to identify and address the challenges that SSIs encounter in implementing GSCM, and concurrently, to provide recommendations to promote sustainable growth within this context. SSIs facing challenges in embracing GSCM practices, including insufficient awareness, financial constraints, and technological limitations (Govindan, 2011; Narasimhan& Carter, 1998).In the MIDC area of Jalgaon District, small-scale industries face various challenges while maintaining competitiveness. Despite the growth-oriented approach, these industries grapple with inefficiencies in inventory management, skilled workforce shortage, material underutilization, and safety concerns. This research addresses these challenges by investigating the implementation of GSCM practices to enhance environmental, economic, and operational performances. The study employs the AHP framework to prioritize Green Drivers, Barriers, and Pressures, aiming to enhance the understanding and implementation of GSCM principles in the context of small-scale industries.

## 2. Objectives of the study

The primary objectives of this study are to identify operational parameters of Green Supply Chain Management (GSCM) practices, assess the prevailing GSCM landscape in the Jalgaon district, explore challenges encountered by enterprises during GSCM implementation, formulate sector-specific and overarching GSCM models, analyze the financial and environmental dimensions of the proposed GSCM model, delineate criteria for green supplier selection in small-scale industries, employ Multi-Criteria Decision-Making (MCDM) techniques to evaluate suppliers on economic and environmental grounds, and finally, utilize diverse MCDM methods to identify the optimal supplier choice.

Researchers have identified approximately 24 different definitions, showcasing the field's positive evolution. Numerous researchers have made efforts to define GSCM based on their scholarly work. Table 1provides an overview of various definitions proposed over the years by different authors.

Table 1 GSCM Definitions

| Year | Term | Definition | Authors |
| --- | --- | --- | --- |
| 1997 | Environmental Supply Chain Management (ESCM) | "ESCM involves the application of environmental management principles to all activities within the customer's control cycle. This includes aspects such as design, supply, manufacturing, assembly, packaging, logistics, and distribution." | Handfield et al. |
| 1998 | Environmental Supply Chain Management (ESCM) | "ESCM encompasses the active participation of the purchasing function in activities aimed at reduction, recycling, reusing, and substituting materials within the supply chain." | Narasimh and Carter |
| 1999 | Green Supply Chain Management (GSCM) | "GSCM defines a supply chain that extends beyond the traditional model by incorporating recycling, reusing, and/or remanufacturing activities for both the product and its packaging, thus creating a semi-closed loop." | Beamon |
| 2000 | Green Supply Chain Management (GSCM) | "GSCM is the integration of environmental criteria into the conventional supply chain network. This is achieved through the redesign of purchasing policies and active involvement of suppliers in the entire procurement process." | Gilbert |
| 2001 | Environmental Supply Chain Management (ESCM) | "ESCM comprises a set of supply chain management policies, actions, and relationships designed in response to environmental concerns related to the design, acquisition, production, distribution, use, reuse, and disposal of the firm's products." | Zsidisin and Siferd |
| 2003 | Green Supply Chain Management (GSCM) | "GSCM involves a combination of activities that incorporate environmental considerations and reverse logistics within the supply chain." | Sarkis |
| 2005 | Green Supply Chain | "GSCM is mathematically defined as Green Supply Chain Management (GSCM) = Green Purchasing + Green Manufacturing / Materials | Hervani, Helms, and Sarkis |

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| | Management (GSCM) | Management + Green Distribution / Marketing + Reverse Logistics." | |
| 2008 | Green Supply Chain Management (GSCM) | "GSCM involves the adoption of eco-friendly practices that encompass internal environmental management, green purchasing, collaboration with customers, and eco-design for developing corporate and operational strategies to promote environmental sustainability." | Zhu |
| 2008 | Green Supply Chain Management (GSCM) | "GSCM involves the integration of environmental dimensions with the traditional supply chain network." | Carter and Rogers |
| 2009 | Green Supply Chain Management (GSCM) | "GSCM is a process that introduces environmentally conscious elements into existing supply chain management, illustrating how the reverse supply chain, organizations, and innovative activities reshape the system." | Johny |
| 2009 | Green Supply Chain Management (GSCM) | "Green supply chain management represents a strategic action undertaken by collaborating partners and stakeholders within the supply chain to mitigate and/or eliminate the adverse environmental impacts of business activities throughout the chain, thereby ensuring sustainability." | Shukla, Deshmukh, and Kanda |
| 2011 | Green Supply Chain Management (GSCM) | "GSCM embodies an organizational philosophy aimed at reducing environmental risks." | Govindan |
| 2013 | Sustainable Supply Chain Management (SSCM) | "Sustainable supply chain management refers to a focal company collaborating with its suppliers to enhance environmental performance." | Ahi, P., & Searcy, C |
| 2015 | Green Supply | "GSCM plays a vital role in leveraging the overall environmental impact of any company | Thoo Ai China, |

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| | Chain Management (GSCM) | involved in supply chain activities, thereby contributing to improved performance in terms of sustainability, encompassing economic, social, and environmental aspects." | Huam Hon Tatb, ZuraidahS ulaiman |
| 2017 | Green Supply Chain Management (GSCM) | "Innovative techniques in supply chain management that aim to reduce environmental impact and maximize economic benefits are collectively known as GSCM practices." | Sharma et al. |

## 3. Significant factors to Implement GSCM Practices

The significant factors for implementation of green practices in SSIs is illustrated in Figure 1.


Figure 1Key Parameters to Implement GSCM

**Green Purchasing:** Green purchasing is a sustainable procurement practice that assesses the environmental impact of products. It involves selecting materials that minimize waste and encourage remanufacturing. According to EltayebT.K. et al., (2010), green purchasing is an environmentally focused procurement activity that emphasizes reducing waste, promoting recycling, reusing materials, and resource efficiency. Several drivers of green purchasing have been identified in the literature, including environmental collaboration, top management commitment, regulatory pressure, environmental investment, and customer demands (Yen, Y., & Yen, S., 2011; Kaufmann, H.R., Panni, M.F.A.K., &Orphanidou, Y., 2012).

**Green Design**: Green design pertains to the sustainable design of products, requiring careful consideration of both quantity and quality throughout the product life cycle (Jagannath Reddy et al., 2018; Niraj Kumar et al., 2015). It is a critical component of sustainable product development (Knight, P., & Jenkins, J.O., 2009). Adopting green design methods and practices leads to more eco-friendly and sustainable product designs, although it presents challenges related to cost, durability, and other factors.

**Green Manufacturing**: Green manufacturing involves the transformation of raw materials into finished products with a focus on reducing energy consumption and increasing profitability by minimizing waste (Jagannath Reddy et al., 2018; Niraj Kumar et al., 2015). It emphasizes the use of eco-friendly materials and production technologies, with the goal of mitigating the negative environmental impacts of the production process.

**Green Distribution and Packaging:** Green distribution and packaging refer to transportation practices that have minimal environmental impact and streamline the timing of storing, order processing, packaging, and transportation (HariharanGaneshan& Dr. P. Suresh, 2015; Jagannath Reddy et al., 2018; Niraj Kumar et al., 2015). Effective and environmentally friendly packaging methods are crucial in this context.

**Green Marketing:** In today's digitally connected world, green marketing of products is a highly effective branding strategy, creating a positive image for products compared to other marketing approaches.

**Reverse Logistics**: Reverse logistics involves managing the flow of goods from their destination back to the source, addressing various aspects such as consumer returns, marketing returns, asset returns, damage returns, return avoidance, and gate-keeping (Curtis Greve and Jerry Davis, 2015; Zhu, Q., & Sarkis, J., 2004). Implementing a robust reverse logistics management system can lead to enhanced customer satisfaction and the establishment of long-term customer relationships. The primary objective of reverse logistics is recycling, reusing, repairing, remanufacturing, and responsible product and material disposal (Das, K., &Chowdhury, A.C., 2012).

## 4. Literature Review

Multi-criteria decision-making (MCDM) methods play a crucial role in aiding decision-makers when multiple criteria influence decision outcomes. They offer flexibility, allowing decision-makers to choose from a variety of techniques. However, this diversity can lead to varying results, which is a significant challenge in the field of MCDM (Mulliner, E., et al., 2016). MCDM has wide-ranging applications spanning various domains, including finance and engineering. It can be broadly categorized into Multiple Attribute Decision-Making (MADM) and Multiple Objective Decision-Making (MODM).

MADM is employed for decision problems with implicit objectives and finite decision spaces, involving a limited number of alternatives and attributes. In contrast, MODM deals with explicit objectives within a continuous decision space, accommodating an infinite number of alternatives and attributes. The choice of an appropriate MCDM method depends on the specific nature of the decision problem. While there are numerous MCDM methods available,

Mardani et al. (2019) categorized research articles based on their utilization of MCDM methods. These methods include AHP, TOPSIS, ELECTRE, ANP, PROMETHEE, DEMATEL, VIKOR, hybrid MCDM, and DM aggregation methods. Hybrid methods combine two or more different techniques to enhance decision outcomes, while aggregate methods encompass techniques such as Complex Proportional Assessment (COPRAS), Additive Ratio Assessment (ARAS), Weighted Aggregated Sum Product Assessment (WASPAS), Step-wise Weight Assessment Ratio Analysis (SWARA), and Multi-Objective Optimization by Ratio Analysis (MOORA or MULTIMOORA). MULTIMOORA represents an updated version of MOORA. Given that most MCDM decision problems involve discrete decision spaces, our discussion will primarily focus on common MADM methods.

Analytical Hierarchy Process (AHP) emerges as one of the most extensively applied methods in practical scenarios due to its inherent simplicity. AHP aids in determining criterion weights, ranking alternatives, or simultaneously performing both tasks. For example, ChandimaRatnayake and Markeset (2010) employed AHP to select maintenance strategies for oil and gas installations, taking into account health, safety, environmental, and financial criteria. In another context, M. Rajak and K. Shaw (2019) utilized AHP to assign weights to criteria while selecting ideal mobile health applications. AHP's popularity in handling complex problems arises from its ability to break down problems into hierarchical structures, facilitating a clear visualization of the primary goal, criteria, sub-criteria, feasible alternatives, and their interrelationships.The Comparison of various MCDM methodsare presented in Table 2.

Table 2Comparison of various MCDM methods

| **MCDM Method** | **Description** | **Applications** |
|---|---|---|
| Analytical Hierarchy Process (AHP) | - Simplicity and ease of use. - Decomposes complex problems into hierarchical structures. - Effective for determining criterion weights, ranking alternatives, or both simultaneously. | - Maintenance strategy selection. - Mobile health app selection. - Various domains. |
| Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) | - Logical and straightforward mathematical approach. - Ranks alternatives based on proximity to ideal reference and distance from anti-ideal point. - Sensitivity compared to other methods. | - Machinery selection. - Material selection problems. - Various applications. |
| Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) | - Outranking method estimating the superiority of one alternative over another. - Versions include PROMETHEE I | - Transportation fuel vehicle selection. - Evaluation of energy technologies. - Various |

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| | (partial ranking) and PROMETHEE II (full ranking). | applications. |
| Elimination and Choice Translating Reality (ELECTRE) | - Outranking method using pair-wise comparisons to rank alternatives. - Suitable for decision problems with few criteria and numerous alternatives. - Longer computational process compared to other techniques. | - Ranking sites for construction. - Supplier selection. - Various applications. |
| Analytic Network Process (ANP) | - Extends AHP to model complex networks of interrelated criteria and alternatives. - Allows for feedback and dependencies among elements. - Handles complex decision problems with multiple factors. | - Strategic planning. - Supply chain management. - Complex decision contexts. |
| Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) | - Outranking method estimating the superiority of one alternative over another. - Versions include | - Transportation fuel vehicle selection. - Evaluation of energy technologies. - |

| | | |
|---|---|---|
| | PROMETHEE I (partial ranking) and PROMETHEE II (full ranking). | Various applications. |
| Decision-Making Trial and Evaluation Laboratory (DEMATEL) | - Focuses on understanding cause-and-effect relationships among criteria. - Represents complex systems through a structural model. - Identifies influential factors. | - Environmental impact assessment. - Systems analysis. - Identifying critical factors. |
| VlseKriterijumskoKOmpromisnoRangiranje (VIKOR) | - Multicriteria optimization method that identifies compromise solutions. - Balances decision criteria and distances from the ideal solution. - Ranks alternatives based on compromise ranking index. | - Supplier selection. - Green supply chain management. - Compromise ranking problems. |
| Hybrid MCDM Methods | - Combine two or more different MCDM techniques to enhance decision results. - Integrate strengths of various methods. - Improve robustness and | - Various complex decision problems in diverse domains. |

| | | |
|---|---|---|
| | accuracy of decision outcomes. | |
| Aggregate MCDM Methods | - Utilize specific mathematical procedures to aggregate information from criteria and alternatives. - Include methods like COPRAS, ARAS, WASPAS, SWARA, and MOORA (MULTIMOORA). | - Decision problems requiring aggregation of multiple factors. - Complex evaluation scenarios. |

## 5. Research Methodology

**Analytic Hierarchy Process (AHP) Framework**

The AHP is a widely recognized as multi-criterion decision-making technique developed by Thomas L. Saaty (Saaty 1994). It employs the Priority theory to address complex problems and can simultaneously consider multiple criteria or alternatives. The AHP technique effectively integrates expert judgment and data into a logical mathematical model. Its scalability allows for establishing priorities and addressing interdependencies within a system, making it a popular and successful approach.

The steps necessary for applying the AHP technique are as follows.

**Step-1:** Goal of the study

The purpose of the present study is to investigate the most influencing Key factorsfor GSCM implementation in SSIs to get a maximum identified performance during implementation journey.

The team of ten experts was selected to identify the key parameters which affect decision making in GSCM implementation are illustrated Figure 2.

**Step-2:** Development of Analytical hierarchy process framework and pairwise matrix.

After recognizing the goal, the necessary and key parameters were identified, as discussed earlier. The gathered information was compiled through the participation of GSCM experts, primarily selected from manufacturing organizations and academicians. In this study, a total of ten experts provided their assessments on the key parameters.

The AHP framework was employed to compare the key parameters, which are referred to as criteria A and B. In column "A," criterion 1 was compared with the criteria in the second column "B," such as criterion 2, 3, and so forth. In the third column “C”, the participants had to choose either "A" (indicating that criterion 1 is more important than criterion 2) or "B" (indicating that criterion 2 is more important than criterion 1). Additionally, in the third column of the Table for AHP frame work, the participants specified the intensity of importance, indicating how much more important criterion 1 is compared to criterion 2 or vice versa. Valid inputs for the intensity are integers ranging from 1 to 9, as mentioned in the Table3.

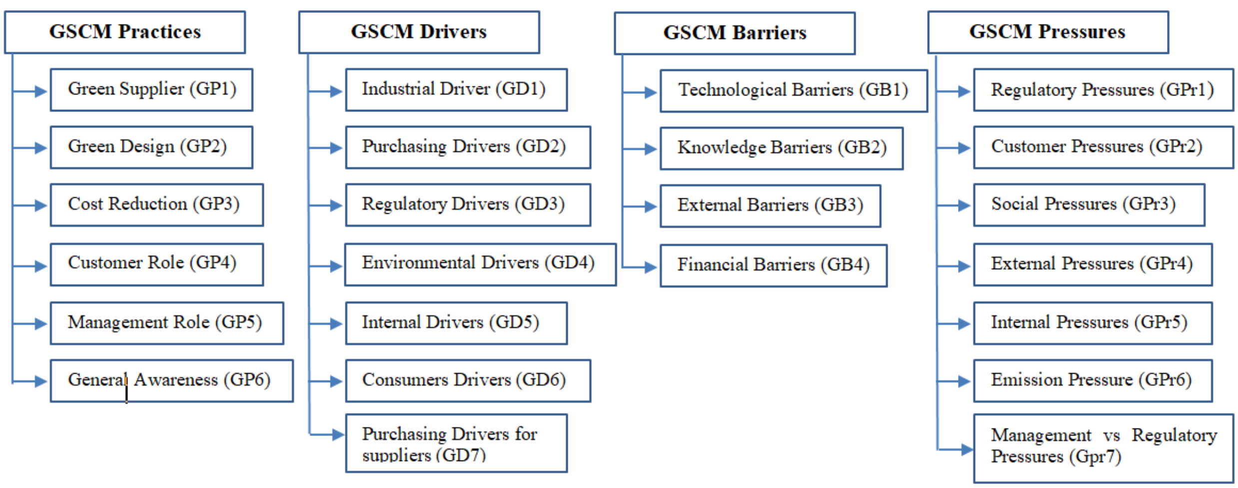



Figure 2.Categorization of Key GSCM Factors

Table3 List of attributes on Comparison Scale

| Degree of preference | Effect of factors |
|---|---|
| 1 | No preference |
| 3 | Less importance |
| 5 | Strong importance |
| 7 | Very Strong importance |
| 9 | Absolute importance |
| 2,4,6,8 | Intermediate values between the two adjacent judgements |

The selected ten experts developed the questionnaires, and their insights to thoroughly examine. To ensure a consensus among the experts, interviews were conducted, allowing them to reach a common opinion. Pilot testing was carried out with ten small-scale industries (SSIs) to assess the questionnaires' effectiveness. These sessions also provided an opportunity for further discussions with the experts. The AHP methodology was then utilized to prioritize practices, drivers, pressures, and barriers identified in the study.

The opinions of the ten experts played a significant role in conducting the AHP analysis using a nine-point scale and developing pairwise matrices. The study involved senior personnel, owners, and production managers as experts, who were actively engaged in green supply chain management (GSCM) practices.The Table4 illustrates AHP framework for GSCM key factors and their comparison on the above mentioned scale, further used to analyzed pairwise matrix.

## 6. Analytic Hierarchy Process (AHP)

The research methodology employed in this study is detailed below, focusing on the utilization of the Analytic Hierarchy Process (AHP) framework to prioritize Green Drivers, Barriers, and Pressures within the context of Green Supply Chain Management (GSCM).

Table 4AHP framework for GSCM Key factors

| **GSCM Practice** | | | **GSCM Driver** | | | **GSCM Barriers** | | | **GSCM Pressures** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Criteria | | Scale (1-9) | Criteria | | Scale (1-9) | Criteria | | Scale (1-9) | Criteria | | Scale (1-9) |
| A | B | C | A | B | C | A | B | C | A | B | C |
| GP1 | GP2 | 2 | GD1 | GD2 | 6 | GB1 | GB2 | 4 | GPr1 | GPr2 | 4 |
| | GP3 | 2 | | GD3 | 6 | | GB3 | 4 | | GPr3 | 3 |
| | GP4 | 3 | | GD4 | 5 | | GB4 | 3 | | GPr4 | 3 |
| | GP5 | 3 | | GD5 | 4 | GB2 | GB3 | 2 | | GPr5 | 2 |
| | GP6 | 1/3 | | GD6 | 3 | | GB4 | 4 | | GPr6 | 3 |
| GP2 | GP3 | 2 | | GD7 | 3 | GB3 | GB4 | 4 | | Gpr7 | 3 |
| | GP4 | 4 | GD2 | GD3 | 5 | | | | GPr2 | GPr3 | 3 |
| | GP5 | 2 | | GD4 | 5 | | | | | GPr4 | 3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | GP6 | 2 | | GD5 | 4 | | | GPr5 | 4 |
| GP 3 | GP4 | 4 | | GD6 | 4 | | | GPr6 | 2 |
| | GP5 | 2 | | GD7 | 3 | | | Gpr7 | 1/3 |
| | GP6 | 2 | GD3 | GD4 | 1 | | GPr 3 | GPr4 | 1 |
| GP 4 | GP5 | 1/2 | | GD5 | 1/2 | | | GPr5 | 2 |
| | GP6 | 1/2 | | GD6 | 1/2 | | | GPr6 | 1/2 |
| GP 5 | GP6 | 1/2 | | GD7 | 1/2 | | | Gpr7 | 1/2 |
| | | | GD4 | GD5 | 1/2 | | GPr 4 | GPr5 | 1 |
| | | | | GD6 | 1/2 | | | GPr6 | 2 |
| | | | | GD7 | 1/2 | | | Gpr7 | 1/3 |
| | | | GD5 | GD6 | 2 | | GPr 5 | GPr6 | 3 |
| | | | | GD7 | 1/2 | | | Gpr7 | 2 |
| | | | GD6 | GD7 | 1/2 | | GPr 6 | Gpr7 | 1/3 |

It involves a systematic process of breaking down complex decisions into a hierarchy of factors and sub-factors, followed by pairwise comparisons and the derivation of relative weights. Pairwise comparisons are conducted for each level of the hierarchy to determine the relative importance of factors within each level. The collected pairwise comparison data is used to calculate the relative weights of the criteria and sub-criteria. The Analytic Hierarchy Process uses mathematical techniques to derive these weights by considering the consistency and the ratios of comparisons. The Consistency Index (CI) is calculated to assess the consistency of the collected pairwise comparison data. It indicates the extent to which the judgments provided by the respondents are consistent. The consistent weights obtained from the AHP analysis, critical factors are identified for GSCM practices, drivers, barriers, and pressures. These critical factors represent the elements with the highest relative importance within each category.

## 7. Results and Discussions

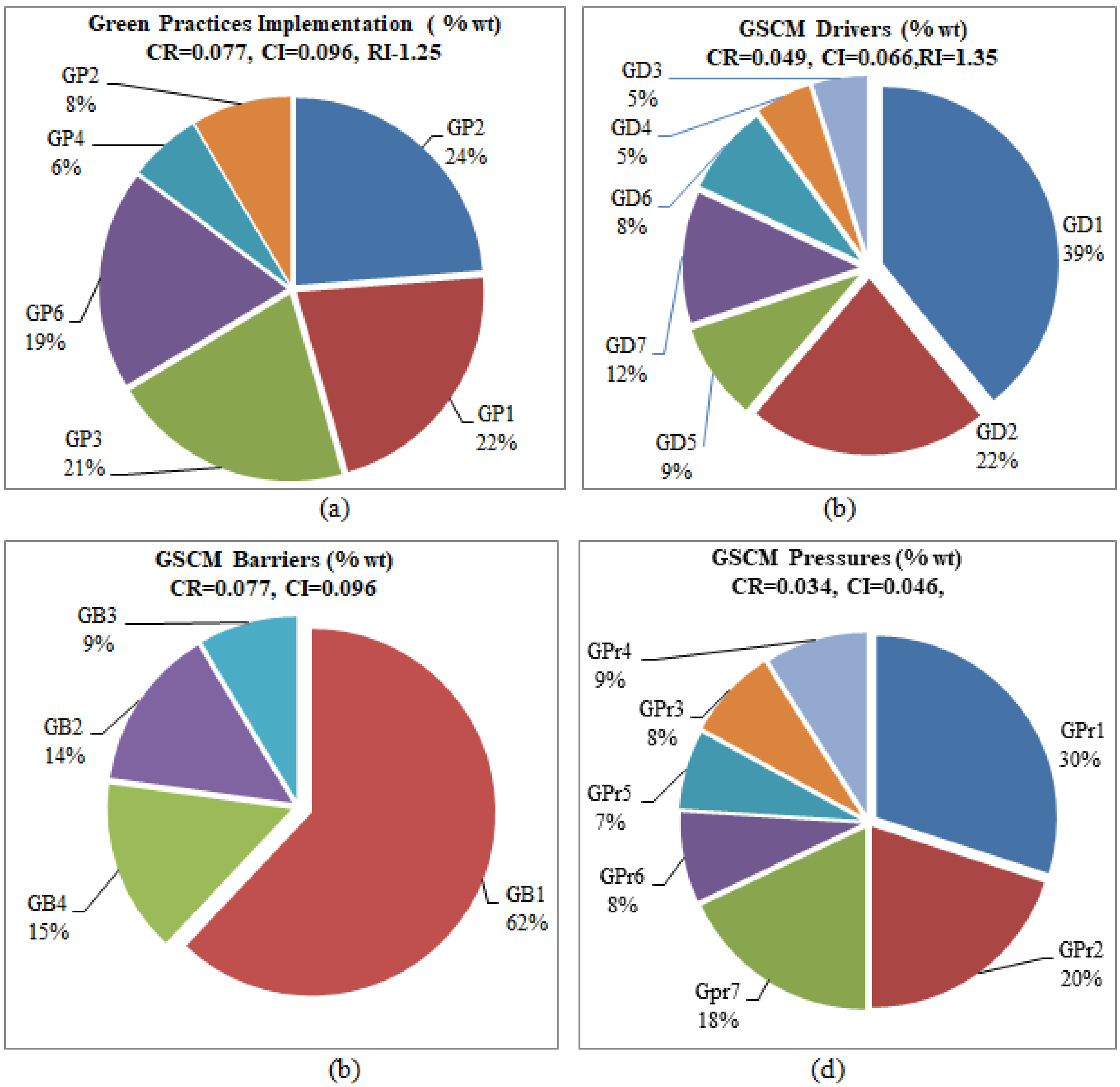
The results of the AHP analysis, including the prioritized factors and their relative weights, are illustrated in Figure 3a,b,c and d. The results are discussed in the context of the research objectives.

In the context of Green Supply Chain Management (GSCM), the significance and rank of various various key factors are discussed as follows

**GSCM Practices:** Green Design (GP2) is the most crucial green practice, holding the top rank with a substantial weight of 23.77%. This underscores the paramount importance of incorporating eco-friendly features and design principles into products, ensuring that sustainability is a central focus in GSCM.Green Supplier (GP1) is the second most important practice, with a weight of 21.80%. It is ranked just below Green Design and plays a pivotal role in GSCM by emphasizing the selection of environmentally responsible suppliers. This practice ensures that the sourcing process aligns with sustainable objectives.Cost Reduction (GP3) practices, while still significant, occupy the third position with a weight of 20.81%. These practices focus on identifying ways to reduce costs while maintaining environmental sustainability. They strike a balance between economic considerations and ecological responsibility.General Awareness (GP6) practices are placed in the fourth position, with a weight of 18.92%. These practices involve creating awareness and educating stakeholders about green initiatives, fostering a culture of sustainability within the organization.Customer Role (GP4) practices are the fifth most significant, with a weight of 6.15%. These practices center around engaging customers in green initiatives. While customer engagement is vital, it is assigned a relatively lower priority in the GSCM hierarchy.It's important to note that the ranking of these practices is based on the assigned weights, reflecting their relative importance in the context of GSCM. This ranking can guide decision-makers in prioritizing their efforts and resources to enhance sustainable supply chain practices.With a CR of 0.077, the ranking is relatively consistent, and the low CI of 0.096 further supports its significance.

**GSCM Drivers:** Industrial Drivers (GD1): These drivers are of utmost importance in GSCM, carrying a weight of 39.18% and securing the top rank. They significantly influence decision-making by emphasizing industrial aspects that align with green practices. Purchasing Drivers (GD2): Ranked second with a weight of 21.94%, these drivers pertain to the procurement process and their impact on GSCM.Internal Drivers (GD5): These drivers, with a weight of 8.84%, are ranked third and focus on internal factors within an organization that drive green initiatives. The CR and CI values are not provided, but lower CR values would strengthen the ranking's reliability and the importance of these drivers.Supplier Awareness Drivers (GD7): Ranked fourth with a weight of 12.00%, these drivers emphasize creating awareness and education among suppliers regarding green practices.Consumer Drivers (GD6): Occupying the fifth position with a weight of 8.08%, these drivers involve customer-related factors that influence GSCM. Drivers (GD4Regulatory Drivers (GD3): Ranked seventh with a weight of 4.91%, regulatory drivers focus on the influence of governmental and legal factors on GSCM. The relatively low CR of 0.049 indicates that the ranking is consistent and reliable, and the low CI of 0.066 further supports the significance of these drivers.

**GSCM Barriers:**Technological Barriers (GB1): These barriers hold the utmost importance in GSCM, carrying a substantial weight of 62.01% and securing the top rank. Technological barriers encompass challenges related to the adoption and integration of green technologies and innovations. Financial Barriers (GB4): Ranked second with a weight of 15.16%, financial barriers revolve around challenges related to funding and resource allocation for green initiatives. Knowledge Barriers (GB2): These barriers are ranked third, with a weight of 14.23%, and pertain to limitations in understanding and knowledge dissemination concerning GSCM practices. External Barriers (GB3): Ranked fourth with a weight of 8.60%, external barriers encompass challenges originating from outside the organization, such as market dynamics and industry factors. The relatively low CR of 0.077 suggests a consistent ranking, and the low CI of 0.096 further reinforces the significance of these barriers.




CR= Consistent Ratio, CI= Consistency Index

Figure 3 (a) % wt. of GSCM Practices, (a) % wt. of GSCM Drivers, (a) % wt. of GSCM Barriers, (a) % wt. of GSCM Pressures

**GSCM Pressures:** Regulatory Pressures (GPr1): Regulatory pressures take the top position in importance in GSCM, with a weight of 30% and a CR of 0.034. These pressures stem from compliance with environmental regulations and legal frameworks, emphasizing the critical role of regulations in shaping sustainable practices.Customer Pressures (GPr2): Ranked second, customer pressures carry a weight of 20%. They are centered on customer demands and expectations for environmentally responsible products and services. Management to Regulatory Pressures (GPr7): These pressures secure the third rank, with a weight of 18%. They revolve around the alignment of an organization's management practices with regulatory requirements. Emission Pressure (GPr6): Ranked fourth with a weight of 8%, emission pressures are focused on reducing and managing emissions and environmental footprints. Internal Pressures (GPr5): These pressures hold the fifth position, with a weight of 7%. They originate from within the organization and emphasize the importance of internal commitment to sustainability. Social Pressures (GPr3): Ranked sixth with a weight of 8%, social pressures are related to societal expectations and ethical considerations regarding sustainable practices. External Pressures (GPr4): Ranked seventh with a weight of 9%, external pressures encompass influences from the broader business environment, such as market dynamics and industry factors. The low CR signifies a consistent ranking, and the low CI of 0.046 reinforces the significance of regulatory pressures.

**Conclusion**

The findings reveal that, "Green Design" emerges as the most significant, highlighting the pivotal role of incorporating eco-friendly features into products for sustainable operations. It is worth noting that efforts to enhance "General Awareness" and engage "Customer Role" practices, while essential, may require further attention in the pursuit of GSCM objectives.

In terms of GSCM drivers, "Industrial Drivers" occupy the top rank, emphasizing the prominence of industrial factors which is closely followed by "Purchasing Drivers" and "Internal Drivers," underlining the significance of procurement processes and internal organizational factors. Creating awareness among suppliers and considering "Consumer Drivers," "Environmental Drivers," and "Regulatory Drivers" remain crucial aspects in GSCM initiatives.

The analysis of GSCM barriers emphasizes the critical role of addressing "Technological Barriers" as the most substantial hurdle, reflecting the challenges related to adopting green technologies. "Financial Barriers" and "Knowledge Barriers" are also significant challenges, calling for strategic measures to overcome funding limitations and knowledge gaps. External challenges, encompassed as "External Barriers," remain essential aspects in the GSCM landscape.

The GSCM pressures, "Regulatory Pressures" has vital role of environmental regulations in shaping sustainable practices. Meeting "Customer Pressures" and harmonizing management practices with "Management to Regulatory Pressures" are paramount in addressing customer expectations and aligning with legal requirements. "Emission Pressures" and "Internal Pressures" require due consideration, underlining the importance of managing emissions and fostering internal commitment to green practices. Societal expectations and ethical considerations, known as "Social Pressures," and influences from the broader business environment, categorized as "External Pressures," are also critical in driving green initiatives.

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