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Environmental Sustainability of the Agro-food Industry through Strategic Green Supply Chain Management

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Abstract

The agro-food industry and environmental sustainability are two areas that have raised concern among scholars in recent times. When it comes to the agro-food industry it is one of the most important and controversial industries in terms of environmental impact. Therefore, the concern towards establishing green elements within the supply chain has become essential for related actors to operate responsibly in the industry. Hence, this research would provide benefits to a range of organizations engaged in upstream and downstream supply chains such as farming, packaging, warehousing, distributing entities, and customers. The purpose of this research is to critically evaluate and establish a strategic green supply chain management framework for the agro-food industry. Thus, the key objectives are outlined as follows: to evaluate key areas and specific elements in Green Supply Chain, to evaluate the key elements, green practices or strategies specific to the agro-food industry, and finally, to develop and establish an effective strategic green supply chain management framework for the agro-food industry. This study used systematic review as its research strategy. The PRISMA flow diagram was applied to select the journal articles for the review. Accordingly, 14 articles were selected and analyzed using the thematic synthesizing technique. The findings indicated that the general green supply chain elements would not be applicable as it is at the agro-food supply chain due to the nature of the industry. It also observed that the expansion in the agro-food industry does necessarily generate considerable environmental hazards mainly in farming, processing and packaging, transportation, and warehousing echelons. The proposed strategic framework for the agro-food industry is a comprehensive approach to guide the respective supply chain partners while educating them on strategies to minimize the environmental hazards, factors require for the implementation, and areas of organizational performance.

Keywords: Agro-food Industry, Environment Sustainability, Green Supply Chain, Strategic Framework, Systematic Review

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Introduction

Green Supply Chain Management (GSCM) is one of the most researched areas in the field of Supply Chain Management. Greening the supply chain or embedding environmental sustainability into the supply chain has become an emerging trend in the corporate community. Thus, Zhu et al. (2012) defined GSCM as integrating environmental concerns with supply chain management.

Environmental sustainability is one of the key drives towards sustainability which is a construct of the triple bottom line. The expansion of the agro-food industry and environmental sustainability seem to have a negative correlation since, it is accepted that the expansion in agriculture could result in deforestation, which consequently contributes to global warming and climate change (Rueda et al., 2017).

The agro-food sector deals with food. Therefore, the supply chain elements utilized in this industry are more significant than the supply chain elements observed in the general manufacturing sector (Raut et al., 2019). Accordingly, it is expected to provide a thorough understanding of critical areas and elements applicable to the agro-food sector.

It is found that there is a lack of studies on supply chain management in the agro-food industry. Therefore, this study contributes to the literature by developing a framework for GSCM in the agro-food industry. As a controversial industry in terms of environmental sustainability, this study would generate invaluable insights into a comprehensive framework for GSCM in the agro-food industry.

The research aims to evaluate and establish a strategic GSCM framework for the agro-food industry. Accordingly, the following objectives are designed to align with the aim;

- Evaluate the key elements, green practices, or strategies specific to the agro-food industry.
- Develop and establish an effective strategic GSCM Framework for agro-food industry.

This research would provide benefits to a range of organizations engaged in supply chain activities such as farming, packaging, warehousing, distributing, and customers. The developed framework would provide a systematic

approach with a series of eco-friendly elements and practices to guide and educate the relevant entities. Additionally, the framework would benefit the supply chain partners to understand the critical elements and implementation factors specific to the agro-food industry while, improving the image, profits, recognition, and providing hygiene and healthy produce to customers.

Literature Review

GSCM is an emerging area in the field of supply chain management. Therefore, it has been the central focus of many scholars in doing investigations related to supply chain management. However, there is hardly any evidence of a single definition for GSCM, as the researchers have defined the term in different ways.

Ahi and Searcy (2013) researched the available definitions presented by different scholars on GSCM and Sustainable Supply Chain Management (SSCM). They analyzed 22 definitions for GSCM and 12 definitions for SSCM and found that the scope of GSCM is narrower than the SSCM. Moreover, it explains the importance of devising a reasonably acceptable definition for GSCM focusing on the scope and the theory. Chin et al. (2015) and Zhu et al. (2012) introduced the GSCM as the incorporation of environmental concerns into supply chain management. Hervin et al. (2005) viewed the GSCM as a collection of eco-friendly supply chain elements such as green purchasing, green manufacturing/ materials management, green distribution/ marketing, and reverse logistics. Thus, the key idea underpinning the GSCM is the conservation of the environment while limiting the influences from supply chain activities.

Key elements specific to the agro-food industry

Horton et al. (2015) explored the total agri-food system and illustrated it graphically including the areas of the eco-system, climate, resources, supply chain activities, and outcomes. The study identified four key attributes that could be observed in a general agri-food system that constitutes with 1. Agricultural activities and land use strategies, 2. Crop production and harvesting strategies, 3. Processing, storage, and distribution, and 4. Retailing and consumption. Moreover, the losses and waste generated from each of the

segments directly impact the environment and are thus expected to seek solutions by managing the agricultural eco-system.

Bhat and Joudo (2019) proposed a food traceability system and outlined the agro-food supply chain components as farming, processing and packaging, storage and transportation, and retailing. Iakovua et al. (2014) identified agro-food supply chain echelons as farming, industrial production, packaging, transportation, warehousing, and distribution. Based on these echelons the scholars adopted green supply chain areas related to the agro-food industry as sustainable farming, supply chain management, marketing, environmental management, reverse logistics, and corporate social responsibility. Krishnan et al. (2019) assessed a mango food supply chain to determine the areas required to redesign by embedding environmental sustainability. As per the study, cultivation, processing, pulp packaging, and transportation stages were identified as significant areas to adopt green practices.

Green practices/ strategies specific to the agro-food industry

Aivazidou et al. (2015) determined the importance of managing water footprint in agro-food supply chains and classified the water footprint management strategies applicable at each of the supply chain levels namely, farming, processing, packaging, logistics, and retailing. Moreover, it examined the relationship of water footprint management strategies with corporate green image and the financial performances of organizations involved in the agro-food industry. This study proved that the implementation of water footprint management strategies has a substantial influence on an organization's green image while positively impacting the profitability of the supply chain (Aivazidou et al., 2016). A study done by Sanchez et al. (2011) examined the water management aspect of the agro-food industry evaluating two Spanish taxation models: waste control tax and sanitary tax. The study found that imposing taxes to preserve water is an inadequate measure. Furthermore, it suggested the necessity of designing strong environmental regulations for proper water management by food processing entities.

Burrell (2011) explored the 'Good Agricultural Practices (GAP) utilized in agri-food supply chains. The term 'GAP' is defined as the on-farm practices used to ensure social, economic, and environmental sustainability. More importantly, the study revealed vertical and horizontal extensions of GAP; the

vertical aspect was concerned with utilizing GAP within external areas such as upstream and downstream of the supply chain whereas the horizontal aspect focused on practices applicable within the farm. Kaur (2013) found that it is a timely requirement to construct agriculture policies to promote green farming, for instance, policies on land management, fertilizer usage, and resource deployment. Tilman et al. (2011) found that the expansion of the cultivation fields is essential to meet the global demand in 2050 and suggested investing in improving and transferring agriculture-based technology, for instance, sustainable use of nitrogen as the practical option to minimize land clearing.

Del Borghi et al. (2014) introduced green practices applicable in the cultivation phase such as the use of organic fertilizers and balanced use of inorganic fertilizers, crop rotation, and water management. Moreover, once the processing is done the residuals and used water are treated effectively by utilizing the waste in generating fertilizer and implementing water treatment plants respectively. The scholars also emphasized the packaging is mainly based on recyclable products where pallets are reusable. Similarly, Dinu (2016) identified the waste management practice at each echelon of the agri-food supply chain as the key practice to reduce environmental depreciation. Moreover, it emphasized the capturing and the use of biodegradable waste to make organic fertilizer generated at each echelon of the supply chain.

Thorlakson, Hainmuellerb, and Lambinc (2018) analyzed Farming for the Future, a set of standards implemented by Woolworth Holdings Ltd. of South Africa. This study determined that the voluntary engagement of firms to implement environmentally friendly farming management practices has contributed positively to adopting a green agricultural supply chain. Furthermore, Miranda-Ackerman and Azzaro-Pantel (2017) emphasized the impact of eco-labeling on agricultural practices referring to the orange juice supply chain. This study justified that it is beneficial to use the general eco-labeling practices representing the overall supply chain, moreover, confirmed that organic certification is important in eco-labeling as well as in upgrading environmental performances.

Evidence of effective strategic GSCM Frameworks

Ghobakhloo (2013) developed an interactive framework to support the implementation of GSCM in a typical supply chain. This framework mainly

focused on greening the supply chain components such as product design, material management, manufacturing, marketing, distribution, and reverse logistics. More importantly, the scholars also proposed practices for achieving environmental friendliness at each level. For instance, it incorporated the product life cycle assessment and environmentally friendly design aspects to deliver a green product design. It emphasized the factors such as green material selection and green material sourcing as significant under the green material management component. Moreover, it focused on factors like the minimization of resources consumption, waste, and energy to green the manufacturing component. The elements, reuse, recycling, and remanufacturing were considered under reverse logistics. Also, this framework emphasized utilizing green activities at the point of disposal.

Lakshmimeera and Palanisamy (2013) delivered a framework to evaluate the GSCM practices. This framework outlined the green practices under four broader supply chain elements namely inbound, operational, outbound, and reverse logistics. The scope of the inbound component focused on areas of supplier management to incorporate green practices. The product design, technology and processes, and other internal operations were considered under the operational component and the factors such as packaging, warehousing, inventory management, and distribution were considered under the outbound operations aspect. The management of disposal items is outlined under reverse logistics. Apart from these core practices it also presented two supportive elements such as management practices and consumer involvement that enable the implementation of core practices.

Kusi-Sarpong, Sarkis, and Wang (2016) designed a framework for the evaluation of the green practices that could be adopted in the supply chain of the Ghanaian mining industry. The goal of this framework is to achieve sustainable organizational performance. The attainment of this goal is based on six major practices such as green information technology and systems, strategic supplier partnership, operational and logistics integration, internal environmental management, eco-innovation, and end-of-life practices. However, an Interpretive Structural Modelling model proposed by Muduli et al. (2013) on the Indian mining industry outlined several other factors required for the implementation of green practices such as top management commitment, performance evaluation, and reward, communication, green training, employee empowerment, green teamwork, work culture, green

motivation, accept change, trust and respect, and strategic planning capabilities.

Iakovou et al. (2014) introduce a methodological framework for GSCM in the agri-food sector. The scholars listed several activities to implement under six thematic areas to use in operating towards greening the AgriChains. The presented six thematic areas are: sustainable farming, supply chain management, marketing, reverse logistics, corporate social responsibility, and environmental management. Moreover, this framework suggested a comprehensive and state-of-the-art approach to implementing GSCM while focusing on reducing operational costs in farming thereby uplifting the income of the farmer community.

Methodology

This research adopts a deductive approach, utilizing a systematic review process as its research strategy. It evaluates publications extracted from the Elsevier and Emerald databases, focusing on themes such as general Green Supply Chain Management (GSCM) and GSCM within the agro-food industry. The selected journal articles, spanning the period from 2009 to 2019, were chosen based on the PRISMA flow diagram, ensuring the inclusion of peer-reviewed academic journals published in English. Consequently, the publications included in this study are both current and relevant. The collected data will be analyzed using a qualitative thematic synthesizing technique, underscoring the research's qualitative methodological approach.

The review process began with planning, followed by an extensive search of relevant literature. Key terms such as GSCM elements and practices, GSCM frameworks, environmental sustainability in supply chain management, GSCM in the agri-food industry, agri-fresh food supply chains, perishable food supply chains, and agro-food supply chains were employed to identify suitable publications.

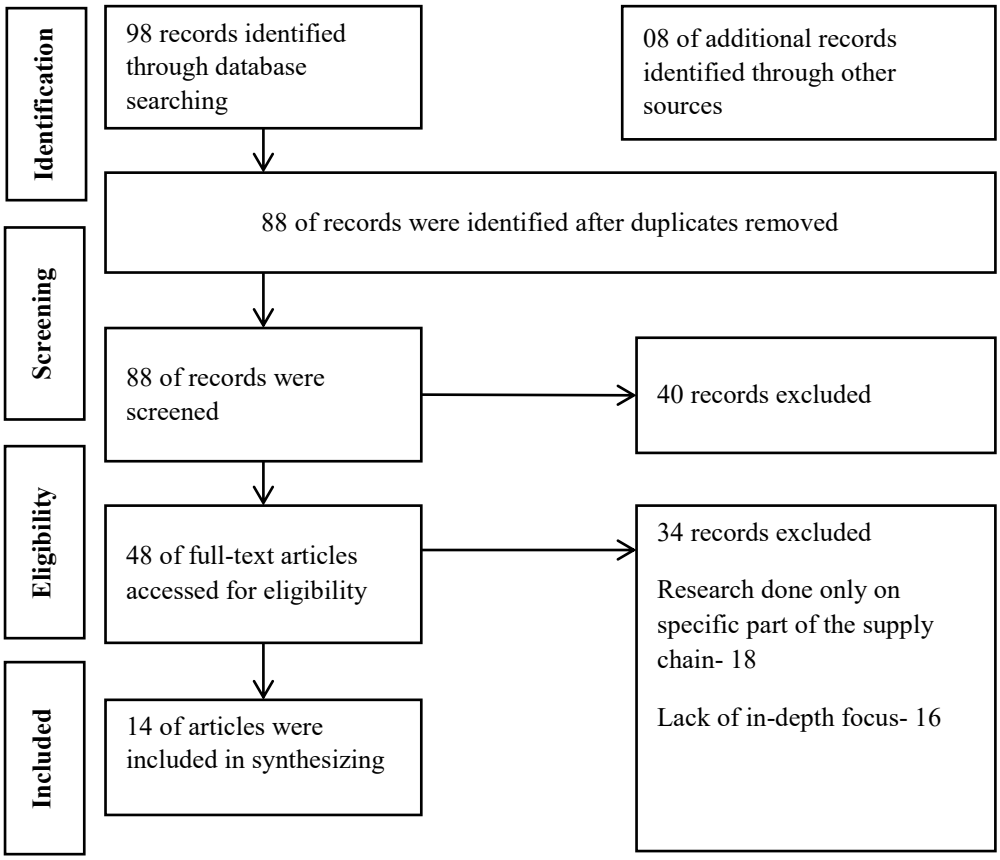
The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram was used to select qualified journal articles for this study (Liberati et al., 2009; Moher et al., 2009). Moher et al. (2009) emphasized the utility of the PRISMA flow diagram in systematically arriving at a final set of qualified articles for review. This four-phase process involves identification, screening, eligibility, and inclusion (See Figure 1). Initially,

many articles are identified; however, as they pass through the screening and eligibility stages, the number of articles included in the review is narrowed down.

As illustrated in Figure 1, the literature search initially identified 106 records, with 98 sourced from database searches and 8 from other sources. After removing duplicates, 88 records were screened based on the selection criteria related to the chosen databases and time frame. From this stage, 48 articles were selected for the eligibility phase. Upon accessing these articles, 18 were excluded due to their partial focus on supply chains, and 16 were eliminated due to the limited in-depth focus. Ultimately, 14 articles were qualified for inclusion in the review.

Figure 1:

PRISMA flow diagram



Source: *Adapted from Moher et al. (2009)*

Data Analysis

Thematic synthesizing is the data analysis technique employed in this research. Saunders, Lewis, and Thornhill (2017) stated this method as the basic method that could be used in qualitative data analysis. Moreover, a key advantage of this technique is that it allows the researcher to explore themes, identify patterns and organize data related to the research question. Therefore, this technique provides a systematic approach to analyzing qualitative data (Saunders, Lewis, and Thornhill, 2017).

Discussion and Findings

Key areas and specific attributes in Green Supply Chain

As per the analysis, it is apparent that the supply chains generally share a myriad of attributes or elements under a few key areas. However, few of the studies have focused on classifying GSC elements under key broader areas and many of the studies were found to be focused on elaborating on the specific elements of the green supply chain required for applying environmental friendliness. For instance, Sarkis (2012) categorized the key areas of the green supply chain as upstream supply chain, downstream supply chain, and internal supply chain operations. However, Sari (2017) classified the green supply chain elements under four broader areas: inbound, production, outbound, and reverse logistics.

The reviewed literature suggested that there is no agreement among scholars regarding the specific attributes of the green supply chain. Sari (2017), Sarkis (2012), Rostamzadeh et al. (2014) and Green et al. (2012) highlighted green purchasing as an important element in a typical green supply chain. As per their evidence, the major concern behind green purchasing is supplier management for purchasing eco-friendly raw materials for production. Green production is stressed as one of the green elements in which the main concern was to implement eco-friendly manufacturing processes (Sarkis, 2012, Sari, 2017 and Rostamzadeh et al., 2014). Sari (2017) and Rostamzadeh et al. (2014) outlined the focused areas of green production as utilization of cleaner technology, capacity utilization, and remanufacturing capacities.

Sarkis (2012) and Rostamzadeh et al. (2014) agreed with the elements, green transportation, green distribution, green packaging, and green warehousing.

Rostamzadeh et al. (2014) emphasized the factors utilized under the green transportation aspect as eco-friendly and efficient modes of transportation and distribution, and eco-driving. The green warehousing aspect is concerned with minimizing and balancing the carbon footprint of warehouses by following practices such as eco-packaging, balanced inventory levels, and sale of excess, used and scrap inventories, equipment, and other materials. However, Sari (2017) classifies these elements under a broader category, namely 'outbound operations'. Reverse logistics is another widely spoken element of the green supply chain, and the covered aspects under this element are the recovery of products, and waste management (Sarkis, 2012, Sari, 2017 and Rostamzadeh et al., 2014).

Accordingly, based on the evidence, the accepted elements/attributes specific to a green supply chain are, green purchasing, green production, green transportation, green distribution, green packaging, green warehousing, and reverse logistics.

Key elements, green practices, or strategies specific to the agro-food industry

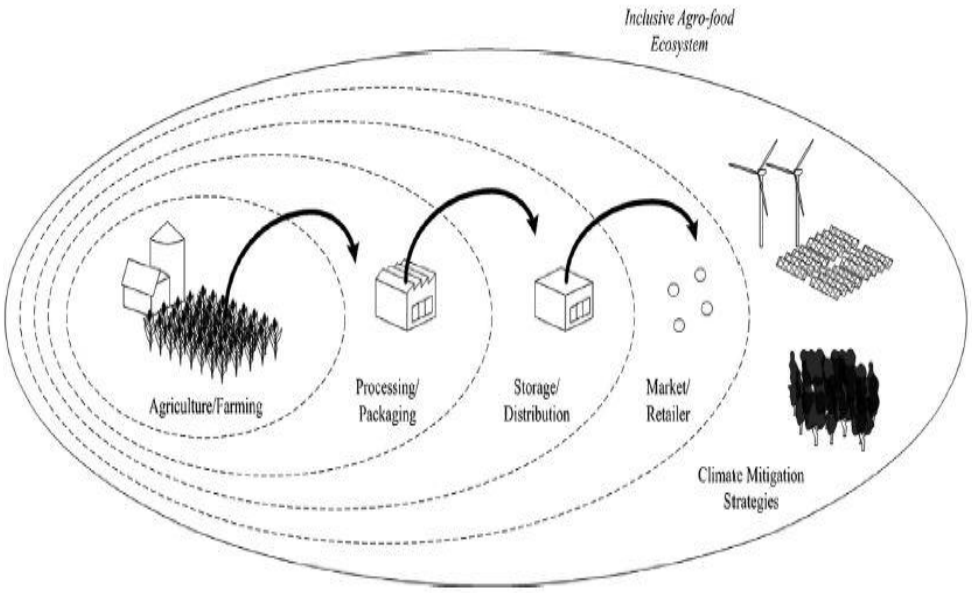
The analyzed literature provides compelling evidence regarding the key elements relevant to the agro-food industry. Tsolakis et al. (2014) indicate that the components present in the agro-food supply chain differ significantly from those of a general supply chain, suggesting that the general green supply chain elements may not be applicable in this context.

According to Tsolakis et al. (2014), an agro-food supply chain encompasses several critical elements, including farming, warehousing, processing, transportation, and distribution. In addition to these components, Accorsi et al. (2015) highlight the importance of market and retail aspects, emphasizing the contribution of end consumers to the supply chain (see Figure 1). Moreover, Garofalo et al. (2017) and Manzini and Accorsi (2013) underscore the significance of end-of-life practices alongside the other supply chain elements. Another crucial aspect noted in the literature is the integration of cold storage with green transportation, as discussed by Tasca, Nessi, and Rigamonti (2016) and Sharma, Chandna, and Bhardwaj (2017).

These insights collectively illustrate the unique characteristics and requirements of the agro-food supply chain, highlighting the need for tailored approaches to green supply chain management in this specific context.

Figure 1:

Agro-food Ecosystem



Source: *Accorsi et al. (2015)*

As explained above, a new echelon, green farming applies to the agro-food green supply chain that is not presented in the general green supply chain (Tsolakis et al., 2014, Accorsi et al., 2015). The green production element discussed under the general green supply chain change as green processing and packaging under the agro-food green supply chain. However, the green transportation and warehousing, and reverse logistics or end-of-life practices elements could be applied to both contexts without any change (Garofalo et al., 2017, Manzini and Accorsi, 2013, Tsolakis et al., 2014, Accorsi et al., 2015). Based on the synthesized literature, the green elements applicable to the agro-food supply chain could be outlined as green farming, green processing and packaging, green transportation and warehousing, and reverse logistics.

GSCM implementation in the agro-food industry is another area that has raised concern among scholars. Thus, Sharma, Chandna, and Bhardwaj (2017)

revealed 13 performance indicators, and 79 sub-indicators related to GSCM implementation in the agro-food industry. As per the study, the indicators, internal environmental management, environment designs, and regulatory pressure were considered crucial in implementing GSCM in the agro-food industry. Similarly, Gardas et al. (2017) emphasized that organizational environmental management, regulatory pressure, and competitive pressure are crucial in implementing the GSCM in the agro-food industry. Akhtar et al. (2016) explained that the factors; data focus and adjustable leadership style utilized in agro-food supply chains are supportive in gaining financial and non-financial outcomes via waste management, eco packaging, and energy efficiency practices. Furthermore, Green et al. (2012) described the antecedents required for the implementation of a typical green supply chain as internal organizational management and green information systems.

Sharma, Chandna, and Bhardwaj (2017), Gardas et al. (2017), and Green et al. (2012) agreed on the organizational environmental management as a factor required for the implementation of GSCM and all the scholars mentioned above emphasized the top and middle management commitment under the organizational environmental management element. However, Akhtar et al. (2016) stressed the necessity of an adaptable leadership style for managers to capture the changes that occur in internal and external environments to take effective decisions. Moreover, the availability of a green information system or a data repository to gather and develop knowledge related to greening the supply chain while improving the supply chain processes and activities is another implementation element discussed in the literature (Akhtar et al., 2016, Green et al., 2012).

Based on the synthesized literature, each echelon in the agro-food supply chain plays a role in environmental degradation, contributing to issues such as greenhouse gas emissions, soil erosion, biodiversity loss, and water pollution (Horton et al., 2015; Tasca, Nessi, and Rigamonti, 2016; Garofalo et al., 2017). These environmental impacts manifest at varying degrees across the supply chain, making it crucial for green elements—such as sustainable farming, eco-friendly processing and packaging, green transportation and warehousing, and reverse logistics—to be strategically implemented. These practices, when employed effectively, can significantly reduce the ecological footprint of the agro-food supply chain.

Tasca, Nessi, and Rigamonti (2016), along with Garofalo et al. (2017), emphasized that eco-friendly practices within the green farming element primarily focus on fertilizer use, cultivation methods, and pest control. Tasca, Nessi, and Rigamonti (2016) observed that the use of organic fertilizers, as well as a combination of organic and inorganic fertilizers, produces mixed results regarding environmental sustainability, highlighting the need for technological advancements in organic farming to enhance eco-friendliness. In contrast, Garofalo et al. (2017) supported the use of organic fertilizers such as manure, agri-food waste, and compost as sustainable alternatives to inorganic fertilizers, citing their positive effects on soil health and water conservation. Both studies discussed the emissions generated by conventional pest control mechanisms and advocated for integrated pest management systems to reduce environmental impact. Additionally, green cultivation practices, such as crop rotation, the use of energy-efficient machinery, and the adoption of biofuels, were highlighted as crucial for minimizing the environmental footprint (Tasca, Nessi, and Rigamonti, 2016; Garofalo et al., 2017).

Accorsi et al. (2015) and Garofalo et al., (2017) agreed upon the use of renewable energy sources for implementing green processing. Waste management is another practice considered under green processing (Garofalo et al., 2017). Bortolini et al. (2018) highlighted that there should be a balanced use of reusable and disposable packaging (47.1% reusable and 52.9% disposable) to reduce environmental impact, however, this initiative is not cost-efficient.

Sari (2017) and Rostamzadeh et al. (2014) suggested strategies for green transportation in the agro-food supply chain including eco-driving, energy-efficient transportation, avoidance of empty or half-loaded running, and utilization of combined modes of transportation. Moreover, the green warehousing element applied strategies such as maintenance of optimum inventory levels and investment recovery (Rostamzadeh et al., 2014). However, Sharma, Chandna, and Bhardwaj (2017) and Gardas et al. (2017) emphasized the importance of understanding the relationship between transportation with cold storage for the agro-food supply chain to minimize waste and emissions to improve environmental performance.

Reverse logistics mainly consider waste management utilizing strategies such as reducing, recycling, and remanufacturing. Thus, the recovery of the agro-food products could be utilized in generating compost. Sari (2017) identified the practice of taking back packages as a strategy under reverse logistics.

Effective strategic GSCM Frameworks for agro food industry

Sari (2017) and Green et al. (2012) developed two frameworks providing two different insights to evaluate the GSCM practices of a typical supply chain. Sari (2017) evaluated the influence of GSCM practices on organizational performance and classified the green practices under four broader supply chain elements: inbound operations, production, outbound operations, and reverse logistics. However, Green et al. (2012) without merely evaluating the practices, focused on the implementation stage and performance evaluation stage. As the first level of this model, it outlined two key requirements as Internal Environmental Management and Green Information System focusing on the implementation of environmental friendliness within the organization. Then, it outlined the green supply chain elements, green purchasing, cooperation with consumers, eco-design, and investment recovery, and finally combined with the outcome of improved organizational performances.

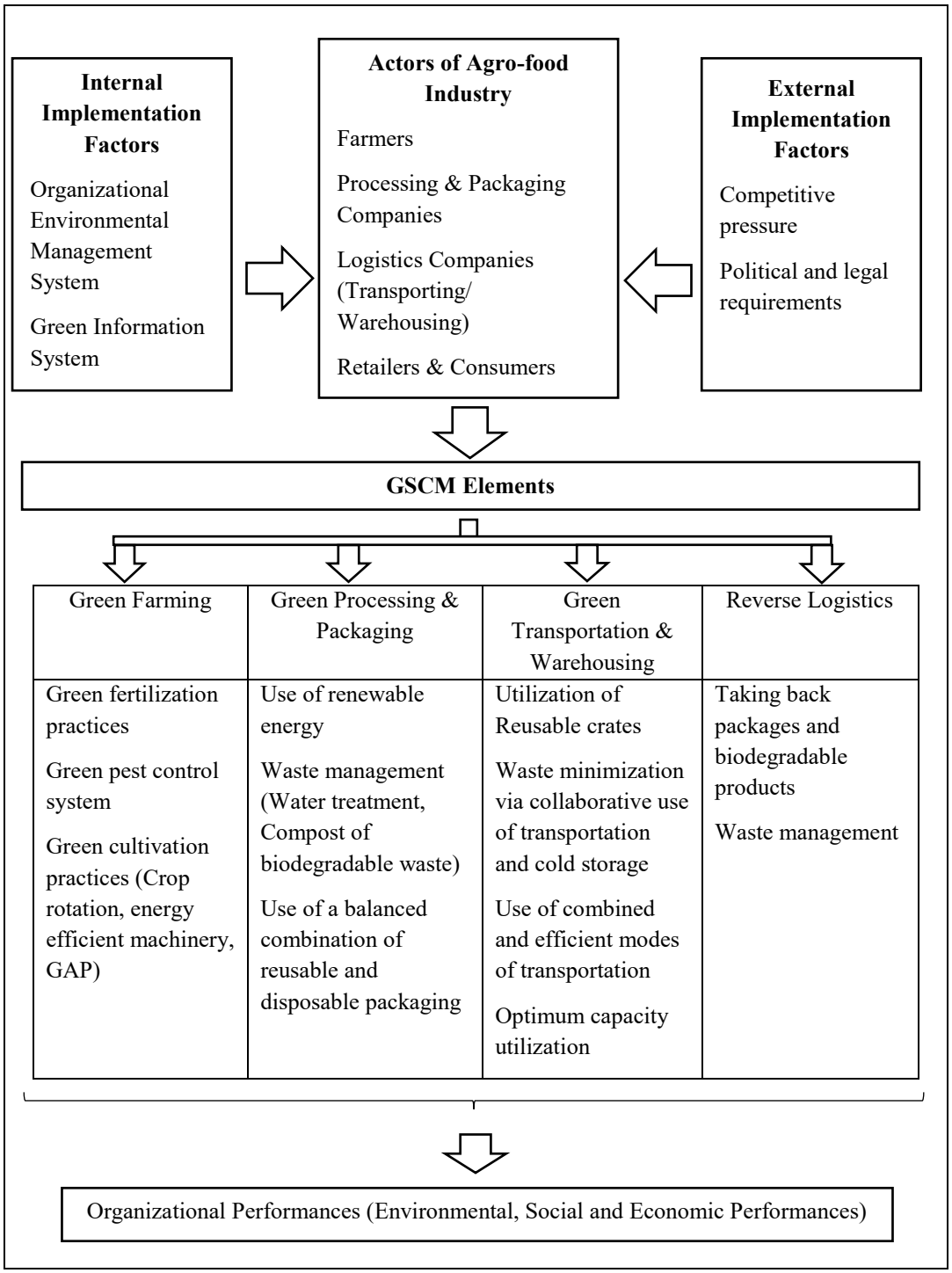
Manzini and Accorsi (2013) presented a conceptual framework for the food supply chain integrating multiple decisions and activities with the aim of achieving quality, safety, sustainability, and efficiency in the supply chain and ultimately within the food products and processes. To elaborate, this framework constitutes three main models eco-farm, eco-factory, and eco-logistics containing a wider scope. The eco-farm model comprised activities related to harvesting and purchasing of raw materials. The eco-factory section contained the processes and activities related to manufacturing and processing of the products, and maintenance and monitoring of the machines, and the plant whereas the eco-logistics model included the logistic activities and processes related to the delivery of raw materials, distribution of finished products, and reverse logistics. However, Gardas et al. (2018) is concerned on evaluating the relationships among implementation factors, green supply chain elements, and organizational performances of the agro-industry.

The proposed strategic framework for GSCM in the agro-food industry

Based on the above discussion, *Figure 2* illustrates the proposed strategic framework for Green Supply Chain Management (GSCM) in the agro-food industry. According to this framework, the key actors involved in the agro-food supply chain, as identified through the literature review, are: (1) Farmers, (2) Processing and packaging companies, (3) Logistics companies (transportation and warehousing), and (4) Retailers and consumers. Each of these actors is influenced by both internal and external factors that facilitate the implementation of GSCM elements within the agro-food supply chain. These pressures encourage stakeholders to focus on greening their core functions, which include: (1) Green farming, (2) Green processing and packaging, (3) Green transportation and warehousing, and (4) Reverse logistics.

Moreover, the adoption of environmentally sustainable practices by each actor at every stage of the supply chain contributes to the overall environmental sustainability of the supply chain. This, in turn, enhances organizational performance in three key dimensions: (1) Economic, (2) Environmental, and (3) Social. Economic performance is improved through cost efficiencies, environmental performance is bolstered by the implementation of eco-friendly practices, and society benefits through improved health and well-being. Consequently, the strategic focus on GSCM promotes a more sustainable and socially responsible agro-food supply chain.

Figure 2:
Proposed strategic green supply chain management framework for agro-food industry



Conclusion

This systematic review revealed that the green supply chain attributes typically applied to general supply chains are not fully applicable to the agro-food industry. Consequently, this study identified the specific green supply chain elements relevant to the agro-food sector as green farming, green processing and packaging, green transportation and warehousing, and reverse logistics. Additionally, the factors supporting the implementation of these elements were classified into internal and external categories. External factors include competitive pressure and political and legal requirements, while internal factors encompass an organization's environmental management system and green information system.

The study further outlined green strategies and practices that can be implemented within each element as guidelines for supply chain partners in the agro-food industry. Under green farming, the strategies include eco-friendly fertilization, pest control, and cultivation methods. For green processing and packaging, key strategies involve the use of renewable energy, effective waste management, and a balanced approach to using reusable and disposable packaging. Green transportation and warehousing strategies focus on utilizing reusable crates, minimizing waste through collaborative transportation and cold storage efforts, optimizing transportation modes, and maximizing capacity utilization. The reverse logistics element emphasizes strategies such as taking back packaging materials and biodegradable products, along with effective waste management.

Based on these findings, the study developed a strategic Green Supply Chain Management (GSCM) framework tailored to the agro-food industry. This framework highlights the organizational requirements, resources, and initiatives necessary to engage each actor in the supply chain and achieve an environmentally sustainable agro-food supply chain. Ultimately, the framework aims to promote sustainable organizational performance across the sector.

Recommendation

The development of the agro-food industry has led to increased environmental hazards, such as deforestation and greenhouse gas emissions. This reality

serves as a catalyst for supply chain partners to adopt more eco-friendly practices within their operations. The findings of this study support existing supply chain actors in recognizing and implementing green practices. Furthermore, the research contributes to the theoretical development of Green Supply Chain Management (GSCM) knowledge within the context of the agro-food industry.

Additionally, the proposed framework serves as a guideline for both current and prospective supply chain actors engaged in the agro-food sector, emphasizing the importance of environmentally sustainable practices. Consequently, this framework can be utilized by various stakeholders, including researchers, policymakers, and supply chain partners, as a roadmap for adopting and monitoring environmentally sustainable practices in the agro-food supply chain. By leveraging this framework, stakeholders can work collaboratively toward reducing the environmental impact of the agro-food industry while enhancing overall sustainability.

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