



Review Article

Review of Agro-Food Sustainability Supply Chain: Causal-Loop and Mitigation for Environmental Risk

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Abstract | Agro-food supply systems are essential for maintaining global food security. However, they encounter growing environmental risks that pose significant challenges. Recognizing environmental hazards present throughout the agricultural food supply chain can improve its sustainability. This review compiles relevant data from recent literature and evaluates it to identify strategies for managing sustainable agro-food supply chains while mitigating environmental risks. It emphasizes the importance of gathering such information in order to devise approaches that can effectively address the challenges inherent in the agro-food industry. This review also provides a concise overview of intervention strategies to address disruptions in sustainable agro-food supply chains. These strategies include enhancing natural farming techniques, optimizing fertilizer management, improving food waste management among consumers, and implementing more efficient management practices for clean water, agricultural land, and energy during processing.

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Introduction

The sustainability of the agro-food supply chain is presently a prominent concern that is garnering growing interest from various stakeholders, including consumers, companies, government organizations, and academics (Allaoui *et al.*, 2018; Avikal *et al.*, 2023; Ivo de Carvalho *et al.*, 2022). The deteriorating environmental circumstances are the reason for this heightened attention. The rising demand is necessitating deliberations aimed at harmonizing economic expansion with the

imperative of environmental sustainability (Accorsi *et al.*, 2016). In order to develop a sustainable food production and consumption system, it is imperative to take into account the entirety of the supply chain and the various stakeholders involved at each stage of the process (Desiderio *et al.*, 2022). The agro-food business encompasses a multitude of factors that introduce uncertainty and risk, which, if not well managed, can detrimentally affect the performance of the supply chain (Esteso *et al.*, 2023).

The development and application of sustainability

metrics and sustainability indicators, which serve to ensure that the industry operates in a responsible manner, can facilitate the enhancement of sustainable industrial development (Hale *et al.*, 2019; Husgafvel *et al.*, 2015). In light of escalating pressures to enhance and sustain agricultural production, the agro-food industry has emerged as a prominent contributor to environmental degradation. Understanding the worst-case scenarios related to environmental concerns in agro-food supply chains is crucial. Enhancing the robustness of agro-food supply chains and improving risk management are crucial factors in achieving these objectives. Agro-food supply chains face a substantial sustainability challenge due to the presence of environmental risk factors. Addressing these challenges necessitates prioritizing risk factor reduction in order to enhance sustainability. Supply chain performance management models offer useful information to both managers and academic researchers on effectively managing conflicting goals within agro-food supply networks (Ramos *et al.*, 2022).

Indeed, a growing apprehension exists regarding the tangible threats that climate change presents to the human population (Richards *et al.*, 2021). The historical record indicates that farmers have consistently encountered climate-related hazards throughout the course of agricultural development. However, it is now becoming increasingly apparent that climate change is exacerbating the severity, occurrence, and diversity of these risks. The potential consequences of climate change pose significant financial risks, particularly for small-scale farmers, who are disproportionately vulnerable. Climate change represents a substantial threat to sustainable development, as highlighted by reputable sources such as the International Fund for Agricultural Development (IFAD, 2015) and the Asian Development Bank (Asian Development Bank, 2021).

Beyond the survival and expansion of individual enterprises, supply chain resilience has broader implications for countries, an area that has received relatively little attention in academic literature. Governments that possess an understanding of the requirements for firm resilience can implement frameworks and procedures that enhance the investment appeal of their respective countries (Martínez *et al.*, 2020). The impact of supply chain finance on supply chain resilience is dependent on

the degree of environmental unpredictability (Yuan and Li, 2022). However, the impact of environmental practices on cost and operational performance is more complex at the purchasing category level (Miemczyk and Luzzini, 2019). Companies can achieve environmental performance without incurring additional expenses or compromising other performance aspects. Managers should understand that the alignment between subjective perception and objective assessment of environmental conditions, rather than solely based on uncertainty, influences supply chain relationship management (Yu *et al.*, 2018). Furthermore, the integration of sustainability into supply chain management poses numerous problems. While the significance of collaboration among supply chain partners is growing, it remains predominantly focused on the upstream segment of the supply chain (Moralí and Searcy, 2013). Companies that demonstrate a propensity for innovation often display a higher degree of sustainability performance, particularly in circumstances marked by elevated levels of uncertainty (ss).

This paper constructs a conceptual framework based on a thorough examination of the existing literature. This review helps to identify and tackle many factors that contribute to environmental risks in agro-food supply chains. Consequently, it aids in enhancing sustainability efforts. Using causal-loop analysis, this review compiles relevant information from existing literature and evaluates it to outline options for managing sustainable agro-food supply chains while reducing environmental concerns. This literature review delineates the distinct phases of the agro-food supply chain system, commencing with production, followed by processing, transit logistics, retail sales, and ultimately culminating at the consumer level. During each step, any environmental elements that may lead to issues are carefully considered, along with the causes and consequences of the entire agro-food supply chain system. The discussion session in this review focuses on the agro-food supply chain, taking into account environmental risk factors at the agro-food production level, processing level, transportation logistics level, consumer level, and mitigation strategies in the agro-food supply chain, with a specific focus on climate actions in the supply chain, logistics management actions, and consumer waste actions. This contributes to the maintenance of optimal performance over an extended period of time. Therefore, this paper aims to provide a comprehensive

analysis, using a literature review, of supply chain sustainability in the agro-food industry, specifically focusing on mitigating environmental risks.

Agro-food supply chain by considering environmental risk factors

Agro-food supply chains play a crucial role within the broader framework of the global food system (Belhadi *et al.*, 2024; Melesse *et al.*, 2023). Nevertheless, the agricultural food supply chain has witnessed a surge in environmental issues such as the destruction of natural habitats, excessive utilization of fertilizers, disposal of chemical waste, emissions of greenhouse gases, field emissions, CO₂ emissions, consumer waste, and environmental degradation (Assis *et al.*, 2023; Elhidaoui and Kota, 2023; Philip and Marathe, 2022; Ramos *et al.*, 2022; Takavakoglou *et al.*, 2022). These concerns have led to the emergence of significant risks. The imperative of maintaining the sustainability of agro-food supply networks necessitates the mitigation of risk factors (Elhidaoui and Kota, 2023; Krstić *et al.*, 2023; Rahbari *et al.*, 2023; Takavakoglou *et al.*, 2022).

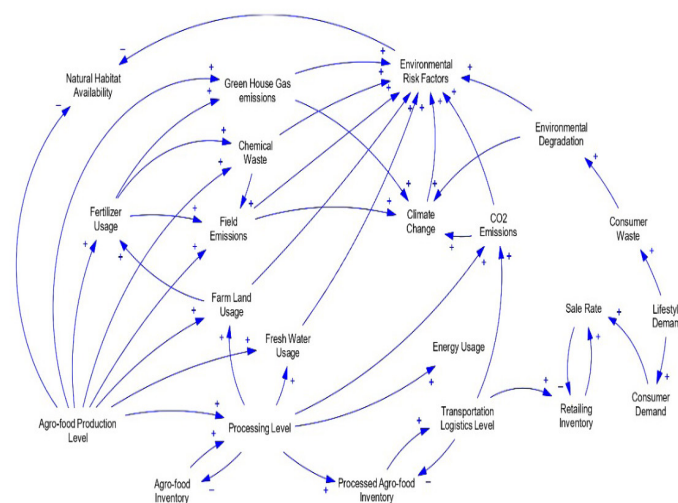


Figure 1: *Environmental risk factors in agro-food supply chain.*

This review categorizes the investigated agro-food supply chain risks based on the stages they impact. The use of classification enables the identification of pivotal risks that hold significance throughout all phases of the agro-food supply chain (Kuizinaite *et al.*, 2023). Targeting various stages of the supply chain is necessary to achieve substantial enhancements in its viability and sustainability. Figure 1 elucidates the origins of environmental risks that are present at various stages within the supply chain. The stages encompassed in this framework are agro-food

production, processing, transit logistics, retailing, and the ultimate consumers.

Figure 1 illustrates the interdependencies and causal interactions among various components within the agro-food supply chain. This diagram serves as a valuable tool for comprehending the functioning of the supply chain and subsequently constructing flow diagrams for modeling purposes. An arrow represents the relationship between two variables, indicating a positive sign when the variables are directly proportional (i.e., an increase in one variable leads to an increase in the other), and a negative sign when the variables are inversely proportional (i.e., an increase in one variable results in a decrease in the other). In the upcoming session, there will be a more extensive discussion on the environmental risks associated with each level of the agro-food supply chain. The session will conclude with a focus on ideas to mitigate these risks within the agro-food supply chain.

Environmental risks at agro-food production level

Primary producers, or farmers, are the principal players responsible for agricultural food production at the agro-food production level. At the production level in the agricultural sector, the presence of dynamic environmental elements gives rise to major environmental concerns (Ahmad and Afzal, 2020). Agricultural activities have the potential to cause environmental pollution and safety emergencies, underscoring the importance of adopting environmentally sustainable production strategies to alleviate environmental consequences (Yu *et al.*, 2022). The susceptibility of newly harvested agricultural products to environmental impacts contributes to both social and natural risk factors throughout their supply chains (Bian *et al.*, 2020). Agricultural production can generate environmental strain due to improper practices, the impact of CO₂ concentrations, and climate (Doğan, 2018).

Meanwhile, the identification of primary emission sources within the agro-food supply chain facilitates the formulation of policies aimed at establishing agro-food systems that are both sustainable and low in carbon emissions (Boenzi *et al.*, 2022). Field emissions arise from primary agricultural and food production activities, manifesting themselves through both direct and indirect means. Activities occurring at the agro-food production level result in the direct emission of

pollutants into the atmosphere, exacerbating climate change and increasing environmental vulnerability (Azab *et al.*, 2023; Boenzi *et al.*, 2022). Apart from primary production operations, the use of fertilizers, particularly chemical waste, also contributes to field emissions, exacerbating environmental hazards (Long and Deng, 2024; Pietrzyk *et al.*, 2021). Fertilizer application both directly and indirectly generates greenhouse gas (GHG) emissions in the context of agro-food production. This phenomenon contributes to the escalation of climate change and poses significant environmental hazards (Mehmood *et al.*, 2021; Yadav *et al.*, 2022).

The augmentation of activities within the agro-food production sector will result in a corresponding rise in emissions released into the environment at the field level (Boenzi *et al.*, 2022; Elhidaoui and Kota, 2023). Additional sources of field emissions could arise from the use of fertilizers and the disposal of chemical waste, making a significant contribution to climate change (Rana *et al.*, 2021; Takavakoglou *et al.*, 2022). In the context of climate change, it is noteworthy that greenhouse gas (GHG) emissions originate from the agricultural food supply chain and make a substantial contribution (Taşkın and Bilgen, 2021). Meanwhile, in close proximity to agro-food production, the processing level poses a significant environmental concern. Gas emissions will rise in direct proportion to the processing level of agricultural products.

Environmental risks at processing level

During the processing phase, the producer distributes the results of their production to the food processing sector or directly to retailers and final customers. Furthermore, the execution of processing activities exerts a direct influence on the quality and visual aesthetics of products, thereby enabling merchants to effectively satisfy client demands and foster long-term customer loyalty (Essien *et al.*, 2024; Zhong *et al.*, 2023).

The agro-food processing industry poses environmental hazards due to waste production, energy consumption, and chemical use. The substantial quantity of trash generated not only leads to environmental contamination but also incurs financial losses for the respective industries (Castro-Muñoz *et al.*, 2022; Fierascu *et al.*, 2019; Ngwasiri *et al.*, 2022). Agro-industrial operations

have a significant impact on the environment and the profitability of the food sector. This is due to their contribution to environmental burdens during food production, processing, and distribution (Akratos *et al.*, 2021; Ngwasiri *et al.*, 2022).

Meanwhile, in the context of CO₂ emissions, it is important to consider the potential for growth stemming from activities occurring at the processing and transportation logistics stages (Boenzi *et al.*, 2022). Specifically, this pertains to practices that include the utilization of equipment and transportation methods that are not environmentally sustainable. Such practices have the potential to exacerbate environmental concerns and should be carefully evaluated (Boenzi *et al.*, 2022; Takavakoglou *et al.*, 2022). The next section will provide an increased understanding of the association between environmental risks and transportation logistics.

Environmental risks at transportation logistics level

Environmental hazards in the transportation logistics aspect of the agro-food supply chain stem from issues such as heightened carbon emissions, energy usage, and ineffective distribution networks (Galati *et al.*, 2023; Joshi and Sharma, 2022; Peterson *et al.*, 2023). The use of traditional transportation techniques in agro-food supply chains leads to increased environmental effects, namely in terms of food miles and carbon footprint (Galati *et al.*, 2023).

At the transportation logistics level, logistics operators have the option to engage in vertical integration with other entities, such as wholesalers and retailers, or to subcontract their services for the storage and distribution of items based on the specific requirements of retailers. Retail inventory management is closely linked to the process by which merchants distribute finished goods to end consumers, who are the primary recipients of the supply chain (Navarro-del Aguila and de Burgos-Jiménez, 2022; Ramirez *et al.*, 2021).

In the realm of transportation, various factors, including the type of vehicle, the efficiency of the chosen route, and prevailing traffic circumstances, exert an influence on fuel consumption (Fu *et al.*, 2020). Consequently, these factors contribute to the generation of CO₂ emissions, which mostly emanate from the transportation logistics level within the supply chain stage. CO₂ emissions exhibit

a direct correlation with fuel usage and specific vehicular characteristics, hence yielding significant ramifications in terms of both financial expenses and environmental consequences (Bosona and Gebresenbet, 2023; Taghikhah *et al.*, 2021). The emissions of CO₂ exhibit a strong correlation with the different fuel types employed in transportation logistics (Trivellas *et al.*, 2020). Meanwhile, transportation logistics that are inefficient and not sustainable can heighten environmental concerns when producers prioritize product convenience, speed, and accessibility to meet consumer demands. The following section will enhance comprehension of environmental hazards at the consumer level.

Environmental risks at consumer level

The ultimate consumer is the one who purchases the product. Consumer lifestyles exert a substantial influence on environmental degradation by means of consumption patterns, waste generation, and resource utilization (Tuni and Rentizelas, 2022). Individual preferences for agricultural food products can influence consumer demand. Consumer preferences, including the growing need for snacks and disposable products, have a negative impact on the environment by contributing to food waste and greenhouse gas emissions (Tuni and Rentizelas, 2022). According to their lifestyle preferences, consumers' selection of agro-food items has the potential to exacerbate the issue of food waste.

Consumer-generated food waste has the capacity to exacerbate waste management issues and adversely affect the environment (Galati *et al.*, 2023). However, the pressures of a contemporary way of life can motivate consumers to choose agricultural food goods that generate consumer waste, resulting in the production of unconsumed products. Customizing agricultural food production to suit unique lifestyle preferences may necessitate a greater utilization of materials and resources. Customizing agricultural food production to meet certain lifestyles may necessitate higher resource allocations, such as water, energy, and chemicals, which could potentially contribute to environmental deterioration (Belaud *et al.*, 2019). Lastly, the session will highlight strategies for mitigating environmental risks in the supply chain.

Mitigation strategies in agro-food supply chain

Sustainable supply chain risk management includes

recognizing, analyzing, and controlling risks, choosing suppliers, evaluating distribution risks, and planning production capacity (Abadi and Darestani, 2023). To improve business and supply chain performance, risk management must address firm and supply chain level disruption risk, analyze its impact, and resolve supply and process disruptions (Parast and Subramanian, 2021). Logistics unpredictability is the primary factor that influences the likelihood of supply interruption risk. The level of variability in the logistics service has a direct impact on the delivery service's reliability and raises the likelihood of supply interruption risk. Furthermore, the likelihood of environmental disruption can have an impact on the risk associated with supply distribution (Tse *et al.*, 2016). The proposed network design problem entails a novel methodology for designing distribution systems that facilitate the movement of agricultural produce from farmers to central hubs and subsequently to designated warehouses (Dwivedi *et al.*, 2020). Managers and entrepreneurs are increasingly recognizing the benefits of sustainability-driven innovations. However, it is critical for them to take into account the complex nature and potential risks associated with these initiatives. The formation of long-lasting collaborations with supply chain partners is crucial for the effective implementation of sustainability initiatives (Caccialanza *et al.*, 2023). Figure 2 presents an overview of mitigation strategies for environmental risks in the agro-food supply chain.

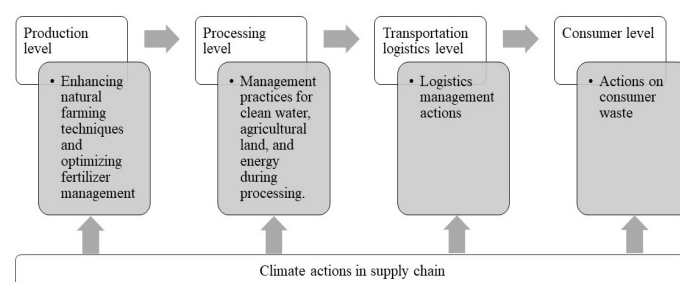


Figure 2: Mitigation strategies in agro-food supply chain for environmental risks.

As the implementation of environmental measures becomes more prevalent across the supply chain, the dynamics of the buyer-supplier relationship undergo a transformation, transitioning from a transactional one to a collaborative one and from a commodity-centric focus to a strategic orientation. Suppliers should recognize that implementing environmental initiatives with clients is a distinguishing factor. The collaborative establishment of environmental indicators can assist organizations in effectively

managing environmental projects (Murfield and Tate, 2017). Unless consumers present them with more explicit incentives like price premiums and increased market shares, firms should exercise caution when engaging with environmental supply chain sustainability programs. Additionally, governments could play a role by offering tax cuts to firms that demonstrate environmentally sustainable supply chains while imposing fines on those that do not. Furthermore, green investors could contribute to this effort by providing additional capital to firms with environmentally sustainable supply chains while withholding capital from non-green firms. This also implies that stakeholder groups should provide more precise incentives for firms with ecologically sustainable supply chains while imposing penalties on those that do not meet such standards (Dam and Petkova, 2014).

Agro-food supply chains use knowledge management approaches in response to supply chain concerns. More resilient food supply networks could preserve food supplies and create jobs in the food business. Exposure to supply chain risks and assessment of their potential negative impact or loss are critical for reducing disruption or maintaining resilience (Ali *et al.*, 2023). Managers should also work with all supply chain partners and analyze results from a supply chain perspective for integrated environmental risk management (Zhu *et al.*, 2017). Multiple supply chains can help manufacturers adapt to environmental changes and mitigate supply chain risks for organizational growth (Liu and Lee, 2019). The biggest sustainability risks in manufacturing enterprises' supply chain management were poor planning and scheduling, environmental accidents, production capacity risk, product design risk, and exploitative recruiting policies (Wang and Rani, 2022). On the other hand, there is a significant amount of loss and waste in the fresh agricultural product supply chain, affecting a wide range of agricultural products at different stages and operating levels. Post-harvest loss and waste creates a disparity between demand and supply of agricultural and food products, leading to challenges in ensuring the provision of wholesome and nourishing sustenance for the community (Anand and Barua, 2022). In contrast, suppliers are allocating more resources towards enhancing product quality and implementing quality improvement initiatives to optimize supply chain efficiency and achieve optimal outcomes (Zhao, 2023). The upcoming session will

focus on environmental risk mitigation in climate action within supply chains, logistics management actions, and actions on consumer waste.

Climate actions in supply chain

Sustainable development integrates environmental practices into market systems, promoting adoption and performance (Warshawsky, 2016). While there are various dimensions to environmental sustainability, it is crucial to emphasize the growing significance of addressing human-induced climate change in order to reduce emissions (Accorsi *et al.*, 2016). The agro-food business is confronted with substantial risks due to climate change and variability, which in turn jeopardize ecosystems and natural capital. The identification and mitigation of climate-related risks within supply chains can significantly contribute to risk reduction and the enhancement of overall resilience for enterprises. The introduction of innovative products and services that are designed to withstand climate-related challenges can potentially create opportunities in previously untapped industries, such as the insurance sector and the field of water-efficient irrigation systems (Groot *et al.*, 2019).

There has been a strong emphasis on prioritizing climate and environmental policy reform and disruption (Marsden, 2022). Ensuring climate resilience should be regarded as a crucial concern in the context of value chain development, as it serves to mitigate poverty levels and enhance food security. It is imperative for all participants within the chain to possess knowledge regarding climate hazards and possess the necessary capabilities to effectively handle them (Dazé and Julie, 2016). The potential for climate change-related consequences varies significantly depending on the specific circumstances; however, it is anticipated to be more pronounced in regions that are already characterized by high temperatures and possess weak socio-economic and institutional capacities to mitigate and adapt to these changes. The future of the climate and the interaction between humans and natural systems in response to climate change over time continue to be subjects of significant uncertainty. Hence, it is imperative for adaptation strategies to encompass a range of potential future scenarios, even those that may appear insignificant but possess significant ramifications (Godde *et al.*, 2021). These encompass alterations in mean precipitation, climatic anomalies such as

prolonged periods of high temperatures, variations in temperature patterns, shifts in the prevalence of pests and diseases, modifications in atmospheric carbon dioxide and ground-level ozone levels, fluctuations in sea levels, and modifications in the nutritional composition of food (Yadav *et al.*, 2022).

Moreover, the mitigation of greenhouse gas emissions is of utmost importance in enhancing sustainability (Morella *et al.*, 2021; Yadav *et al.*, 2021). Enhancing fertilizer management techniques is one potential approach to mitigating greenhouse gas emissions. Conversely, the degradation of habitats poses a substantial environmental menace to biodiversity. Enhancing the sustainability of agro-food supply chains necessitates the implementation of many measures, including the establishment of protected areas, the mitigation of deforestation, and the reduction of chemical fertilizers and pesticides. These initiatives play a crucial role in mitigating habitat degradation. Furthermore, the implementation of environmentally sustainable innovations, such as the development or enhancement of novel goods, technologies, processes, and management strategies that yield both ecological advantages and economic value, can facilitate the achievement of such objectives (Bhatia *et al.*, 2022). And agroforestry, as a viable alternative to monoculture, has emerged as a prominent avenue for promoting sustainability within the agricultural business (Martins *et al.*, 2023).

Logistics management actions

The lack of organization within the transportation industry, particularly in developing nations, poses a significant challenge (Arya *et al.*, 2020). While delivering local products to end consumers over shorter distances offers environmental and human health benefits, using smaller and less efficient vehicles for delivery instead of larger, more efficient ones typically used for large-scale product distribution can compromise or even negate these advantages. To fully harness these potential benefits and meet the increasing demand for locally supplied goods, optimizing the use of larger vehicles becomes paramount. Furthermore, it's essential to recognize that the advantages of local procurement carry even greater weight in geographically distant regions far removed from the processing centers of ready to eat vegetables (Tasca *et al.*, 2017).

It becomes imperative to mitigate the ecological

consequences of sustainable transportation alternatives within the supply chain. And it is necessary to consider various forms of transportation to facilitate the movement of goods between different supply stages, thereby enabling efficient delivery between warehouses. Shipping agrifood is responsible for the highest levels of carbon emissions. Therefore, it is recommended that the distribution and transportation sectors implement an environmentally friendly distribution strategy (Yuniarti *et al.*, 2023). Nevertheless, it is advisable to employ this approach just for intermodal transportation modes, such as truck-to-rail, which effectively mitigate the environmental consequences associated with distribution activities (Accorsi *et al.*, 2016).

Actions on consumer waste

In the context of environmental conservation, it is worth noting that heightened consumer consciousness regarding sustainable food options and effective waste management practices can contribute significantly to mitigating adverse environmental consequences (Cui *et al.*, 2020; Gaitán-Cremaschi *et al.*, 2017; Galati *et al.*, 2023). In order to mitigate the effects of consumer waste and environmental degradation within the agro-food supply chain, it is imperative to advocate for the adoption of a more sustainable consumer lifestyle, endorse ecologically conscious production and distribution methods, and enhance consumer and food waste management strategies. Therefore, adopting sustainable consumption practices, such as endorsing eco-friendly items and minimizing food waste, can effectively alleviate the ecological consequences of consumer lifestyles (Tuni and Rentizelas, 2022). Consumer consciousness, instruction, and inclination to invest in ecologically conscious products are crucial in advancing sustainable practices in the agro-food supply chain (Tuni and Rentizelas, 2022).

The act of reducing food waste at the consumer level has the capacity to yield numerous advantages for both society and the environment. Addressing the issue of food waste necessitates a comprehensive approach, including measures that promote and mitigate food waste-related behaviours. Due to the frequently incomplete recognition and realization of the potential advantages associated with food waste reduction measures, there exists a necessity for educational initiatives employed by policymakers to enhance household consciousness pertaining

to matters related to food waste (Matharu *et al.*, 2022). Consumer awareness and education can exert a significant influence on individuals' behavior and preferences, prompting them to adopt a more sustainability-oriented approach. The attainment of genuine environmental sustainability necessitates the comprehensive consideration of all potential environmental consequences, with the goal of making informed decisions regarding investments in technology that can enhance environmental performance (Arya *et al.*, 2020).

However, it is imperative for all corporations to adopt sustainable supply chain management techniques in order to mitigate potential dangers. In order to proficiently execute sustainable supply chain management methods, a company must possess a comprehensive understanding of its product's life cycle as well as its location within the supply chain. There exists a positive correlation between heightened perceptions of sustainability risk and increased levels of monitoring of supplier sustainability practices by focal enterprises (Zhu *et al.*, 2019). Meanwhile, an elevated perception of sustainability risk prompts a heightened level of scrutiny towards supplier behavior, thereby resulting in greater investment in efforts aimed at enhancing the supply chain and higher attention towards social monitoring. And also, the use of behavior-oriented techniques, such as the monitoring of environmental and social practices, has been shown to be successful in enhancing the sustainability performance of firms (Shafiq *et al.*, 2017).

It is critical to use environmental risk management models and promote environmental responsibility in agricultural operations to achieve sustainable production while minimizing resource consumption and pollution (Gómez and Triana, 2023; Huang *et al.*, 2022). Using agro-industrial waste to create products with added value can effectively decrease pollution and production expenses while also providing sustainable solutions to environmental issues (Faustino *et al.*, 2019; Sath *et al.*, 2018). Utilizing cutting-edge technologies and extraction methods can aid in the effective utilization of by products, hence decreasing the environmental consequences of agricultural processing (Castro-Muñoz *et al.*, 2022; Coelho *et al.*, 2020). Moreover, the utilization of digital technology and sustainable practices has the potential to enhance supply chain efficiency and mitigate the

environmental impact (Joshi and Sharma, 2022). The COVID-19 pandemic has brought attention to weaknesses in the transportation and distribution of goods, underscoring the importance of implementing methods to withstand disruptions and maintain uninterrupted operations (Coelho *et al.*, 2020). Implementing blockchain technology and quality management strategies can enhance traceability and operational capacities, leading to significant changes in logistics and agro-food transportation (Babu and Devarajan, 2023; Joshi and Sharma, 2022).

Conclusions and Recommendations

The enhancement of agro-food supply chain sustainability is contingent upon the imperative task of mitigating environmental risk elements. Implementing effective management practices throughout the supply chain has the potential to significantly mitigate environmental risk factors. These practices encompass a range of strategies, including the enhancement of natural farming techniques, the optimization of fertilizer management, the improvement of food waste management among consumers, and the more efficient management of fresh water, farm land, and energy at the processing stage. The adoption of best practices and legislation that prioritize environmental sustainability in the agro-food supply chain holds significant importance. By using this measure, it can be ensured that the agro-food supply chain maintains its ability to deliver high-quality food products while simultaneously safeguarding the natural environment. Thus, promoting circular economy principles, green practices, and sustainability standards for sustainable agro-food supply chains can be a policy intervention.

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Novelty Statement

The review article provides a concise and current overview of the environmental risks associated with each stage of the agro-food supply chain, as well as suggested approaches to mitigate these risks.

Author's Contribution

Anisa Aprilia: Conducted a comprehensive search

and analysis of the existing literature, organized the discovered information, and wrote the manuscript.

Syafrial: Offered expert advice and direction along each step of the research work.

Djoko Koestiono, Fitria Dina Riana, Silvana Maulidah: Proofread the manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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