The compatibility of the triple-a agri-food supply chain with the United Nations Sustainable Development Goals

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Abstract. The triple-a supply chain model focuses on ensuring the agility, adaptability, and alignment of the supply chains in order to develop a sustainable competitive advantage. These characteristics have extended the supply chain desired traits from just being cost-effective and responsive. The agri-food supply chains include a diverse range of products, which differentiate in various aspects such as processing, life-cycle, seasonality, vulnerability, etc. These characteristics lead to different supply chain typologies and various requirements for synergies among stakeholders in order to meet these objectives. The situation gets even more complicated when sustainability objectives enter into the supply chain design and operation process. The scope of this paper is to analyze and assess the compatibility of the triple-a agri-food supply chain with the UN sustainable development goals and outline the interventions that could facilitate decision-making concerning the design and operation of sustainable agri-food supply chains.

1. Introduction
Sustainability is one of the biggest challenges of our time. The need to move to a more sustainable pattern of human activities is captured by the Sustainable Development Goals (SDGs) 2030 Agenda which was published by the United Nations (UN) and includes guidelines available to all countries in order to improve the quality of life in our planet [1]. Supply chains of all kinds of products have a significant role to play in this respect, being the dominant model that connects supply with demand.

During the last decades, different frameworks are proposed in order to ensure a sustainable competitive advantage for the supply chains [2]. Various approaches have been presented in order to ensure the effectiveness and efficiency of the supply chains. One of the predominant proposals was made by Professor Hau Lee in 2004. According to his approach, which is called the triple-a supply chain model, the fundamental characteristics of a competitive supply chain are agility, adaptability, and alignment. A supply chain should be able to respond to short-term sudden changes in the market (agility), predict and monitor the long-term changes (adaptability) and define roles and responsibilities in order to adjust rewards through the whole supply chain (alignment).

The agri-food supply chains differentiate from other kinds of supply chains. The products involved in them are characterized by various properties considering their quality, seasonality, vulnerability, etc. influencing their course throughout the supply chains. In addition, the stakeholders have varying
interests, come from various fields and their objectives are diverse. That is why agri-food supply chain management is challenging and cannot be easily framed [3].

In this paper, the compatibility of the triple-a agri-food supply chain with the UN sustainable development goals is analyzed and the interventions that could facilitate decision-making concerning the design and operation of sustainable agri-food supply chains are outlined.

2. Background
In the past years, firms strived to make their products available globally. With the location of suppliers and customers being in every part of the world, the supply chains become the only means of gaining a competitive advantage at a global level [4]. Firms participate in various complex supply chain systems and as result supply chains become even more connected to each other. The increased complexity of supply chain systems and the interdependence among stakeholders make their management more challenging as the visibility across their stages reduces, creating an uncertain environment through the supply chains. For this reason supply chains develop new characteristics to adapt to the new challenges caused by their globalization.

2.1. The triple-a supply chain model
An approach proposed by Lee in 2004, was the triple-a model of supply chains, according to which supply chains should be, apart from effective, also agile, adaptable, and aligned. According to this model, supply chains should be modified according to these three parameters in order to achieve long-term evolution and effectiveness through the supply chain systems, providing stakeholders at the same time with a sustainable competitive advantage.

According to the triple-a supply chain system model the supply chains should be agile, responding quickly to short-term changes in market demand and handle any external disruptions smoothly [5]. The idea of agility was first promoted as a part of the concept of agile and flexible manufacturing [6]. Later, researching the supply chain networks of fashion companies was proved that agility consists one of the most important capabilities of the supply chains [5]. Agility indicates that the firm’s response to short-term changes has to be immediate and targeted to each of them. As soon as a change is detected through the supply chain, this information should be able to be shared with all stakeholders and modifications should be made in order to ensure the functionality of the supply chain.

The triple-a supply chain model indicates that supply chains should also be adaptable, being adjusted according to the market’s trends [5]. Adaptability focuses more on long-term decisions and strategic plans which include the monitoring of trends and the ability to influence them by finding ways to control them. These trends may include economic, political, and social changes, and even the influence of the technological evolution to the standards that supply chains have to meet [7]. In order for a supply chain to retain its competitive advantage through these continuous changes, adaptability is the key to long-term efficiency.

Alignment is the third characteristic of a triple-a supply chain system. Alignment refers to creating incentives for all stakeholders in order to ensure the achievement of higher performance for the supply chain. This means that all stakeholders should benefit from the improvement of the efficiency of each stage, focusing on aligning their objectives with each other’s and at the same time with the supply chain’s strategic goals and not to pursue just their own interest. In order to achieve this, cooperation between stakeholders is necessary and all the information should be available to them at every time. As the supply chains become more complex, the alignment plays a significant role in overcoming the difficulties and attaining a higher competitive advantage.

2.2. Sustainability and Sustainable Development Goals
The adoption of sustainable practices in various human activity fields has started to be applied and supported by international organizations [8]. The United Nations have formulated the Sustainable Development Goals (SDGs) 2030 Agenda which includes 17 aspirational objectives with 169 targets about all dimensions of sustainable development [1]. The content of the SDGs covers all the emerging
issues that our planet comes against, including poverty, health, education, inequalities, economic growth, climate change, and environmental protection. Through this program, the SDGs have become a pursuing target for countries for the next years. As long as the SDGs 2030 Agenda actually does not include legally binding regulations, each country can shape its own framework towards achieving them and prioritize them accordingly. Depending on each countries regulation system, this framework can include either modifications to the existing legislation or shape a brand new approach to sustainable practices [9]. Moreover, in our globalized world cooperation beyond national borders is a prerequisite condition. Therefore, international organizations including corporations owe to work closely with their business partners and various stakeholders to develop and spread a shared vision and shape feasible solutions to meet the SDGs.

Agri-food supply chains have been striving to adopt new practices towards sustainability. It should be noted that these efforts may be regarded as the outcome of a natural evolutionary process which has sporadically addressed economic, environmental or social goals, but not in a coherent, systematic and comprehensive manner. Eventually, this evolution is related with an institutional approach, which is about the policies that facilitate, support and enhance sustainable development. In this aspect, several of the SDGs proposed by the UN are associated with sustainability in agri-food supply chains.

3. Triple-A agri-food supply chains towards sustainability

3.1. The core characteristics of agri-food supply chains

Agri-food supply chain systems are distinguished from other supply chains due to the products and the stakeholders involved in them. Food products have a lot of different properties that have to be retained through the stages of agri-food supply chains. That is because the assurance of product quality and safety in the case of food products is the only way for them to survive through the changes in all the stages of the agri-food supply chains and end up being appropriate for consumption. The perishability of products is one of the main properties that make this kind of supply chain different from the others [10]. In this case, quality degradation is easy to occur and products should be treated carefully through all the stages. Considering that consumers’ needs and demands are increased, the quality of the product treatment through the agri-food supply chain affects their added value and thus the profit.

Agri-food supply chains consist of different parties connected with each other “from farm to fork”, including farmers, transporters, manufacturers, retailers, and consumers. Starting from the field, agricultural products have a lot of standards to meet. As the products on this stage may consist of either the primary ingredients of the final products or the final products themselves the procedures that take place are highly important. During the stages of transportation and process food loss is the main problem that has to be faced in order to achieve the highest efficiency of the agri-food supply chain. The retailing management activities, such as the accurate forecasting of demands, can affect the operation and efficiency of the agri-food supply chains as it is the link between producers and consumers. All the parties are involved in the risk management activities and their actions should be taken into consideration during the strategic planning processes [11].

As it occurs from the composition of the agri-food supply chains, the need of monitoring its activities is crucial in order to achieve both its strategic goals and the objective of each stakeholder. A holistic approach such as the triple-a supply chain model could give the answers to the difficulties that agri-food supply chains have to overcome. During the recent COVID-19 pandemic the food supply chains had to face a challenge due to the change of the disposal, transportation methods, and demand levels of food products. An agile agri-food supply chain could adapt to sudden changes which could occur due to such unexpected situations. Adaptability could also ensure a long-term sustainable competitive advantage for the agri-food supply chains despite the continuous economic, environmental, social, and nutritional changes leading not only to the increased efficiency but also enhancing its sustainable development [12]. In order to put these practices into application, an alignment of the interests between all stakeholders is necessary. In agri-food supply chains the involved parties have different objectives and their communication has been difficult, especially due to
the large distances and the different orientation of each company. In order to achieve an optimization of the agri-food supply chains, all stakeholders should cooperate and obtain common goals.

3.2. The SDGs and the agri-food supply chains

Agri-food supply chains are continuously adopting new methods in order to achieve a more sustainable outcome. As sustainability is globally approached through the SDGs, their content is connected to the concept of the sustainable agri-food supply chains. Researching the 17 goals presented in the SDGs 2030 Agenda we could record the level of their interconnection. In this subsection, the relevance of each SDG with agri-food supply chains is explored.

SDG 1: End poverty in all its forms everywhere.

As poverty still remains one of the biggest problems worldwide this goal aims to provide universal access to the basic services needed in order to live with dignity and reduce poverty at least by half. As food is indisissually connected with the ability of living, the agri-food supply chain systems play a significant role in the accomplishment of this goal.

SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

This goal is strongly connected to all the decisions which are made in order to ensure sustainable agri-food supply chains. The increase of the food availability for all people through the creation of sufficient and sustainable agri-food supply chain systems, the reduction of food waste, and the cover of demands worldwide are the main topics discussed concerning this target.

SDG 3: Ensure healthy lives and promote well-being for all at all ages.

This goal should be approached from many different sides. As health is connected to the safety and quality of the food we consume we could assume that this target is linked to all the efforts for the protection and retaining of food safety and quality through all the stages of agri-food supply chains.

SDG 4: Ensure inclusive and quality education for all and promote lifelong learning.

This goal refers to the availability of education to all people, regardless of their income, age, race, gender, etc. Education should be easily and safely accessible to all people in the world. Although there is no direct connection with the agri-food sector, we can notice that healthy nutrition and sustainable consumption are integral parts of modern curricula in primary and secondary education.

SDG 5: Achieve gender equality and empower all women and girls.

This SDG does not seem to be relevant in the context of agri-food supply chains.

SDG 6: Ensure access to water and sanitation for all.

Water management is one of the biggest challenges worldwide as the availability of drinkable water is reduced over the years. In the case of agri-food supply chains, one way of achieving sustainability is water management, especially during primary production. Ways of reducing water waste and using the available water smart have been applied recently.

SDG 7: Ensure access to affordable, reliable, sustainable, and modern energy for all.

Sustainable energy is crucial for all dimensions of human activity. Energy is practically necessary everywhere. As the agri-food supply chains’ sustainability relies on the utilization of energy through all the stages [13], the pursuit of this target is a part of the sustainable development of the agri-food supply chains.

SDG 8: Promote inclusive and sustainable economic growth, employment, and decent work for all.

The connection with the agri-food sector is obvious both in terms of creation of jobs but also with respect to the economic pillar of sustainability. Adding value along the agri-food supply chain is expected to enhance economic growth.

SDG 9: Build resilient infrastructure, promote sustainable industrialization, and foster innovation.

This goal is targeted to the industry’s ability to foster sustainable technological development and innovation. As long as the food industry is a big part of the industry worldwide, its sustainable development can affect the accomplishment of this goal. Moreover, relevant interventions are applicable to all supply chain stages.

SDG 10: Reduce inequality within and among countries.
This goal aims to decrease the economic inequalities throughout the world by ensuring equal opportunity and reducing inequalities of outcome including, promoting appropriate legislation, policies, and action in this regard. This can SDG can be linked with agri-food supply chains, as it has to do with having access to resources, knowledge, technology and products.

SDG 11: Make cities inclusive, safe, resilient, and sustainable.
As people nowadays tend to live in cities, retaining a healthy environment is highly important. The agri-food supply chains as part of this equation could adopt eco-friendly activities, reducing waste and pollution and helping to create a more sustainable environment. Moreover, without steps to ensure that poor and vulnerable populations have access to food, hunger and deaths in urban areas might skyrocket.

SDG 12: Ensure sustainable consumption and production patterns.
This goal consists of an objective for every sustainable agri-food supply chain. The proper use of resources and the reduction of waste through the stages of production, processing, and consumption is the core of the practices used in a sustainable agri-food supply chain system.

SDG 13: Take urgent action to combat climate change and its impacts.
Climate change directly affects food production. That is why the sustainable agri-food supply chains adopt policies that contribute to the stabilization of the climatic conditions.

SDG 14: Conserve and sustainably use the oceans, seas, and marine resources.
Sea is one of the most important production fields for agri-food supply chains. As people nowadays tend to consume fish and other seafood the agri-food supply chain activities are also spread to the marine section. Apart from this, part of the transportation of agri-food products is also made by sea. That is why the sustainable activities of the agri-food supply chains can affect the conservation of marine resources.

SDG 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
The use of land is a big part of the agri-food production systems. Land management and the preservation of its properties is the main target for agri-food supply chains and almost all sustainable actions are focused on this.

SDG 16: Promote just, peaceful and inclusive societies
Even in the modern world peace is not taken for granted. In a lot of places on the planet, people live under war conditions, not being able to cover their basic needs. For the UN it is highly important to ensure peaceful societies around the world in order for the rest of the SDGs to be achieved.

SDG 17: Revitalize the global partnership for sustainable development
This last goal aims to assist developing countries in attaining long-term debt sustainability through coordinated policies and enhance international cooperation between countries. The agri-food supply chains through the establishment of sustainable practices worldwide can promote the accomplishment of this goal.

In Table 1 there is a categorization of the SDGs according to their interconnection with the sustainable agri-food supply chains using the following continuum:
(I) Not connected: The goal is not linked or is loosely connected to the sustainable agri-food supply chain systems.
(II) Slightly or indirectly connected: The targets proposed from this goal are affected by the activities of the agri-food supply chains, but not at a great level.
(III) Directly connected. The accomplishment of this goal can be achieved through the modification of agri-food supply chain management.

Table 1. The level of interconnection between the SDGs and the sustainable agri-food supply chains.
3.3. The triple-a paradigm for the accomplishment of the SDGs

From the analysis in the previous sub-section it is evident that most SDGs are linked to the agri-food supply chain systems. In order to meet these goals and at the same time ensure the efficiency of the agri-food supply chain, there has to be a strategic framework to accommodate decision-making during its stages. The triple-a supply chain paradigm’s principles seem to fit the requirements of the sustainable agri-food supply chain systems in order to meet the SDGs.

In order to establish a triple-a supply chain model innovation and rethinking of the parameters that influence its planning is necessary. The markets nowadays are dynamic, changing according to the new needs and trends that occur. Especially in the case of the agri-food supply chains, these changes are promoted by the continuous innovations in the agri-food sector and the new needs that emerge from the side of the consumers [14]. In order for the agri-food supply chains to gain a sustainable competitive advantage the evolution of its agility is necessary, so as they can respond to sudden, short-term changes. This can be achieved by the monitoring and the insurance of better visibility through all the stages of the agri-food supply chains. Establishing relationships and cooperating with other partners could be an effective way to improve the performance of the agri-food supply chains [15]. The monitoring also refers to the reverse supply chain systems as food waste management plays an important role in the promotion of sustainability through the agri-food supply chains [16]. The reverse supply chains include the procedures that take place after the product reaches the end of life, including retrieving, reusing, and recycling [17]. In order to achieve high profit, the companies should create an agile reverse logistic system in order to manage the volume of the products involved which can lead to the creation of a bigger sustainable competitive advantage (sustainable triple-a). The need for immediate response to short-term changes alongside the need of achieving the sustainable goals could disrupt the agri-food supply chain balanced system leading either to losing profit or failing to accomplish its sustainable objectives. That is why agility is an important parameter that should be included in the sustainable agri-food supply chain management [18].

Apart from the short-term interventions to the agri-food supply chain systems, their management includes the monitoring and control of the long-term changes that occur. The use of forecasting models in order to predict the demand of products and the use of this information in order to influence the upcoming trends compose an adaptable agri-food supply chain. As the new demands and trends are not always aligned with sustainable practices, firms should frame their decision-making plan in order to achieve the best combination of economic and sustainable growth [19]. Long-term strategic planning is required in order to achieve adaptability. This can be achieved through the exploration of innovative supply network systems or by reconsidering the functionality of the existed networks. The investment in updating the way agri-food supply chains function could be an effective way to make

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**Table:**

| Goal number | with the AFSC | Goal number | with the AFSC |
|-------------|---------------|-------------|---------------|
| 1           | II            | 10          | II            |
| 2           | III           | 11          | II            |
| 3           | II            | 12          | III           |
| 4           | II            | 13          | III           |
| 5           | I             | 14          | III           |
| 6           | III           | 15          | III           |
| 7           | III           | 16          | I             |
| 8           | III           | 17          | III           |
| 9           | III           |             |               |
them competitive. If the stakeholders evolve and update their skills according to the market’s needs then the supply chains could be prepared to confront and control the upcoming changes without losing time and money in making fundamental changes that influence the cooperation between stakeholders [15]. At the same time, the agri-food supply chains can develop new practices in order to ensure the retaining of a sustainable profit and thus accomplish their sustainable goals.

In order to ensure the agility and adaptability of a sustainable agri-food supply chain system, the interests of all the stakeholders should be aligned both between them and with the strategic plans of the agri-food supply chains. In order to motivate stakeholders to follow aligned procedures through all the stages, their own profit should be linked to the increase of the efficiency of the whole agri-food supply chain. As long as the stakeholders cooperate and share all the information necessary in order to achieve a better result the alignment of interests becomes easier. Technologies such as blockchain [20] and the Internet of Things (IoT) [21] can be used to provide all stakeholders, from producers to consumers, all the information required. In this way, the possibility for the agri-food supply chain systems to succeed increases and the products gain added value due to the transparency of the procedures that products undergo through all the stages. The alignment of interests mostly targets to motivate stakeholders through the promise of bigger economic growth. Sustainability should also be included in this equation as it is also important for the agri-food supply chains to have a sustainable impact on the supply chain networks.

4. Concluding remarks
The SDGs, as promoted by the United Nations, include the guidelines to achieving the creation of a sustainable impact throughout our planet. As food orientation, handling and availability are some of the main issues that interest the world, a lot of actions towards sustainability are linked to the performance of the agri-food networks. Agri-food supply chains have a lot of particularities compared to conventional supply chains due to the kinds of products that are involved in the procedures. As a result, the management of such networks is challenging. A lot of the SDGs could be achieved by reinforcing the adoption of practices that make agri-food supply chains more sustainable through all their stages. At the same time, agri-food supply chains have to ensure their survival, through the accommodation of a competitive advantage and the maximization of its efficiency. In order to achieve the best combination of profit and sustainable development, agri-food supply chains come up with the shape of frameworks to accommodate the decision-making through all the stages. The triple-a supply chain paradigm, which is applied to other kinds of supply chains, is proposed as an effective way for the agri-food supply chains to obtain a sustainable competitive advantage. The agility, adaptability, and alignment are described as the basic traits of a competitive agri-food supply chain network. Although in the triple-a paradigm the fundamentals of the maximization of the agri-food supply chains’ efficiency are established, less attention is paid to the parallel development of their sustainable impact and thus to accomplishing the SDGs. Even though an agile, adaptable and aligned agri-food supply chain can gain a higher competitive advantage and survive through long-term and short-term changes that occur, the targets put by applying the triple-a paradigm sometimes do not reinforce its sustainable evolution, disrupting the balances of the sustainable agri-food networks. As a result, the triple-a model should be enriched with targets towards a more sustainable outcome without losing its advantages.

References
[1] Food and Agriculture Organization of the United Nations (FAO) 2016 Food and Agriculture: Key to Achieving the 2030 Agenda for Sustainable Development (Rome: FAO)
[2] Arana-Solares I A, Alfalla-Luque R and Machuca J A D 2012 An analysis of the variables that provide a supply chain with sustainable competitiveness Intang. Cap. 8 92–122
[3] Manning L 2018 Systems for Sustainability and Transparency of Food Supply Chains Sustainable Food Systems from Agriculture to Industry (Amsterdam: Elsevier) pp 153–87
[4] Reklitis P, Sakas D P, Trivellas P and Tsoulfas G T 2021 Performance Implications of Aligning
Supply Chain Practices with Competitive Advantage: Empirical Evidence from the Agri-Food Sector. Sustain. Switz. 13 8734

[5] Lee H L 2004 The triple-A supply chain Harv. Bus. Rev. 82 102–12

[6] Feizabadi J, Gligor D and Alibakhshi Motlagh S 2019 The triple-As supply chain competitive advantage Benchmarking 26 2286–317

[7] Alfalla-Luque R, Machuca J A D and Marin-García J A 2018 Triple-A and competitive advantage in supply chains: Empirical research in developed countries Int. J. Prod. Econ. 203 48–61

[8] Mouzakis Y 2017 Governing the sustainability transition towards a circular economy of eco-industrial parks: a conceptual model for the role of management agencies of industrial estates Int. J. Decis. Sci. Risk Manag. 7 219–31

[9] Horn P and Grugel J 2018 The SDGs in middle-income countries: Setting or serving domestic development agendas? Evidence from Ecuador World Dev. 109 73–84

[10] Pérez Mesa J C, Piedra-Muñoz L, Galdeano-Gómez E and Giagnocavo C 2020 Management Strategies and Collaborative Relationships for Sustainability in the Agrifood Supply Chain Sustain. Switz. 13 749

[11] Choirun A, Santos I and Astuti R 2020 Sustainability risk management in the agri-food supply chain: literature review IOP Conf. Ser. Earth Environ. Sci. 475 012050

[12] Gligor D, Feizabadi J, Russo I, Maloni M J and Goldsby T J 2020 The triple-a supply chain and strategic resources: developing competitive advantage Int. J. Phys. Distrib. Logist. Manag. 50 159–90

[13] Zanoni S and Zavanella L 2012 Chilled or frozen? Decision strategies for sustainable food supply chains Int. J. Prod. Econ. 140 731–6

[14] Tzatsi S, Magoutas A and Chountalas P 2018 The impact of marketing expenditures on economic performance: The case of agricultural processed products industry MIBES Transactions 12 186–99

[15] Erhun F, Kraft T and Wijnsma S 2021 Sustainable Triple-A Supply Chains Prod. Oper. Manag. 30 644–55

[16] Richards C, Hurst B, Messner R and O’Connor G 2021 The paradoxes of food waste reduction in the horticultural supply chain Ind. Mark. Manag. 93 482–91

[17] Brindley C and Oxborrow L 2014 Aligning the sustainable supply chain to green marketing needs: A case study Ind. Mark. Manag. 43 45–55

[18] El-Khalil R and Mezher M A 2020 The mediating impact of sustainability on the relationship between agility and operational performance Oper. Res. Perspect. 7 100171

[19] Devika K, Jafarian A and Nourbashksh V 2014 Designing a sustainable closed-loop supply chain network based on triple bottom line approach: A comparison of metaheuristics hybridization techniques Eur. J. Oper. Res. 235 594–615

[20] Patelli N and Mandrioli M 2020 Blockchain technology and traceability in the agrifood industry J. Food Sci. 85 3670–8

[21] Chandra A 2019 A paradigm shift: Supply chain management 4.0 triple “A” method agile, anytime anywhere, always visible Int. J. Eng. Adv. Technol. 8 338–43