agriculture

MDPI

Article

Strategic Analysis for Advancing Smart Agriculture with the Analytic SWOT/PESTLE Framework: A Case for Turkey

Deniz Uztürk [1] and **Gülçin Büyüközkan** [2,*]

[1] Department of Business Administration, Business Research Center, Galatasaray University, Istanbul 34349, Turkey; duzturk@gsu.edu.tr
[2] Department of Industrial Engineering, Galatasaray University, Istanbul 34349, Turkey
* Correspondence: gbuyukozkan@gsu.edu.tr

Abstract: In the contemporary discourse, smart agriculture (SA) stands out as a potent driver for sustainable economic growth. The challenges of navigating SA transition are notably intricate in developing nations. To effectively embark on this transformative journey, strategic approaches are imperative, necessitating a thorough examination of the prevailing agricultural ecosystem. This study seeks to formulate strategies that advance Turkey's agricultural sector. The primary research questions focus on optimizing the benefits of SA by aligning strengths and opportunities with diverse socio-economic and environmental factors, while also exploring effective strategies to mitigate the impact of weaknesses and threats within the agricultural landscape. To achieve this objective, the utilization of the 2-Tuple linguistic (2TL) model integrated DEMATEL (Decision-Making Trial and Evaluation Laboratory) methodology in conjunction with SWOT (Strengths, Weaknesses, Opportunities, and Threats) and PESTLE (Political, Economic, Social, Technological, Legal, Environmental) analyses is proposed. The integration of linguistic variables enhances the capacity to delve deeper into system analysis, aligning more closely with human cognitive processes. The research commences with SWOT and PESTLE analyses applied to Turkey's agricultural sector. Subsequently, the 2TL-DEMATEL approach is employed to investigate interrelationships among analysis components. This inquiry aims to establish causal relations, facilitating the derivation of relevant strategies. The case study centers on Turkey, a developing country, with outcomes indicating that the highest-priority strategies revolve around addressing 'environmental threats' and 'economic weaknesses'. The subsequent evaluation encompasses eight dimensions, resulting in the generation of fifteen distinct strategies, a process facilitated by collaboration with field experts. Importantly, both the results and strategies undergo rigorous validation, drawing upon insights from the recent literature and field experts. Significantly, these findings align seamlessly with the Sustainable Development Goals (SDGs), substantiating the study's broader significance in fostering a sustainable future for Turkey.

Keywords: smart agriculture; strategy generation; Turkey; SWOT/PESTLE analysis; DEMATEL; 2-Tuple linguistic model

Citation: Uztürk, D.; Büyüközkan, G. Strategic Analysis for Advancing Smart Agriculture with the Analytic SWOT/PESTLE Framework: A Case for Turkey. *Agriculture* **2023**, *13*, 2275. https://doi.org/10.3390/agriculture13122275

Received: 7 November 2023
Revised: 8 December 2023
Accepted: 13 December 2023
Published: 15 December 2023

1. Introduction

The imperative transition toward smart agriculture (SA) is an inevitable response to the imperatives of a dynamic market and climatic conditions. Agricultural production, as a pivotal component of any nation's economy, remains significantly susceptible to fluctuations within its ecosystem. To mitigate this vulnerability and enhance production efficiency, the adoption of SA emerges as a paramount focus [1].

The term "smart agriculture" pertains to the application of data-centric technologies aimed at the enhancement of agricultural methodologies with a focus on elevating productivity, sustainability, and profitability [2]. The essence of SA encompasses a multifaceted process that encompasses the acquisition, retention, processing, and comprehensive analysis of substantial datasets emanating from diverse origins, including but not limited to sensors, unmanned aerial vehicles (drones), and satellite systems [2]. This sophisticated approach stands as a transformative force within the agricultural domain, poised to revolutionize and optimize farming practices through the efficient utilization of data-driven insights and advanced technology integration.

Developed nations have, in response, formulated and initiated comprehensive strategies and objectives to facilitate their agricultural transformation [3]. This commitment extends to developing countries, particularly in the case of Turkey, which holds strong ties with European Union (EU) member states. However, the effective implementation of these devised strategies remains a consistent challenge which highlights a persisting gap in the application of these initiatives [4]. To bridge this disparity, this study places its emphasis on conducting an exhaustive analysis of both external and internal determinants influencing the state of Turkish agriculture. This analysis will be carried out through the application of SWOT (Strengths, Weaknesses, Opportunities, Threats)/PESTLE (Political, Economic, Social, Technological, Legal, Environmental) methodologies. When used together, SWOT and PESTLE analyses provide a comprehensive, balanced view of the agricultural landscape, supporting well-informed decision-making and strategic planning, and helping to manage risks and seize opportunities effectively in the agriculture sector [5,6].

Motivated by the inherent advantages derived from the concurrent utilization of the SWOT and PESTLE tools, this study endeavors to strategically propel Turkey, a developing nation, toward the seamless integration of SA. The principal motivation behind this research lies in the imperative need to formulate efficacious strategies that facilitate a harmonious transition to SA within the Turkish agricultural landscape. To address this motivation, the paper is dedicated to responding to the following research questions (RQs):

RQ1: How can the identified strengths and opportunities from the SWOT analysis be aligned to maximize the benefits of SA, considering the PESTLE factors?

RQ2: In what ways can Turkey mitigate the impact of weaknesses and threats identified in the SWOT analysis through effective strategies aligned with the PESTLE factors?

RQ3: How might the augmentation of the SWOT/PESTLE analysis with analytical techniques like MCDM fortify its robustness?

RQ4: In what ways does the incorporation of a linguistic framework into the SWOT/PESTLE analysis contribute to its enhanced potential?

Accordingly, this study introduces a linguistic-based assessment methodology for formulating strategies. The utilization of the SWOT/PESTLE framework is instrumental in conducting an in-depth exploration of the subject matter. Moreover, the integration of a linguistic-based MCDM framework enhances the capacity for comprehending the SWOT/PESTLE components in a more nuanced manner [7]. In this context, the study proposes the application of the 2-Tuple linguistic (2TL) model integrated with the Decision-Making Trial and Evaluation Laboratory (DEMATEL) framework [8]. The principal rationale behind the selection of the 2TL model is its unique ability to capture the inherent imprecision associated with decision-making processes and to incorporate linguistic variables during computational stages [9]. Additionally, the DEMATEL technique is chosen due to its aptitude for delineating the interdependencies among SWOT/PESTLE components, affording a more comprehensive understanding of the complex relationships inherent in the analysis. The primary contributions of this study can be summarized as follows:

- Providing a holistic analysis of Turkey's SA transition by integrating SWOT and PESTLE analysis. (RQs 1, 2);
- Unveiling nuanced interrelationships among SWOT/PESTLE factors by employing the 2TL-DEMATEL approach, enriching the understanding, and facilitating the generation of more robust strategies (RQs 3, 4);
- Identifying strategies seamlessly aligned with the Sustainable Development Goals (SDGs), offering a practical and adaptable methodology for policymakers, agricultural practitioners, and researchers.

In the forthcoming sections of this paper, the organization will be as follows: The subsequent section will encompass a comprehensive literature review focusing on SWOT and PESTLE analysis and the suggested DEMATEL technique. Following this, the materials and methods will be outlined to establish the foundational framework. The fourth section will detail the SWOT/PESTLE analysis factors for Turkish agriculture. Section 5 presents the application of 2TL-DEMATEL for SWOT/PESTLE analysis factors' prioritization and investigation with their results. Section 6 provides the Discussion section. Finally in the seventh section, the conclusions drawn from this study will be elucidated.

2. Literature Review

In this section, the presentation will commence with a brief overview of smart and sustainable agriculture (SSA), followed by an overview of SWOT and PESTLE analyses, and the DEMATEL technique.

2.1. Smart and Sustainable Agriculture

SSA relies on advanced technologies like the Internet of Things (IoT), precision sensors, drones, and automation systems, transforming farming into precision agriculture (PA) [10]. PA optimizes crop management, enhances resource efficiency, and boosts overall productivity [11]. Sustainable agriculture emphasizes resource efficiency, employing practices such as judicious water use, optimized fertilizer application, and reduced post-harvest losses [12]. Data-driven decision-making, facilitated by analytics and artificial intelligence, enhances monitoring, disease prediction, and crop yield, contributing to environmental stewardship [13–15].

SSA prioritizes environmental preservation by mitigating soil erosion, chemical pollution, and greenhouse gas emissions through eco-friendly practices [15]. Resilience and adaptability are crucial in addressing climate change challenges, involving crop diversification, adaptive strategies, and the use of weather data [16–18]. Economic viability is central, as SSA reduces input costs, optimizes resource use, and improves crop quality, fostering a sustainable and economically stable farming model [19,20].

Recent studies in this field continue to advance our knowledge and understanding of the benefits and challenges associated with SSA [21–23]. Ongoing research focuses on innovation in agricultural technology, the impact of smart agriculture on global food security, and the role of policies and regulations in promoting sustainability [24]. This dynamic field holds the promise of addressing critical global challenges in the realms of food production, ecological preservation, and economic prosperity. As it continues to evolve, SSA remains at the forefront of sustainable development and agricultural innovation.

Moreover, SSA is closely aligned with several SDGs outlined by the United Nations. This innovative agricultural approach intersects with the SDGs focusing on environmental sustainability, food security, and economic growth. In the context of environmental sustainability (SDGs 13, 14, and 15), SSA addresses climate action and the preservation of life below water and on land [25]. Through precision farming and responsible resource management, it mitigates climate change, minimizes soil erosion, and contributes to biodiversity conservation. Furthermore, the alignment with food security (SDGs 2 and 3) is evident as smart agriculture optimizes yields, reduces post-harvest losses, and enhances food quality, fostering a reliable food supply and improving community well-being. Additionally, economic growth (SDGs 1, 8, and 9) is promoted through the reduction of input costs, increased resource efficiency, and improved crop quality, providing opportunities for decent work, sustainable infrastructure development, and poverty reduction [25].

This interconnection between SSA and the SDGs underscores the pivotal role of this approach in advancing global sustainable development objectives. Through the integration of precision technologies, eco-friendly practices, and data-driven strategies, smart agriculture operates in harmony with the broader global effort to create a more equitable, sustainable, and resilient future.

2.2. SWOT and PESTLE Analysis

SWOT analysis is a strategic assessment tool used in business to assess both internal strengths and weaknesses and external opportunities and threats. The acronym SWOT stands for Strengths, Weaknesses, Opportunities, and Threats.

Strengths represent the favorable attributes of a business, including aspects like a unique value proposition, a skilled workforce, or a strong brand image [26]. Weaknesses are areas where a business may be lacking, such as financial underperformance, outdated technology, or ineffective marketing tactics. Opportunities encompass external factors that a business can leverage to its advantage, like emerging markets, technological advancements, or shifts in consumer behavior. Threats are external factors that could adversely affect a business, including heightened competition, economic downturns, or regulatory changes [13].

SWOT analysis finds valuable application within the agricultural sector [27,28]. For instance, it serves as a means to assess the inherent strengths and weaknesses of farms or agricultural enterprises, alongside the opportunities and threats prevalent in the agricultural industry. This analytical approach aids farmers and agricultural entities in pinpointing areas for enhancement, crafting strategies for heightened productivity and profitability, and maintaining competitiveness within the market.

Benzaghta et al. (2021) [26] identified five prevalent domains in which SWOT analysis finds common application: general management, education, marketing, healthcare, and agriculture. Their study encompassed an integrative literature review of SWOT analysis within these domains. The primary objective was to furnish a comprehensive historical perspective of SWOT analysis, thereby facilitating the potential formulation of novel theoretical viewpoints and frameworks. A comprehensive review of the SWOT-related research and its various applications up to the year 2021 was conducted [26].

This paper, in turn, focuses on a more recent examination, specifically concentrating on the utilization of SWOT analysis within the agricultural context from 2021 onward. The recent SWOT studies are given in Table 1.

Table 1. Recent SWOT studies within the agricultural context.

Objectives of the Studies	References	Integrated MCDM Methods
Sustainability and Agricultural Practices	[13,29,30]	BWM–WASPAS, neutrosophic cognitive maps (NCM), TOWS matrix analysis
Agricultural Strategy and Education	[27,28,31]	AHP, TOWS matrix analysis
Technology Assessment in Agriculture	[32,33]	-
Innovative Approaches in Agriculture	[34–39]]	-

As demonstrated in Table 1, previous research has encompassed various agricultural aspects, from the assessment of technology to the enhancement of production and land utilization. Our study aspires to provide a broader perspective on the agricultural system. As part of this endeavor, we aim to explore the causal linkages among the components of the SWOT analysis, with the ultimate goal of formulating more robust strategies for the transition to SA. To facilitate this exploration, we have chosen Turkey as a case study, recognizing it as a prominent example of a developing country.

On the other hand, PESTLE analysis, an instrumental framework, serves as a means of discerning and assessing the external elements that exert influence upon an entity or enterprise. It derives its terminology from the following features: Political, Economic, Sociocultural, Technological, Legal, and Environmental factors [5,40]. This analytical tool is indispensable in affording organizations insight into the macro-environmental forces that possess the potential to influence their functioning and necessitates the formulation of corresponding strategies for their mitigation.

When PESTLE analysis is paired with SWOT analysis, it becomes a valuable tool for organizational development, aiding in the assessment of an organization's current state, capacity, and strategic orientation, as well as its growth or decline prospects [41]. As elucidated by Benzaghta et al. [26], while SWOT analysis predominantly scrutinizes internal factors, PESTLE analysis casts a wider net by acknowledging the external influences that often lie beyond a business's realm of control. Consequently, the amalgamation of SWOT and PESTLE analyses affords a more holistic perspective of the business landscape. In 2020 Wu [41] seamlessly integrated the PESTEL framework and the Five Forces model with a SWOT analysis to scrutinize IKEA's international and cost leadership strategy. More recently, Tran et al. [6] used SWOT/PESTLE analysis in the agricultural context to assess the adoption potential of an autonomous laser-based weeding system (ALWS) for sustainable weed control. Moreover, in 2021, Parra-López et al. [42] used SWOT and PESTLE analyses together to assess factors influencing digital transformation and design effective policies in the agri-food sector. The combined use of SWOT and PESTLE analyses offers a comprehensive assessment of both internal and external factors influencing digital transformation in the agri-food sector, guiding the design of customized policies for DT promotion while engaging diverse expert stakeholders in a complex and data-scarce environment.

In this research, our approach initiates with a fundamental SWOT analysis framework. However, it is essential to underscore that we judiciously incorporate PESTLE dimensions throughout the assessment of relevant factors and the formulation of strategic initiatives, acknowledging the value of this combined analytical approach.

2.3. DEMATEL

MCDM encompasses a diverse collection of methodologies designed to assist in evaluating and selecting the most suitable option among a set of alternatives, considering multiple and often conflicting criteria. Taherdoost and Madanchian [43] provided a detailed classification of MCDM methods in their conceptual paper. The abundance and diversity of MCDM approaches are noteworthy. However, new methods are still being developed in our current era. Recently, different approaches such as the Ordinal Priority Approach (OPA) have begun to find their place within MCDM studies [44,45]. Such innovative approaches may offer decision-makers a broader range of tools to address complex decision problems by taking multiple criteria into account.

DEMATEL, an MCDM approach, is a methodology designed to dissect complex systems by evaluating interdependencies among factors and delineating cause-and-effect chain components, culminating in a visual structural model [8].

A systematic review conducted by Si et al. [46] in 2018 underscores the manifold advantages of employing DEMATEL. These benefits encompass its capacity to furnish a comprehensive and systematic approach to decision-making processes, its proficiency in pinpointing critical factors and elucidating their interrelationships, and its adeptness at navigating intricate systems replete with multifarious factors and interdependencies. Furthermore, the review elucidates a range of application domains for DEMATEL, encompassing but not confined to fields such as business and management, engineering and technology, environmental management, healthcare and medical decision-making, social and political decision-making, as well as education and academic research [47–50].

Most recently, the DEMATEL approach is also preferred in the agricultural area: blockchain adoption factors are investigated for the food supply chain [51], public–private partnership issues are assessed for sustainable agriculture [52], factor influencing complex manufacturing systems for the food industry are evaluated [53], critical success factors for blockchain-integrated IoT for the food supply chain are investigated [47].

These agricultural-focused studies underscore the applicability and efficacy of the DEMATEL method within the agricultural context. Consequently, this study adopts the DEMATEL approach for factor assessment in conjunction with SWOT/PESTLE analyses.

3. Materials and Methods

This division serves the purpose of enabling a more extensive and multifaceted analysis, thereby providing an opportunity to assess the agricultural ecosystem from diverse points. The general framework is given in Figure 1.

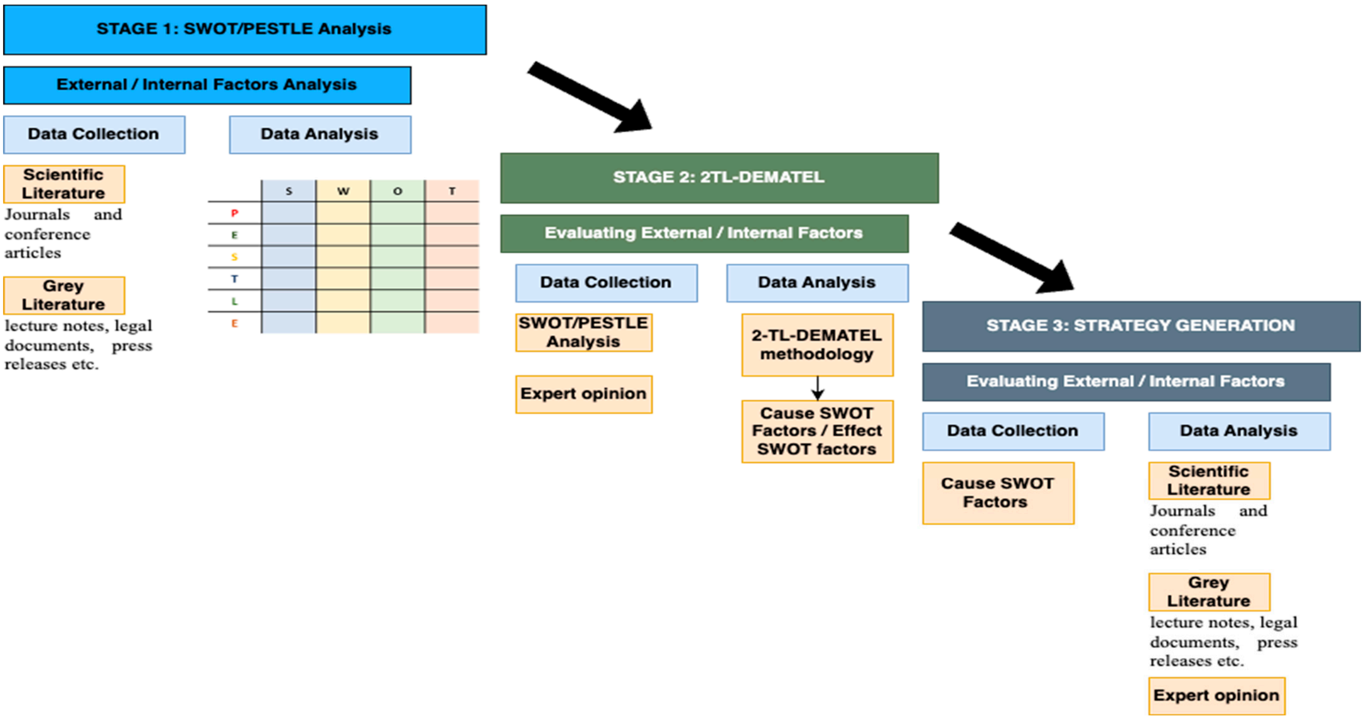

Figure 1. Proposed framework for strategy generation for the agriculture sector.

3.1. SWOT and PESTLE Analysis

The SWOT/PESTLE analysis was rigorously conducted through an extensive literature review, ensuring a well-informed understanding of the Turkish agricultural context. Furthermore, expert consultation was sought to validate and refine the components of the SWOT/PESTLE analysis. It is essential to emphasize that this study primarily adheres to the core SWOT dimensions. However, a distinctive feature of this work lies in the subcategorization of the six fundamental components within the PESTLE framework. This fusion of analytical models enhances the depth of our comprehension, yielding a more holistic view of the agricultural landscape.

3.2. 2-Tuple-Linguistic-Model-Integrated DEMATEL (2TL-DEMATEL)

The 2TL model, rooted in fuzzy logic introduced by Zadeh in 1965 [54], provides a means to preserve information when converting linguistic data into a numerical format. This model represents linguistic information using a 2-Tuple format, denoted as (s, α), where 's' represents a linguistic label and 'α' signifies the numerical value that corresponds to this symbolic translation [55].

For detailed foundational definitions, readers can consult the work of Martínez et al. [9] in 2015. The primary equation that governs the translation within the 2TL framework is expressed as follows:

$$\begin{aligned}
&\Delta_s : [0, g] \to \overline{S} \\
&\Delta_s(\beta) = (S_i, \alpha), \text{with} \begin{cases} i = \text{round } (\beta) \\ \alpha = \beta - i \end{cases} \\
&S_i \in S \Rightarrow (S_i, 0)
\end{aligned} \tag{1}$$

A Linguistic Hierarchy (LH) is formed by combining various levels denoted as 't', where each level 't' is associated with a linguistic term set characterized by an odd granularity, as outlined in [9]. The translation process to convert a linguistic term set with a granularity of $n(t)$ into a linguistic term set with granularity $n(t')$ can be described through the following transformation function:

$$TF_{t\prime}^{t} = \left(S_i^{n(t)}, \alpha^{n(t)}\right) = \Delta\left(\frac{\Delta^{-1}\left(\left(S_i^{n(t)}, \alpha^{n(t)}\right) \times (n(t\prime) - 1)\right.}{n(t) - 1}\right). \quad (2)$$

The transformation function plays a crucial role in consolidating multi-granular information into a unified linguistic framework, a particularly valuable capability when dealing with multiple decision-makers in complex scenarios [9].

DEMATEL is a precise tool within the field of MCDM that excels in gauging the significance of diverse criteria and unraveling causal connections among them. This study integrates DEMATEL into its framework to scrutinize the interdependencies among SWOT and PESTLE factors, ultimately exposing their relationships. The evaluation factors are meticulously identified through an exhaustive review of the pertinent literature and consultations with industry experts.

The essential stages of the 2TL-DEMATEL methodology's formulation can be briefly outlined as follows [56]:

Step 1. Constructing the average matrix (A).

In this step, DMs give their evaluations, $\left(S_{ij}, \alpha_{ij}\right)$. They evaluate the direct effect between criteria i and j.

Step 2. Calculating the initial direct influence matrix (D).

$$D = [s.A]$$
$$s = min\left[\frac{1}{\underset{1\le i\le n}{max}\sum_{j=1}^{n}\left|\Delta^{-1}\left(S_{ij},\alpha_{ij}\right)\cdot\right|}, \frac{1}{\underset{1\le j\le n}{max}\sum_{i=1}^{n}\left|\Delta^{-1}\left(S_{ij},\alpha_{ij}\right)\cdot\right|}\right] \quad (3)$$

Step 3. Calculating the total direct/indirect influence matrix (T).

The matrix encompassing both direct and indirect influences is formally defined through the following relationship:

$$T = D(I - D)^{-1}$$
$$T = \left[\Delta^{-1}\left(S_{ij}, t_{ij}\right)\right] \cdot i, j = 1, 2 \ldots n \quad (4)$$

Within this equation, I represents the identity matrix. The matrix T contains values denoted as "D" and "R", which serve to elucidate the direct and indirect connections among the criteria. "D" signifies the dispatcher, while "R" signifies the receiver. These specific values are computed by applying the subsequent equation:

$$d = d_{n\times 1} = \left[\sum_{j=1}^{n}\Delta^{-1}\left(S_{ij}, t_{ij}\right)\right]_{n\times 1}.$$
$$r = r_{n\times 1} = \left[\sum_{i=1}^{n}\Delta^{-1}\left(S_{ij}, t_{ij}\right)\right]_{1\times n} \quad (5)$$

where r_i gives the summation of the direct and indirect effects of the criterion on the others. If c_i is the sum of the jth column of the matrix T, then it refers to the sum of the direct and indirect effects that the criterion receives from others. In addition, when $j = i$, $(D_i + R_i)$ gives an index of the strength of influences given and received, it refers to the degree of importance of criterion i in the problem. Also, if $(D_i - R_i) < 0$, then criterion i is being affected by other criteria [57]. Moreover, if $(D_i - R_i) > 0$, it means that the degree of affecting others is stronger than the degree of being affected.

Step 4. Analyzing the cause-and-effect diagrams.

In this step, influence diagrams are obtained to investigate the cause–effect relations between criteria.

4. SWOT/PESTLE Analysis for Agriculture in Turkey

This section of the research focuses on providing a comprehensive SWOT/PESTLE analysis for the agricultural ecosystem in Turkey. We will explore the analysis under two primary categories: external factors and internal factors. Each SWOT category will be systematically grouped and evaluated within the context of the corresponding PESTLE analysis headings.

4.1. Internal Factors

Internal factors within this analysis encompass the intrinsic attributes of the Turkish agricultural sector, characterized by strengths and weaknesses.

4.1.1. Strengths

Political Strengths: Turkey exhibits notable political strengths within its agricultural sector. Firstly, the country maintains robust ties with international organizations, a prime example being its close association with the EU [58]. This engagement reflects a commitment to uphold international standards and agreements, ultimately enhancing the quality and competitiveness of Turkish agricultural products in the global market. Additionally, the designation of extensive plains as agricultural protected areas underpins Turkey's dedication to preserving crucial agricultural lands. This strategic move safeguards agricultural sustainability, bolsters food security, and supports the livelihoods of rural communities [59].

Economic Strengths: A critical economic strength in Turkish agriculture is the regional product diversity, which includes products with geographical indications [60]. This diversity is far more than a mere assortment of crops; it plays a significant role in marketing and trade. By showcasing unique regional products, Turkey creates niche markets and adds substantial value to its agricultural sector. This not only fosters economic growth at the local and national levels but also sets Turkish agricultural products apart in a global marketplace.

Social Strengths: The cultural significance of agriculture within Turkish society serves as a remarkable social strength. This cultural attachment goes beyond mere nostalgia for traditional farming practices; it instills a deep appreciation for agriculture and rural life [61]. This cultural underpinning cultivates a strong sense of community support, encourages the preservation of age-old farming traditions, and, importantly, inspires the younger generation to engage in and carry forward the agricultural legacy.

Technological Strengths: Technological advancements in Turkish agriculture are underpinned by the reduction of product and input costs through innovation. This represents a pivotal technological strength, as it not only enhances efficiency in farming practices but also significantly reduces production expenses [14]. The embracing of technology drives the sector's competitiveness, allowing Turkish agriculture to remain at the forefront of sustainable and efficient practices.

Legislative Strengths: Turkey's government exhibits a proactive approach in aligning the country's agricultural policies with those of the European Union, a legislative strength that holds considerable weight [62]. This alignment ensures compliance with international standards, fosters increased trade opportunities, and promotes sustainable agricultural practices that are in line with EU directives.

Environmental Strengths: Turkey boasts a notable environmental strength in the form of diverse climate and geography. This diversity enables the cultivation of an extensive range of crops and agricultural products [63]. Moreover, it provides resilience to climatic fluctuations and supports the year-round production of various goods. This environmental advantage contributes to enhanced food security and export potential, making Turkey a formidable player in the global agricultural arena.

4.1.2. Weaknesses

Political Weaknesses: Political weaknesses in Turkish agriculture include shortcomings in long-term agricultural policies, which have the potential to hinder the sector's strategic planning and adaptability [64]. Additionally, the designation of large plains as agricultural protected areas, while a strength in some contexts, can also be seen as a political weakness if it restricts land use and development opportunities. Inadequate or inconsistent agricultural policies may lead to uncertainties and hinder farmers' abilities to make informed decisions regarding investments and resource allocation, potentially affecting the sector's long-term sustainability.

Economic Weaknesses: Economic instability is a pressing economic weakness faced by Turkish agriculture [65]. Factors such as currency exchange rate fluctuations and inflation can lead to income volatility for farmers, affecting their financial stability and the sector's overall economic resilience [60]. This economic vulnerability can disrupt the ability of farmers to make strategic investments and effectively manage financial risks.

Social Weaknesses: Among the social weaknesses, the lack of interest and awareness among the new generation about agricultural production is a concerning trend. As urbanization and modernization take precedence, the appeal of non-agricultural careers has led to a declining interest in farming among the younger generation [61]. This shift in societal values could lead to a decreasing agricultural workforce, potentially diminishing overall agricultural productivity.

Technological Weaknesses: A notable technological weakness in Turkish agriculture is the sector's struggle to adapt to technological advancements effectively [14]. The inability to fully harness modern agricultural technologies, such as precision farming and data-driven practices, can hinder productivity and risk management. Barriers such as limited access to technology, insufficient education, and financial constraints can lead to inefficiencies in production and overall risk management [11].

Legislative Weaknesses: Land ownership and fragmentation present significant legislative weaknesses [66]. Land parcels fragmented into smaller, less efficient units impede farmers' abilities to optimize land use and invest in modern agricultural equipment, thereby limiting their potential for economies of scale. This fragmentation can lead to decreased agricultural productivity and competitiveness in the long term.

Environmental Weaknesses: The vulnerability of Turkish agriculture to climate change is an environmental weakness of critical concern. Increasingly unpredictable weather patterns, coupled with more frequent droughts and extreme events, have the potential to significantly impact crop yields and livestock production [16,17]. The sector's vulnerability to climate change necessitates the development of adaptation strategies and investments in resilient agricultural practices to mitigate the environmental risks it faces.

4.2. External Factors

External factors in this analysis encapsulate the overarching influences on the Turkish agricultural sector. These factors are examined across six key dimensions: Political, Economic, Social, Technological, Legal, and Environmental.

4.2.1. Opportunities

Political Opportunities: The Turkish agricultural sector stands to benefit from its participation in international treaties, representing a significant political opportunity. These treaties foster international cooperation and trade, offering access to broader markets and potential partnerships [64].

Economic Opportunities: Within the realm of economic opportunities in the Turkish agricultural sector, two crucial prospects come to the forefront [67]. The first opportunity revolves around the continuity of market demand, which highlights the sector's stability and its ability to maintain consistent outlets for agricultural products. The second opportunity stems from the escalating demand for natural products across diverse sectors. This trend capitalizes on the global movement toward natural and sustainable products, offering the sector new pathways for market expansion and value enhancement, particularly within the realm of export markets.

Social Opportunities: Consumer behavior tendencies and habits present social opportunities for the Turkish agricultural sector. As consumer preferences evolve toward healthier, locally sourced, sustainably produced goods, the sector can cater to these demands [12]. This evolution includes a growing interest in products with geographical indications (GIs), which highlight the unique qualities and origins of certain regional agricultural products. By aligning with this trend and offering GI products, the sector can forge a stronger connection with consumers and access new market segments, capitalizing on the appeal of authentic and regionally distinctive agricultural items.

Technological Opportunities: Technological integration in the form of transparent value chains and data-driven decision-making presents technological opportunities. Transparent value chains, enabled by technology, enhance accountability and traceability, ensuring product quality and safety [11]. Data-driven decision-making boosts production efficiency, allowing the sector to optimize processes, reduce waste, and enhance overall productivity.

Legislative Opportunities: The harmonization of Turkish agricultural standards with EU standards represents a legislative opportunity. This alignment not only facilitates trade but also ensures compliance with international quality and safety standards [68].

Environmental Opportunities: The use of renewable energy sources presents an economic opportunity for the Turkish agricultural sector. As renewable energy technologies continue to advance, they offer a sustainable and cost-effective means to power agricultural operations, reducing both operational expenses and environmental impact [69].

4.2.2. Threats

Political Threats: War and political uncertainties represent critical political threats to the Turkish agricultural sector. These uncertainties can lead to disruptions in trade, market instability, and potential challenges in accessing essential resources [66]. Political instability can hinder the sector's ability to make long-term plans and investments, posing a significant risk to its resilience and sustainability.

Economic Threats: Two noteworthy economic threats include rapid urbanization and income volatility due to the increase in extreme weather events. Rapid urbanization can result in the encroachment of urban areas on agricultural land, potentially limiting the availability of arable land and creating land-use conflicts. Income volatility caused by extreme weather events, such as droughts or floods, can disrupt agricultural production, impacting the financial stability of farmers and the sector as a whole [67].

Social Threats: Food security is a vital social threat to the Turkish agricultural sector. Ensuring a consistent and sufficient food supply to meet the needs of the growing population is a complex challenge. Any disruptions in food production, distribution, or access can jeopardize the well-being of the population, highlighting the need for resilience in the agricultural sector [61].

Technological Threats: The Turkish agricultural sector faces technological threats related to cybersecurity risks and dependency on technology and data. Cybersecurity vulnerabilities can compromise the integrity and security of critical digital systems, potentially disrupting agricultural operations [21]. Overreliance on technology and data without sufficient safeguards can lead to data breaches, financial losses, and operational disruptions.

Legislative Threats: Climate regulations pose a critical legislative threat to the Turkish agricultural sector. Evolving climate-related regulations may require the sector to comply with new standards and sustainability practices. These regulations can impose additional costs and administrative burdens, potentially affecting the sector's operations, compliance, and competitiveness [64].

Environmental Threats: Environmental threats, such as climate change and pollution, pose risks to agricultural production [15]. Climate change can alter weather patterns and precipitation, leading to more extreme events. Environmental pollution, including soil and water contamination, threatens land fertility and water resources, compromising agricultural sustainability and product quality. Addressing these challenges requires adaptive strategies and sustainable agricultural practices to enhance resilience in the face of environmental changes [15].

Figure 2 provides a comprehensive summary of the structured SWOT/PESTLE analysis and the identified factors. These factors will serve as essential components in the 2TL-DEMATEL methodology, where they will undergo a weighting process and in-depth causal analysis.

PESTLE/SWOT	Internal	
	Strenghts	**Weaknesses**
Political	**SP1** Strong ties with international organizations and the obligation to comply with international agreements, especially the European Union. **SP2** Designation of large plains as agricultural protected areas.	**PW1** Shortcomings in long-term agricultural policies.
Economical	**EcS1** Regional product diversity, including products with geographical indications, is also significant for marketing purposes.	**EcW1** Economical instability.
Social	**SS1** Cultural significance of agriculture.	**SW1** Lack of interest and awareness among the new generation about agriculture production. **SW2** The decrease in the elderly farmer population and the difficulty in accessing traditional knowledge due to migration.
Technological	**TS1** Reduction of product/input costs through technology.	**TW1** Weakness in adapting to technological advancements and effectively utilizing technology for risk and production management.
Legislative	**LS1** The government's efforts to align Turkish agricultural policies with EU agricultural policies.	**LW1** Land ownership and fragmentation.
Environmental	**ES1** Diverse climate and geograpghy.	**EW1** Vulnerability to climate change.
PESTLE/SWOT	**External**	
	Opportunities	**Threats**
Political	**PO1** Being subject to international treaties.	**PT1** War and political uncertainties.
Economical	**EcO1** Continuity of market demand. **EcO2** Increasing demand for natural products in different sectors.	**EcT1** Rapid urbanization. **EcT2** Income volatility due to increase in extreme weather events.
Social	**SO1** Consumer behavior tendencies and habits.	**ST1** Food security.
Technological	**TO1** Transparent value chains with technological integration. **TO2** Data-driven decision-making for production efficiency.	**TT1** Cybersecurity risks. **TT2** Dependency on technology and data.
Legislative	**LO1** Harmonization with EU Standards.	**LT1** Climate regulations.
Environmental	**EO1** Opportunities for the use of renewable energy.	**ET1** Climate change and environmental pollution.

Figure 2. SWOT/PESTLE analysis factors for Turkish agriculture.

5. SWOT/PESTLE Factor Assessment and Weighting with 2TL-DEMATEL

In this section, we will employ the 2TL-DEMATEL methodology to analyze the identified SWOT/PESTLE factors.

Step 0. Groundwork.

To ensure a comprehensive assessment, we have assembled a decision-making team comprising five experts (DMs) with substantial experience in the agricultural sector. These experts possess diverse backgrounds, specializing in various facets of the agricultural ecosystem, including agri-food supply chain management agricultural production, technological farming, sustainability consultancy for the agri-food sector, and academia. Given their multifaceted expertise, different weights have been assigned to each expert within the 2TL-DEMATEL framework. Their details are provided in the following Table 2.

Table 2. DM's background.

DM1	An academic who works on the use of smart technologies (mostly in supply chains).
DM2	A Ph.D. consultant about digital transformation.
DM3	A manager from an international company that produces smart technology.
DM4	An academician who works on sustainable and smart agriculture.
DM5	A consultant whose expertise is the digital transformation in agriculture.

Step 1. Creating the average matrix (A).

In this phase, individual meetings are arranged with experts, each conducted separately. The identified SWOT/PESTLE factors are presented to the expert group, who are then tasked with evaluating these factors through pairwise comparisons, using the provided linguistic sets. The weighting of their assessments is determined by their experience in the field, measured in working years. Experts with more extensive experience are accorded higher weights, while a finer-grained linguistic set is employed for their assessments. Conversely, experts with less experience are presented with a coarser linguistic set to better capture their perspectives. The following Table 3 presents the linguistic sets provided to the DMs. These linguistic sets play a pivotal role in the DEMATEL application, where they serve as the basis for assessing the relative importance of each factor in relation to every other factor. The weightings for the DM group are given in order:

$$w_n = \{(0.27, 0.21, 0.25, 0.17, 0.10)\}$$

where n represents the number of experts, n = 1, 2, 3, 4, 5.

Table 3. Five and nine scaled linguistic sets provided to the DMs.

2TL Linguistic Sets	
S^5	None (N); Low (L); Equal (E); High (H); Perfect (P)
S^9	None (N); Low (L); Medium Low (ML); Almost Equal (AE); Equal (E); Almost High (AH); High (H); Very High (VH); Perfect (P)

The ultimate aggregated matrix in 2TL beta values is given in Table 4. The assessments of DM1 and DM4 are provided in Appendix A as an example of the assessments for the readers.

Step 2. Calculating the initial direct influence matrix (D).

The D matrix is obtained by applying Equation (3).

Step 3. Calculating the total direct/indirect influence matrix (T).

This matrix is calculated by using Equation (4). In the T matrix, D and R values can be derived to determine the direct/indirect relationships between criteria. As a result, these values are obtained by using Equation (5).

Step 4. Analyzing the cause-and-effect diagrams.

In this step, influence diagrams are obtained (see Figure 3) to investigate the cause–effect relations between the criteria.

Table 4. Final aggregated average matrix with 2TL beta values.

	SP1	SP2	EcS1	SS1	TS1	LS1	ES1	PW1	EcW1	SW1	SW2	TW1	LW1	EW1	PO1	EcO1	EcO2	SO1	TO1	TO2	LO1	EO1	PT1	EcT1	EcT2	ST1	TT1	TT2	LT1	ET1
SP1	0.00	2.00	3.39	6.00	5.39	4.00	5.39	6.00	2.00	2.00	3.39	3.39	4.00	2.00	4.00	5.39	5.39	6.00	5.39	6.00	4.00	6.00	2.00	2.00	2.00	1.39	5.39	5.39	4.00	3.39
SP2	5.39	0.00	2.00	2.00	3.39	5.39	2.00	2.00	6.00	2.00	2.00	2.00	5.39	4.00	5.39	5.39	5.39	5.39	3.39	3.39	5.39	5.39	6.00	2.00	6.00	3.39	3.39	3.39	5.39	5.39
EcS1	6.00	6.61	0.00	3.39	4.00	6.00	3.39	5.39	6.00	2.00	2.00	2.00	6.00	5.39	6.00	6.00	5.39	5.39	4.00	4.00	6.00	6.00	6.00	2.00	6.00	3.39	4.00	4.00	6.00	6.00
SS1	5.39	6.00	3.39	0.00	2.00	5.39	2.00	3.39	5.39	2.00	2.00	3.39	5.39	2.00	5.39	5.39	5.39	5.39	2.00	2.00	5.39	6.00	5.39	2.00	5.39	3.39	2.00	2.00	5.39	5.39
TS1	2.00	5.39	6.61	5.39	0.00	2.00	6.00	6.00	2.00	3.39	3.39	4.00	2.00	5.39	2.00	2.00	6.00	6.00	6.00	6.00	2.00	6.61	2.00	5.39	2.00	5.39	4.00	4.00	2.00	2.00
LS1	4.00	4.00	4.00	3.39	2.00	0.00	2.00	5.39	2.00	3.39	3.39	2.00	4.00	2.00	4.00	4.00	6.00	6.00	2.00	2.00	0.00	6.00	2.00	2.00	2.00	2.00	2.00	2.00	4.00	4.00
ES1	3.39	6.00	4.00	6.00	2.00	3.39	0.00	5.39	5.39	2.00	2.00	2.00	3.39	4.00	3.39	3.39	5.39	5.39	2.00	2.00	3.39	4.00	5.39	2.00	5.39	2.00	2.00	2.00	3.39	3.39
PW1	3.39	6.00	3.39	5.39	2.00	3.39	2.00	0.00	5.39	2.00	2.00	2.00	3.39	5.39	3.39	3.39	5.39	5.39	2.00	2.00	3.39	2.00	5.39	2.00	5.39	1.39	2.00	2.00	3.39	3.39
EcW1	6.61	8.00	2.00	4.00	3.39	6.61	3.39	6.00	0.00	2.00	2.00	3.39	6.61	2.00	6.61	6.61	5.39	5.39	3.39	3.39	6.61	3.39	4.00	2.00	3.39	2.00	3.39	3.39	6.61	6.61
SW1	6.61	6.61	6.61	6.61	6.00	6.61	6.00	6.61	6.00	0.00	6.00	2.00	6.61	6.00	6.61	6.61	5.39	5.39	6.00	6.00	6.61	5.39	6.00	2.00	6.00	4.00	6.00	6.00	6.61	6.61
SW2	6.00	8.00	8.00	6.61	6.00	6.00	6.61	6.61	6.00	4.00	0.00	2.00	6.00	6.00	6.00	6.00	5.39	5.39	6.00	6.00	6.00	5.39	6.00	2.00	6.00	4.00	6.00	6.00	6.00	6.00
TW1	6.00	5.39	3.39	6.00	6.61	6.00	6.00	6.61	6.00	5.39	5.39	0.00	6.00	6.00	6.00	6.00	5.39	5.39	6.61	6.61	6.00	6.00	6.00	2.00	6.00	4.00	6.61	6.61	6.00	6.00
LW1	4.00	4.00	2.00	3.39	2.00	4.00	2.00	3.39	3.39	2.00	2.00	2.00	0.00	4.00	4.00	4.00	5.39	5.39	2.00	2.00	4.00	2.00	3.39	2.00	3.39	3.39	2.00	2.00	4.00	4.00
EW1	6.00	6.61	6.00	6.00	6.00	6.00	6.61	6.00	4.00	2.00	2.00	2.00	6.00	0.00	6.00	6.00	5.39	5.39	6.00	6.00	6.00	5.39	4.00	2.00	4.00	4.00	6.00	6.00	6.00	6.00
PO1	5.39	3.39	3.39	4.00	2.00	5.39	2.00	6.00	2.00	3.39	3.39	2.00	5.39	2.00	0.00	5.39	5.39	5.39	2.00	2.00	5.39	6.00	2.00	2.00	2.00	2.00	2.00	2.00	5.39	5.39
EcO1	2.00	5.39	6.00	3.39	2.00	2.00	2.00	3.39	2.00	2.00	2.00	2.00	2.00	2.00	2.00	0.00	5.39	5.39	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
EcO2	2.00	5.39	6.00	3.39	2.00	2.00	3.39	3.39	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	0.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
SO1	3.39	5.39	3.39	3.39	2.00	3.39	2.00	3.39	1.39	2.00	2.00	2.00	3.39	3.39	3.39	3.39	5.39	0.00	2.00	2.00	3.39	2.00	1.39	2.00	1.39	2.00	2.00	2.00	3.39	3.39
TO1	3.39	6.00	6.00	6.00	5.39	3.39	5.39	6.00	5.39	2.00	2.00	5.39	3.39	5.39	3.39	3.39	5.39	5.39	0.00	5.39	3.39	6.00	5.39	2.00	5.39	5.39	5.39	5.39	3.39	3.39
TO2	2.00	6.61	6.00	6.61	5.39	2.00	5.39	6.00	6.00	2.00	2.00	5.39	2.00	5.39	2.00	2.00	3.39	3.39	5.39	0.00	2.00	6.00	6.00	2.00	6.00	6.00	5.39	5.39	2.00	2.00
LO1	2.00	4.00	4.00	4.00	4.00	2.00	2.00	6.00	2.00	2.00	3.39	2.00	2.00	2.00	2.00	2.00	5.39	5.39	4.00	3.39	0.00	6.00	2.00	2.00	2.00	5.39	4.00	4.00	2.00	2.00
EO1	2.00	5.39	5.39	5.39	4.00	2.00	5.39	5.39	3.39	3.39	3.39	2.00	2.00	3.39	2.00	2.00	5.39	5.39	4.00	3.39	2.00	0.00	3.39	2.00	3.39	2.00	4.00	4.00	2.00	2.00
PT1	6.00	2.00	2.00	5.39	2.00	6.00	2.00	2.00	4.00	2.00	2.00	2.00	6.00	2.00	6.00	6.00	5.39	5.39	2.00	2.00	6.00	2.00	0.00	2.00	4.00	2.00	2.00	2.00	6.00	6.00
EcT1	6.00	6.61	8.00	8.00	6.00	6.00	6.00	6.61	6.00	5.39	6.00	6.00	6.00	6.00	6.00	6.00	5.39	5.39	6.00	6.00	6.00	6.61	6.00	0.00	6.00	4.00	6.00	6.00	6.00	6.00
EcT2	6.00	5.39	6.00	6.00	3.39	6.00	3.39	3.39	4.00	3.39	3.39	2.00	6.00	3.39	6.00	6.00	5.39	5.39	3.39	3.39	6.00	2.00	4.00	2.00	0.00	2.00	3.39	3.39	6.00	6.00
ST1	6.61	8.00	6.61	6.61	4.00	6.61	6.00	6.61	6.61	6.00	6.61	6.61	6.61	6.61	6.61	6.61	8.00	8.00	4.00	5.39	6.61	2.00	6.61	2.00	6.61	0.00	4.00	4.00	6.61	6.61
TT1	6.00	5.39	4.00	5.39	4.00	6.00	6.00	5.39	6.00	6.00	6.00	5.39	6.00	5.39	6.00	6.00	6.61	6.61	4.00	4.00	6.00	6.61	6.00	4.00	6.00	3.39	0.00	4.00	6.00	6.00
TT2	3.39	2.00	6.00	4.00	4.00	3.39	5.39	6.00	6.00	6.00	6.61	5.39	3.39	6.00	3.39	3.39	6.00	6.00	4.00	4.00	3.39	6.00	6.00	4.00	6.00	5.39	4.00	0.00	3.39	3.39
LT1	4.00	3.39	5.39	5.39	2.00	4.00	4.00	2.00	2.00	2.00	2.00	2.00	4.00	4.00	4.00	4.00	5.39	5.39	2.00	2.00	4.00	3.39	2.00	2.00	2.00	2.00	2.00	2.00	0.00	6.00
ET1	6.00	6.00	6.61	6.00	6.00	6.00	5.39	2.00	2.00	2.00	2.00	2.00	6.00	4.00	6.00	6.00	5.39	5.39	6.00	6.00	6.00	3.39	2.00	6.00	2.00	3.39	6.00	6.00	6.00	0.00

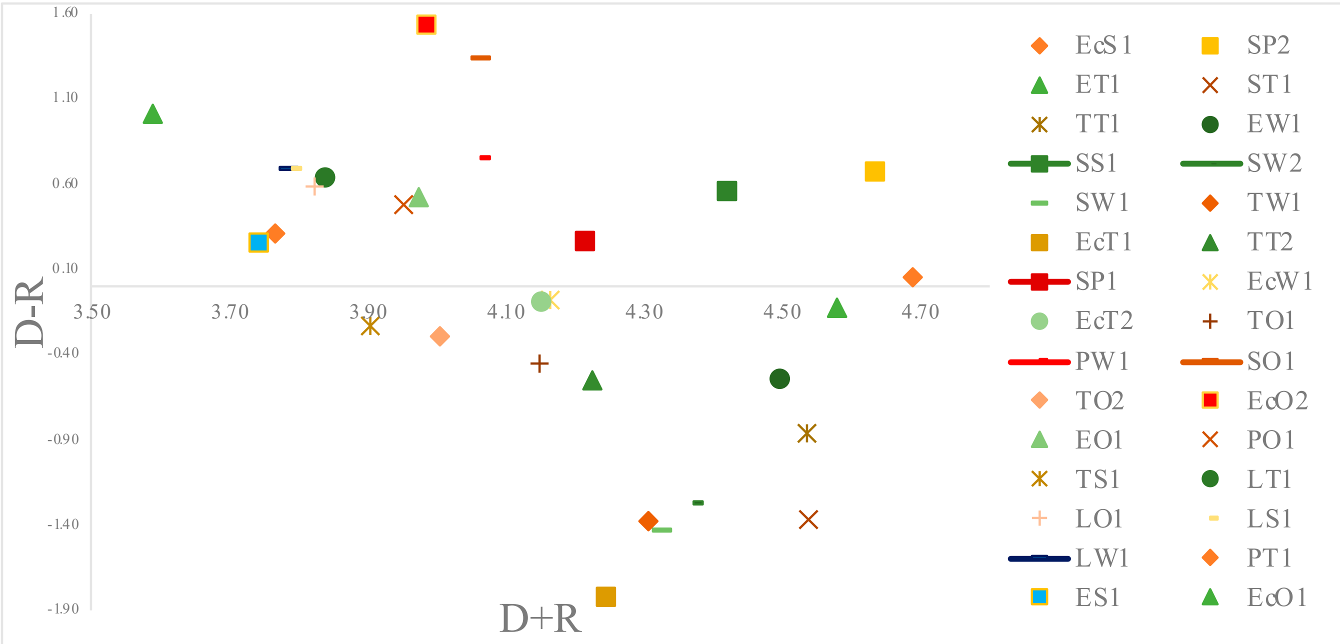

Figure 3. The 2TL-DEMATEL results for the SWOT/PESTLE factors for Turkish agriculture.

5.1. SWOT/PESTLE Factor Assessment and Weighting Results

In the SWOT/PESTLE 2TL-DEMATEL methodology, we turn our attention to the assessment of the 2TL-DEMATEL results, emphasizing factors' prominence and their cause-and-effect relationships. By following the prescribed 2TL-DEMATEL steps and drawing from the evaluations of five field experts (DMs), we arrive at Table 5. In this context, the prominence value is a composite measure of both the causal influence (D) and the overall effect influence (R), computed in accordance with Equation (5). A factor boasting a high prominence value signifies its significance in influencing other factors, while also being subject to influence from other factors, as elaborated by [70].

The ($D + R$) value delineates the 'prominence' or 'importance degree' of each factor. A higher ($D + R$) value underscores the factor's pronounced impact and its interplay with other factors. Conversely, ($D - R$) values are classified into two groups: the effect group and the cause group. Positive ($D - R$) values pertain to the cause group, signifying independence, while negative ($D - R$) values belong to the effect group, implying their susceptibility to the influence of causal group values. Within this context, Figure 3 is a visual representation, illustrating the cause-and-effect relationships among SWOT/PESTLE factors.

In our analysis of the Turkish agricultural sector, we have identified and ranked the most prominent factors that warrant close attention and strategic consideration. Topping the list of these crucial factors is "Food Security" (ST1). The significance of food security cannot be overstated, as it stands as the foremost priority for the sector [16,71]. The stability and adequacy of food supply are of paramount importance, particularly in a rapidly evolving global landscape [24]. Ensuring food security within the Turkish agricultural context is both an obligation and a strategic imperative.

Following closely is "Regional Product Diversity" (EcS1), a factor that emphasizes the value of leveraging the region's product diversity, especially those with geographical indications. This diversity offers not only marketing advantages but also signifies the potential for value addition and market expansion, underlining the need to capitalize on unique regional products to enhance the sector's competitiveness [72].

Table 5. ($D + R$) and ($D - R$) values for SWOT/PESTLE factors.

Factors	$D + R$	$D - R$	Cause or Effect	Rank ($D + R$)	Rank ($D - R$)
SP1	4.22	0.27	Cause	15	14
SP2	4.64	0.68	Cause	3	7
EcS1	4.69	0.06	Cause	2	16
SS1	4.42	0.56	Cause	11	10
TS1	3.9	−0.22	Effect	23	20
LS1	3.79	0.69	Cause	26	6
ES1	3.74	0.26	Cause	29	15
PW1	4.06	0.76	Cause	19	4
EcW1	4.16	−0.08	Effect	17	17
SW1	4.33	−1.43	Effect	7	29
SW2	4.37	−1.27	Effect	8	26
TW1	4.31	−1.37	Effect	10	28
LW1	3.79	0.7	Cause	27	5
EW1	4.5	−0.54	Effect	9	23
PO1	3.95	0.48	Cause	22	12
EcO1	3.59	1.02	Cause	30	3
EcO2	3.98	1.54	Cause	13	1
SO1	4.06	1.35	Cause	12	2
TO1	4.15	−0.45	Effect	16	22
TO2	4.01	−0.29	Effect	20	21
LO1	3.82	0.59	Cause	25	9
EO1	3.97	0.53	Cause	21	11
PT1	3.77	0.32	Cause	28	13
EcT1	4.25	−1.82	Effect	5	30
EcT2	4.15	−0.09	Effect	18	18
ST1	4.54	−1.37	Effect	1	27
TT1	4.54	−0.86	Effect	4	25
TT2	4.23	−0.55	Effect	14	24
LT1	3.84	0.64	Cause	24	8
ET1	4.58	−0.12	Effect	6	19

In the third spot, "Designation of Large Plains as Agricultural Protected Areas" (SP2) reflects the importance of preserving and safeguarding fertile agricultural land [66]. Designating large plains as protected areas underscores the critical role these areas play in the sustainability of agricultural practices. It serves as a pivotal step in ensuring the longevity of productive agricultural ecosystems.

Ranked fourth is "Cybersecurity Risks" (TT1), a factor that underscores the sector's susceptibility to digital threats [73]. With the increasing dependence on technology and data, addressing cybersecurity risks is imperative to secure the integrity of agricultural operations, data, and technological infrastructure.

Finally, "Rapid Urbanization" (EcT1) holds the fifth position, signifying the encroachment of urban development on agricultural land. Balancing the demands of urbanization with the preservation of fertile agricultural land is a critical challenge for the sector. It necessitates thoughtful urban planning and agricultural preservation to ensure sustainable growth and maintain the sector's productivity [74].

A comparative analysis of the ($D + R$) and ($D - R$) ranking reveals that Threats carry a notably high importance, deemed critical for strategy development. However, Opportunities, due to their causal characteristics, can potentially have an even more profound impact on strategy formulation. Among these factors, the top five ranked elements—EcO2, SO1, EcO1, PW1, and LW1—stand out as pivotal determinants with a substantial impact on the overall factor landscape. The profound influence they exert on other factors is indicative of their critical nature in strategic planning.

Notably, within this context, “Increasing demand for natural products in different sectors” (EcO2) emerges as the utmost influential factor in the cause group. With the highest $(D - R)$ value, this indicates its paramount role in the effective transition of Turkish agriculture. Furthermore, this factor boasts the highest D value among others, indicating its significant impact on guiding the strategic shift of the agricultural sector. This underscores the pivotal role of increased demand for natural products in propelling the Turkish agriculture sector toward SA.

Considering the remaining factors, “Consumer behavior tendencies and habits” (SO1) plays a vital role in shaping strategies, reflecting the influence of consumer preferences toward healthier, locally sourced, and sustainable goods. The factor “Continuity of market demand” (EcO1) signifies a persistent market requirement for agricultural products, providing a stable base for strategic planning. Addressing the “Shortcomings in long-term agricultural policies” (PW1) is essential to ensure the sector’s resilience and adaptability, while mitigating “Land ownership and fragmentation” (LW1) issues is imperative to bolster the efficiency of the agricultural landscape [66].

5.2. Strategy Generation Based on SWOT/PESTLE Analysis for Turkish Agriculture

The application of the 2TL-DEMATEL method has been instrumental in categorizing SWOT/PESTLE factors into distinct cause and effect groups. Building on the preceding discussions, it is within the cause group that we find the factors that will inform the formulation of pertinent strategies [7]. These cause factors will serve as the foundation for deriving multiple strategies. These strategies, informed by the relevant literature, will subsequently undergo validation and refinement through the expertise of field experts engaged in the SWOT/PESTLE analysis process. The ranking of the cause factors based on their prominence and $(D - R)$ values are as follows, respectively: (prominence ranking of causal group) EcS1 > SP2 > SS1 > PW1 > SO1 > EcO2 >EO1 >PO1 > LT1 > LO1 > LS1 > LW1 > PT1> ES1, ($(D - R)$ ranking for causal group) EcO2 > SO1 > ECO1 > PW1 > LW1 > LS1 > SP2 > LT1 > LO1 > SS1 > EO1 > PO1 > PT1 > ES1.

When generating strategies based on the provided information, it is advisable to prioritize factors with a combination of high prominence values and substantial $(D - R)$ values, as they not only hold importance but also exert a strong influence on other factors [7]. In this context, “EcS1” (Regional product diversity, including products with geographical indications, is also significant for marketing purposes) stands out as the top-ranked factor in terms of prominence, while “EcO2” (Increasing demand for natural products in different sectors.) holds the highest $(D - R)$ ranking. Therefore, it is recommended to consider “EcS1” and “EcO2” as primary factors when formulating strategies, given their dual significance and potent impact on the overall factor landscape. These factors are pivotal for guiding the strategic decision-making process and warrant close attention in strategy development. The prominence of “EcS1” underscores the critical need for the sector to proactively address economical strengths, particularly in the face of climate change and environmental pollution [75]. The standing of “EcO2” highlights the sector’s economic opportunity, signaling the importance of bolstering economic resilience [19]. The synthesis of these two factors within our strategy formulation becomes apparent as we strive to navigate the complex interplay between environmental sustainability and economic stability. When considering the specific factors “EcS1” and “EcO2”, corresponding strategies should be adapted to directly address these concerns. The strategies are grouped under eight main dimensions and the relevant strategies derived from the literature are listed under them (see Table 6). These are tailored to address the specific challenges posed by the environmental and mostly economic factors “EcS1” and “EcO2”, ensuring that the transition to SA in Turkey aligns with the dual goals of environmental sustainability and economic stability.

Table 6. Strategies for Turkey's agricultural transition to SA based on the SWOT/PESTLE analysis.

Dimensions	Strategies
Environmetal Resilience and Sustainability [76,77]	Promote environmentally friendly agriculture, reducing pollution, and adopting sustainable land-use practices. Invest in renewable energy sources for farming operations to reduce environmental impact.
Economic Stability and Resilience [20,22]	Develop risk management strategies to buffer against economic instability, including crop insurance and income diversification. Facilitate access to affordable credit and financing for farmers to enhance economic stability.
Market Diversification [18,78]	Leverage regional product diversity and continuity of market demand to target niche markets that value environmentally sustainable and locally sourced product. Focus on value-added products, such as organic or sustainably produced goods, to cater to markets with a preference for environmentally responsible products.
Sustainable Technologies [10]	Embrace technology solutions that promote both environmental sustainability and economic efficiency. For example, precision agriculture techniques can optimize resource use while increasing yields. Invest in technology for monitoring and reducing environmental impact, such as soil sensors and climate monitoring tools.
Policy Alignment [22,68]	Collaborate with government agencies and institutions to ensure policies align with the sector's dual needs for ecological and economic resilience.
Sustainable Land-Use Planning [22]	Collaborate on land tenure reforms and conservation programs that reduce fragmentation and promote efficient land use.
Cybersecurity Preparedness [79]	Implement robust cybersecurity measures to protect digital agricultural systems, which are critical for both environmental and economic aspects. Develop incident response plans and provide cybersecurity training to safeguard agricultural data and operations.
Sustainable Innovation [23,80]	Encourage research and innovation focused on environmentally friendly practices and technologies. Invest in the development of innovative, sustainable agricultural practices that mitigate environmental threats and support economic resilience.

6. Discussions for SWOT/PESTLE-2TL-DEMATEL

In the journey toward SSA, our framework draws a clear distinction between the dimensions derived from the existing literature and the strategies meticulously generated and validated in collaboration with field experts. They emphasize the critical need to attain recent studies' focal points, which include environmental resilience and sustainability, economic stability and resilience, market diversification, the adoption of sustainable technologies, policy alignment, sustainable land-use planning, cybersecurity preparedness, and sustainable innovation [10,22,23].

6.1. Assessment from the Perspectives of RQs

As we delve into the strategies gleaned from the literature, it becomes evident that these insights not only contribute to the discourse on sustainable and resilient agricultural practices but also intricately address the RQs offered at the outset of our study.

RQ1: Maximizing the Benefits of SA.

In pursuit of maximizing the benefits of SA in Turkey, our study advocates a multifaceted approach. Strategies centered on promoting environmentally friendly agricultural practices and investing in renewable energy sources are poised to fortify Turkey's commitment to environmental resilience [23,76]. Simultaneously, initiatives addressing economic stability, such as risk management strategies and enhanced access to credit, are poised to augment economic robustness within the agricultural sector. Moreover, market diversification strategies, capitalizing on regional product diversity, and prioritizing value-added goods, emerge as pivotal pathways to harness economic and social strengths, positioning Turkey strategically in the global agricultural landscape [22,77].

RQ2: Mitigating Weaknesses and Threats in SA.

Collaborative efforts with governmental bodies ensure policy alignment, addressing weaknesses and positioning with political and legal dimensions [10]. Initiatives related to sustainable land-use planning, achieved through cooperative land reforms and conservation programs, target environmental weaknesses. Furthermore, cybersecurity preparedness, encompassing robust measures and incident response plans, appears as a key deterrent against technological threats, concurrently addressing the legal and economic dimensions from the PESTLE analysis [23,79].

RQ3 and RQ4: Enhancing Robust Strategies with 2TL-DEMATEL.

In response to the imperative of generating robust strategies for Turkey's SA transition, our study employs the innovative 2TL-DEMATEL approach. Through this methodology, we discern the intricate weights of SWOT/PESTLE factors, unraveling their nuanced interrelationships with the application of linguistic variables. This holistic integration of SWOT, PESTLE, and 2TL-DEMATEL methodologies is poised to streamline the strategy formulation process, propelling Turkey toward a resilient and sustainable future in SA.

This study, dedicated to sustainable agriculture in Turkey, aligns with the UN's SDGs, making significant contributions. The identified strategies, emphasizing environmental resilience, economic stability, and innovation in precision agriculture, directly address SDGs 13 (Climate Action), 15 (Life on Land), 8 (Decent Work and Economic Growth), and 9 (Industry, Innovation, and Infrastructure). Market diversification and consumer-centric approaches align with SDG 12 (Responsible Consumption and Production). These strategies provide a holistic approach to address challenges in Turkish agriculture, contributing to the global agenda for sustainable development [25].

6.2. Comparative Analysis

MCDM encompasses a range of methodologies designed to assist in evaluating and selecting the most suitable option among a set of alternatives, considering multiple and often conflicting criteria [43]. Among these methodologies, DEMATEL and the Best–Worst Method (BWM) have gained prominence due to their distinct strengths and applicability to a wide spectrum of decision-making scenarios [81].

DEMATEL and BWM are both well-established methods for criteria weighting, making them suitable choices for a comparative analysis to evaluate their effectiveness in prioritizing criteria for a decision-making problem related to SWOT/PESTLE factor assessment [82]. The overarching objective is to identify the relative importance of various criteria and gain insights into the underlying relationships among them. By employing both DEMATEL and BWM, we aim to provide a comprehensive evaluation of the criteria's significance and enhance the robustness of the decision-making process.

While both DEMATEL and BWM are well-established criteria weighting methods, BWM also offers the advantage of computational simplicity and ease of implementation. This characteristic makes it an attractive choice for practitioners and researchers. Despite its computational ease, BWM does not compromise on robustness and can effectively handle complex decision-making problems. BWM has demonstrated its effectiveness in a wide range of applications, including environmental management, business strategy, and social policy formulation. The comparative analysis results are given in Figure 4.

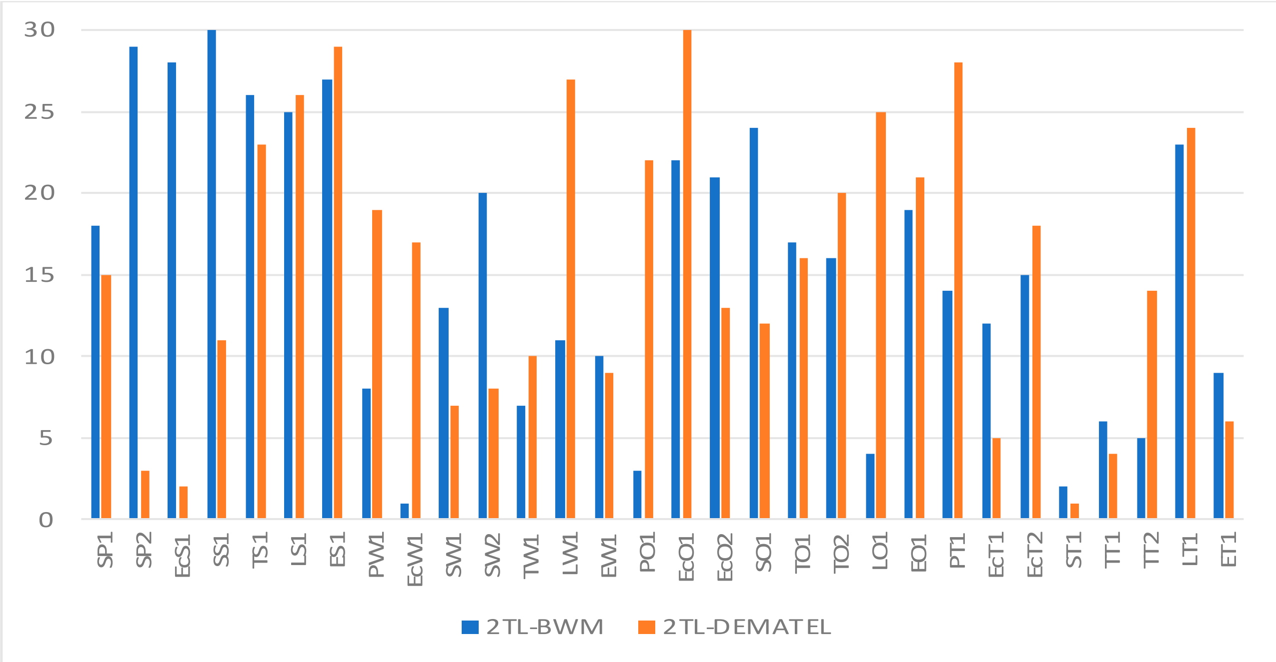

Figure 4. Comparative analysis of SWOT/PESTLE factor assessment.

The comparative analysis of DEMATEL and BWM highlights the dynamic relationship between "Food Security (ST1)" and "Economic Instability (EcW1)" in the context of SA transition.

DEMATEL's consideration of direct and indirect relationships among criteria positions "ST1" at the forefront, emphasizing its fundamental influence on the overall system. This aligns with the widely recognized importance of food security as a cornerstone of human well-being and a prerequisite for sustainable development [25,59,71]. However, BWM's focus on pairwise comparisons, capturing relative importance between criteria, brings "EcW1" to the forefront. This suggests that addressing "EcW1", particularly in volatile or developing contexts, can create a conducive environment for SA practices to flourish [22,25,60].

In essence, the synthesis of DEMATEL and BWM results highlights the interdependent nature of food security and economic instability. While food security remains a fundamental objective, addressing economic instability is crucial for enabling the successful transition to smart agriculture [25]. Strategies must encompass both dimensions to ensure sustainable and equitable outcomes as in Table 6.

7. Conclusions

Central to the primary objectives of this article is the development of an advanced and holistic strategic framework for the Turkish agricultural sector, designed to facilitate its transition to SA. This research advances the quality of decision-making within the agricultural sector by embracing the linguistic-based approach, and complemented by DEMATEL's causal insights, the strategic decision-making process becomes more precise and data-driven. Crucially, the proposed methodology transcends academic realms, offering a practical and adaptable approach for real-world applications. Policymakers, agricultural practitioners, and researchers can readily utilize this framework to formulate effective strategies for SA, thereby fostering economic growth and sectoral resilience.

However, it is crucial to acknowledge the limitations inherent in this study. The assessments, while rooted in the insights of experienced experts, are fundamentally based on subjective evaluations. The strategies proposed, synthesized from SWOT/PESTLE analyses and a comprehensive literature review, are the product of the authors' expertise and creativity, albeit substantiated and approved by experts in the field. Recognizing these limitations underscores the need for ongoing research endeavors, ensuring a continual evolution toward more robust, evidence-based strategies that can navigate the complexities of Turkey's SA landscape.

The DEMATEL method is notably distinguished in the scholarly discourse for its capacity to elucidate causal relationships. Given this inherent quality, its adoption in this article is deliberate. However, the absence of a comparative result analysis represents a limitation in the study, as there lacks a method possessing comparable efficiency to benchmark against the similar criterion structure. While this might be construed as a limitation, it is imperative to underscore that the literature review diligently substantiates the appropriateness and validation of the DEMATEL method. This is evidenced through a meticulous examination of relevant references, notwithstanding the method's prevalent usage in the existing body of literature.

Future directions may see the integration of advanced MCDM methods for further refinement in strategy prioritization, amplifying the efficacy of the agricultural sector's transition to SA. Such advancements hold the promise of fortifying not only Turkey's agricultural landscape but also contributing to global benchmarks in food security, economic stability, and environmental sustainability.

Author Contributions: D.U.: conceptualization, methodology, formal analysis, investigation, writing—original draft. G.B.: conceptualization, methodology, resources, investigation, writing—review and editing, project administration, funding acquisition. All authors have read and agreed to the published version of the manuscript.

Funding: This work has been supported by the Scientific Research Projects Commission of Galatasaray University under grant number FOA-2023-1181.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.

Acknowledgments: The authors would like to thank the experts for their helpful guidance and continued support.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. DM1's assessment for 2TL-DEMATEL.

	SP1	SP2	EcS1	SS1	TS1	LS1	ES1	PW1	EcW1	SW1	SW2	TW1	LW1	EW1	PO1	EcO1	EcO2	SO1	TO1	TO2	LO1	EO1	PT1	EcT1	EcT2	ST1	TT1	TT2	LT1	ET1
SP1	0	ML	AE	H	AH	E	AH	H	ML	ML	AE	AE	E	ML	E	AH	AH	H	AH	H	E	H	ML	ML	ML	L	AH	AH	E	AE
SP2	AH	0	ML	ML	AE	AH	ML	ML	H	ML	ML	ML	AH	E	AH	AH	AH	AH	AE	AE	AH	AH	H	ML	H	AE	AE	AE	AH	AH
EcS1	H	VH	0	AE	E	H	AE	AH	H	ML	ML	ML	H	AH	H	H	AH	AH	E	E	H	H	H	ML	H	AE	E	E	H	H
SS1	AH	H	AE	0	ML	AH	ML	AE	AH	ML	ML	AE	AH	ML	AH	AH	AH	AH	ML	ML	AH	H	AH	ML	AH	AE	ML	ML	AH	AH
TS1	ML	AH	VH	AH	0	ML	H	H	ML	AE	AE	E	ML	AH	ML	ML	H	H	H	H	ML	VH	ML	AH	ML	AH	E	E	ML	ML
LS1	E	E	E	AE	ML	0	ML	AH	ML	AE	AE	ML	E	ML	E	E	H	H	ML	ML	0	H	ML	ML	ML	ML	ML	ML	E	E
ES1	AE	H	E	H	ML	AE	0	AH	AH	ML	ML	ML	AE	E	AE	AE	AH	AH	ML	ML	AE	E	AH	ML	AH	ML	ML	ML	AE	AE
PW1	AE	H	AE	AH	ML	AE	ML	0	AH	ML	ML	ML	AE	AH	AE	AE	AH	AH	ML	ML	AE	ML	AH	ML	AH	L	ML	ML	AE	AE
EcW1	VH	P	ML	E	AE	VH	AE	H	0	ML	ML	AE	VH	ML	VH	VH	AH	AH	AE	AE	VH	AE	E	ML	AE	ML	AE	AE	VH	VH
SW1	VH	VH	VH	VH	H	VH	H	VH	H	0	H	ML	VH	H	VH	VH	AH	AH	H	H	VH	AH	H	ML	H	E	H	H	VH	VH
SW2	H	P	P	VH	H	H	VH	VH	H	E	0	ML	H	H	H	H	AH	AH	H	H	H	AH	H	ML	H	E	H	H	H	H
TW1	H	AH	AE	H	VH	H	H	VH	H	AH	AH	0	H	H	H	H	AH	AH	VH	VH	H	H	H	ML	H	E	VH	VH	H	H
LW1	E	E	ML	AE	ML	E	ML	AE	AE	ML	ML	ML	0	E	E	E	AH	AH	ML	ML	E	ML	AE	ML	AE	AE	ML	ML	E	E
EW1	H	VH	H	H	H	H	VH	H	E	ML	ML	ML	H	0	H	H	AH	AH	H	H	H	AH	E	ML	E	E	H	H	H	H
PO1	AH	AE	AE	E	ML	AH	ML	H	ML	AE	AE	ML	AH	ML	0	AH	AH	AH	ML	ML	AH	H	ML	ML	ML	ML	ML	ML	AH	AH
EcO1	ML	AH	H	AE	ML	ML	ML	AE	ML	ML	ML	ML	ML	ML	ML	0	AH	AH	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML
EcO2	ML	AH	H	AE	ML	ML	AE	AE	ML	ML	ML	ML	ML	ML	ML	ML	0	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML
SO1	AE	AH	AE	AE	ML	AE	ML	AE	L	ML	ML	ML	AE	AE	AE	AE	AH	0	ML	ML	AE	ML	L	ML	L	ML	ML	ML	AE	AE
TO1	AE	H	H	H	AH	AE	AH	H	AH	ML	ML	AH	AE	AH	AE	AE	AH	AH	0	AH	AE	H	AH	ML	AH	AH	AH	AH	AE	AE
TO2	ML	VH	H	VH	AH	ML	AH	H	H	ML	ML	AH	ML	AH	ML	ML	AE	AE	AH	0	ML	H	H	ML	H	H	AH	AH	ML	ML
LO1	ML	E	E	E	E	ML	ML	H	ML	ML	AE	ML	ML	ML	ML	ML	AH	AH	E	AE	0	H	ML	ML	ML	AH	E	E	ML	ML
EO1	ML	AH	AH	AH	E	ML	AH	AH	AE	AE	AE	ML	ML	AE	ML	ML	AH	AH	E	AE	ML	0	AE	ML	AE	ML	E	E	ML	ML
PT1	H	ML	ML	AH	ML	H	ML	ML	E	ML	ML	ML	H	ML	H	H	AH	AH	ML	ML	H	ML	0	ML	E	ML	ML	ML	H	H
EcT1	H	VH	P	P	H	H	H	VH	H	AH	H	H	H	H	H	H	AH	AH	H	H	H	VH	H	0	H	E	H	H	H	H
EcT2	H	AH	H	H	AE	H	AE	AE	E	AE	AE	ML	H	AE	H	H	AH	AH	AE	AE	H	ML	E	ML	0	ML	AE	AE	H	H
ST1	VH	P	VH	VH	E	VH	H	VH	VH	H	VH	VH	VH	VH	VH	VH	P	P	E	AH	VH	ML	VH	ML	VH	0	E	E	VH	VH
TT1	H	AH	E	AH	E	H	H	AH	H	H	H	AH	H	AH	H	H	VH	VH	E	E	H	VH	H	E	H	AE	0	E	H	H
TT2	AE	ML	H	E	E	AE	AH	H	H	H	VH	AH	AE	H	AE	AE	H	H	E	E	AE	H	H	E	H	AH	E	0	AE	AE
LT1	E	AE	AH	AH	ML	E	E	ML	ML	ML	ML	ML	E	E	E	E	AH	AH	ML	ML	E	AE	ML	ML	ML	ML	ML	ML	0	H
ET1	H	H	VH	H	H	H	AH	ML	ML	ML	ML	ML	H	E	H	H	AH	AH	H	H	H	AE	ML	H	ML	AE	H	H	H	0

Table A2. DM4's assessment for 2TL-DEMATEL.

	SP1	SP2	EcS1	SS1	TS1	LS1	ES1	PW1	EcW1	SW1	SW2	TW1	LW1	EW1	PO1	EcO1	EcO2	SO1	TO1	TO2	LO1	EO1	PT1	EcT1	EcT2	ST1	TT1	TT2	LT1	ET1
SP1	0	L	E	H	H	E	H	H	L	L	E	E	E	L	E	H	H	H	H	H	E	H	L	L	L	L	H	H	E	E
SP2	H	0	L	L	E	H	L	L	H	L	L	L	H	E	H	H	H	H	E	E	H	H	H	L	H	E	E	E	H	H
EcS1	H	H	0	E	E	H	E	H	H	L	L	L	H	H	H	H	H	H	E	E	H	H	H	L	H	E	E	E	H	H
SS1	H	H	E	0	L	H	L	E	H	L	L	E	H	L	H	H	H	H	L	L	H	H	H	L	H	E	L	L	H	H
TS1	L	H	H	H	0	L	H	H	L	E	E	E	L	H	L	L	H	H	H	H	L	H	L	H	L	H	E	E	L	L
LS1	E	E	E	E	L	0	L	H	L	E	E	L	E	L	E	E	H	H	L	L	0	H	L	L	L	L	L	L	E	E
ES1	E	H	E	H	L	E	0	H	H	L	L	L	E	E	E	E	H	H	L	L	E	E	H	L	H	L	L	L	E	E
PW1	E	H	E	H	L	E	L	0	H	L	L	L	E	H	E	E	H	H	L	L	E	L	H	L	H	L	L	L	E	E
EcW1	H	P	L	E	E	H	E	H	0	L	L	E	H	L	H	H	H	H	E	E	H	E	E	L	E	L	E	E	H	H
SW1	H	H	H	H	H	H	H	H	H	0	H	L	H	H	H	H	H	H	H	H	H	H	H	L	H	E	H	H	H	H
SW2	H	P	P	H	H	H	H	H	H	E	0	L	H	H	H	H	H	H	H	H	H	H	H	L	H	E	H	H	H	H
TW1	H	H	E	H	H	H	H	H	H	H	H	0	H	H	H	H	H	H	H	H	H	H	H	L	H	E	H	H	H	H
LW1	E	E	L	E	L	E	L	E	E	L	L	L	0	E	E	E	H	H	L	L	E	L	E	L	E	E	L	L	E	E
EW1	H	H	H	H	H	H	H	H	E	L	L	L	H	0	H	H	H	H	H	H	H	H	E	L	E	E	H	H	H	H
PO1	H	E	E	E	L	H	L	H	L	E	E	L	H	L	0	H	H	H	L	L	H	H	L	L	L	L	L	L	H	H
EcO1	L	H	H	E	L	L	L	E	L	L	L	L	L	L	L	0	H	H	L	L	L	L	L	L	L	L	L	L	L	L
EcO2	L	H	H	E	L	L	E	E	L	L	L	L	L	L	L	L	0	L	L	L	L	L	L	L	L	L	L	L	L	L
SO1	E	H	E	E	L	E	L	E	L	L	L	L	E	E	E	E	H	0	L	L	E	L	L	L	L	L	L	L	E	E
TO1	E	H	H	H	H	E	H	H	H	L	L	H	E	H	E	E	H	H	0	H	E	H	H	L	H	H	H	H	E	E
TO2	L	H	H	H	H	L	H	H	H	L	L	H	L	H	L	L	E	E	H	0	L	H	H	L	H	H	H	H	L	L
LO1	L	E	E	E	E	L	L	H	L	L	E	L	L	L	L	L	H	H	E	E	0	H	L	L	L	H	E	E	L	L
EO1	L	H	H	H	E	L	H	H	E	E	E	L	L	E	L	L	H	H	E	E	L	0	E	L	E	L	E	E	L	L
PT1	H	L	L	H	L	H	L	L	E	L	L	L	H	L	H	H	H	H	L	L	H	L	0	L	E	L	L	L	H	H
EcT1	H	H	P	P	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	0	H	E	H	H	H	H
EcT2	H	H	H	H	E	H	E	E	E	E	E	L	H	E	H	H	H	H	E	E	H	L	E	L	0	L	E	E	H	H
ST1	H	P	H	H	E	H	H	H	H	H	H	H	H	H	H	H	P	P	E	H	H	L	H	L	H	0	E	E	H	H
TT1	H	H	E	H	E	H	H	H	H	H	H	H	H	H	H	H	H	H	E	E	H	H	H	E	H	E	0	E	H	H
TT2	E	L	H	E	E	E	H	H	H	H	H	H	E	H	E	E	H	H	E	E	E	H	H	E	H	H	E	0	E	E
LT1	E	E	H	H	L	E	E	L	L	L	L	L	E	E	E	E	H	H	L	L	E	E	L	L	L	L	L	L	0	H
ET1	H	H	H	H	H	H	H	L	L	L	L	L	H	E	H	H	H	H	H	H	H	E	L	H	L	E	H	H	H	0

References

1. Garg, D.; Alam, M. Smart Agriculture: A Literature Review. *J. Manag. Anal.* **2023**, *10*, 359–415. [CrossRef]
2. Zhang, Q. Opinion Paper: Precision Agriculture, Smart Agriculture, or Digital Agriculture. *Comput. Electron. Agric.* **2023**, *211*, 107982. [CrossRef]
3. Schroeder, K.; Lampietti, J.; Elabed, G. *What's Cooking: Digital Transformation of the Agrifood System*; World Bank: Washington, DC, USA, 2021; ISBN 978-1-4648-1657-4.
4. Pakeerathan, K. *Smart Agriculture for Developing Nations: Status, Perspectives and Challenges*; Springer Nature: Berlin, Germany, 2023; ISBN 978-981-19873-8-0.
5. Mihailova, M. The State of Agriculture in Bulgaria—PESTLE Analysis. *Bulg. J. Agric. Sci.* **2020**, *26*, 935–943.
6. Tran, D.; Schouteten, J.J.J.; Degieter, M.; Krupanek, J.; Jarosz, W.; Areta, A.; Emmi, L.; De Steur, H.; Gellynck, X. European Stakeholders' Perspectives on Implementation Potential of Precision Weed Control: The Case of Autonomous Vehicles with Laser Treatment. *Precis. Agric.* **2023**, *24*, 2200–2222. [CrossRef]
7. Nikjoo, A.V.; Saeedpoor, M. An Intuitionistic Fuzzy DEMATEL Methodology for Prioritising the Components of SWOT Matrix in the Iranian Insurance Industry. *IJOR* **2014**, *20*, 439. [CrossRef]
8. Gabus, A.; Fontela, E. *World Problems, an Invitation to Further Thought within the Framework of DEMA^{TEL}*; Battelle Geneva Research Center: Geneva, Switzerland, 1972.
9. Martínez, L.; Rodriguez, R.M.; Herrera, F. *The 2-Tuple Linguistic Model*; Springer International Publishing: Cham, Switzerland, 2015; ISBN 978-3-319-24712-0.
10. Deloitte Transforming Agriculture through Digital Technologies; Deloitte and SCIO. 2020, p. 14. Available online: https://www2.deloitte.com/gr/en/pages/consumer-business/articles/transforming-agriculture-through-digital-technologies.html (accessed on 12 December 2023).
11. FAO. *Building a Common Vision for Sustainable Food and Agriculture: Principles and Approaches*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2014; ISBN 978-92-5-108471-7.
12. Zerssa, G.; Feyssa, D.; Kim, D.-G.; Eichler-Löbermann, B. Challenges of Smallholder Farming in Ethiopia and Opportunities by Adopting Climate-Smart Agriculture. *Agriculture* **2021**, *11*, 192. [CrossRef]
13. Firoozzare, A.; Saghaian, S.; Bahraseman, S.; Dashtabi, M. Identifying the Best Strategies for Improving and Developing Sustainable Rain-Fed Agriculture: An Integrated SWOT-BWM-WASPAS Approach. *Agriculture* **2023**, *13*, 1215. [CrossRef]
14. Tekin, A.B. Analysing the National Data for Agricultural Technology Penetration in Turkey. *Fresenius Environ. Bull.* **2019**, *28*, 2716.
15. Akyüz, Y.; Ceyhan, V.; Türkten, H. Reflection of Environmental-Based Agricultural Land Protection Program (Çatak) on Farmer's Implementation. *JEB* **2020**, *41*, 439–444.
16. Ahmed, N.; Areche, F.O.; Cotrina Cabello, G.G.; Córdova Trujillo, P.D.; Sheikh, A.A.; Abiad, M.G. Intensifying Effects of Climate Change in Food Loss: A Threat to Food Security in Turkey. *Sustainability* **2023**, *15*, 350. [CrossRef]
17. Pilevneli, T.; Capar, G.; Sánchez-Cerdà, C. Investigation of Climate Change Impacts on Agricultural Production in Turkey Using Volumetric Water Footprint Approach. *Sustain. Prod. Consum.* **2023**, *35*, 605–623. [CrossRef]
18. Hadachek, J.; Ma, M.; Sexton, R.J. Market Structure and Resilience of Food Supply Chains under Extreme Events. *Am. J Agri Econ.* **2023**, *106*, 21–44. [CrossRef]
19. Su, Y.; Wang, X. Innovation of Agricultural Economic Management in the Process of Constructing Smart Agriculture by Big Data. *Sustain. Comput.-Inform. Syst.* **2021**, *31*, 100579. [CrossRef]
20. Aksoy, M.T. Financial Stability and Economic Competitiveness in Turkey. *EB* **2023**, *10*, 43–55. [CrossRef]
21. Caviglia, R.; Gaggero, G.; Portomauro, G.; Patrone, F.; Marchese, M. An SDR-Based Cybersecurity Verification Framework for Smart Agricultural Machines. *IEEE Access* **2023**, *11*, 54210–54220. [CrossRef]
22. Çakmakçı, R.; Salık, M.A.; Çakmakçı, S. Assessment and Principles of Environmentally Sustainable Food and Agriculture Systems. *Agriculture* **2023**, *13*, 1073. [CrossRef]
23. Karunathilake, E.M.B.M.; Le, A.T.; Heo, S.; Chung, Y.S.; Mansoor, S. The Path to Smart Farming: Innovations and Opportunities in Precision Agriculture. *Agriculture* **2023**, *13*, 1593. [CrossRef]
24. Wijerathna-Yapa, A.; Pathirana, R. Sustainable Agro-Food Systems for Addressing Climate Change and Food Security. *Agriculture* **2022**, *12*, 1554. [CrossRef]
25. FAO. *Transforming Food and Agriculture to Achieve the SDGs: 20 Interconnected Actions to Guide Decision-Makers*; FAO: Rome, Italy, 2018.
26. Benzaghta, M.A.; Elwalda, A.; Mousa, M.; Erkan, I.; Rahman, M. SWOT Analysis Applications: An Integrative Literature Review. *JGBI* **2021**, *6*, 55–73. [CrossRef]
27. Nigjeh, M.; Mohammadi, I.; Hosseini, S. Analytic Hierarchy Process and SWOT Analysis of Agricultural Bank in Promoting Innovation and Entrepreneurship in Agriculture Sector. *J. Agric. Sci. Technol.* **2023**, *25*, 301–313.
28. Ali, E.; Agyekum, E.; Adadi, P. Agriculture for Sustainable Development: A SWOT-AHP Assessment of Ghana's Planting for Food and Jobs Initiative. *Sustainability* **2021**, *13*, 628. [CrossRef]
29. Obbineni, J.; Kandasamy, I.; Vasantha, W.; Smarandache, F. Combining SWOT Analysis and Neutrosophic Cognitive Maps for Multi-Criteria Decision Making: A Case Study of Organic Agriculture in India. *Soft Comput.* **2023**, *27*, 18311–18332. [CrossRef]
30. Maity, R.; Sudhakar, K.; Razak, A.; Karthick, A.; Barbulescu, D. Agrivoltaic: A Strategic Assessment Using SWOT and TOWS Matrix. *Energies* **2023**, *16*, 3313. [CrossRef]

31. Das, K.; Sharma, D.; Satapathy, B. Electrospun Fibrous Constructs towards Clean and Sustainable Agricultural Prospects: SWOT Analysis and TOWS Based Strategy Assessment. *J. Clean. Prod.* **2022**, *368*, 133137. [CrossRef]
32. Ermetin, O. Evaluation of the Application Opportunities of Precision Livestock Farming (PLF) for Water Buffalo (Bubalus Bubalis) Breeding: SWOT Analysis. *Arch. Anim. Breed.* **2023**, *66*, 41–50. [CrossRef]
33. Khan, K.; Aziz, M.; Zubair, M.; Amin, M. Biochar Produced from Saudi Agriculture Waste as a Cement Additive for Improved Mechanical and Durability Properties-SWOT Analysis and Techno-Economic Assessment. *Materials* **2022**, *15*, 5345. [CrossRef] [PubMed]
34. Firsova, N.; Abrhám, J. Economic Perspectives of the Blockchain Technology: Application of a SWOT Analysis. *Terra Econ.* **2021**, *19*, 78–90. [CrossRef]
35. Abid, A.; Jie, S. Impact of COVID-19 on Agricultural Food: A Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis. *Food Front.* **2021**, *2*, 396–406. [CrossRef]
36. Goli, I.; Azadi, H.; Nooripoor, M.; Baig, M.; Viira, A.; Ajtai, I.; Ozgueven, A. Evaluating the Productivity of Paddy Water Resources through SWOT Analysis: The Case of Northern Iran. *Water* **2021**, *13*, 2964. [CrossRef]
37. Tabash, M.; Singh, P.; Bhatt, R.; Pandey, A. A SWOT Analysis of Groundnut Farm Households: Evidence from Mirzapur District in India. *Bulg. J. Agric. Sci.* **2021**, *27*, 656–666.
38. Gkoltsiou, A.; Mougiakou, E. The Use of Islandscape Character Assessment and Participatory Spatial SWOT Analysis to the Strategic Planning and Sustainable Development of Small Islands. The Case of Gavdos. *Land Use Policy* **2021**, *103*, 105277. [CrossRef]
39. Voicilas, D.; Certan, I. Results of cross-border cooperation—swot analysis on euro-regions. *Sci. Pap.-Ser. Manag. Econ. Eng. Agric. Rural. Dev.* **2021**, *21*, 729–737.
40. Sakrabani, R.; Garnett, K.; Knox, J.W.; Rickson, J.; Pawlett, M.; Falagan, N.; Girkin, N.T.; Cain, M.; Alamar, M.C.; Burgess, P.J.; et al. Towards Net Zero in Agriculture: Future Challenges and Opportunities for Arable, Livestock and Protected Cropping Systems in the UK. *Outlook Agric* **2023**, *52*, 116–125. [CrossRef]
41. Wu, Y. *The Marketing Strategies of IKEA in China Using Tools of PESTEL, Five Forces Model and SWOT Analysis*; Atlantis Press: Amsterdam, The Netherlands, 2020; pp. 348–355.
42. Parra-Lopez, C.; Reina-Usuga, L.; Carmona-Torres, C.; Sayadi, S.; Klerkx, L. Digital Transformation of the Agrifood System: Quantifying the Conditioning Factors to Inform Policy Planning in the Olive Sector. *Land Use Pol.* **2021**, *108*, 105537. [CrossRef]
43. Taherdoost, H.; Madanchian, M. Multi-Criteria Decision Making (MCDM) Methods and Concepts. *Encyclopedia* **2023**, *3*, 77–87. [CrossRef]
44. Ataei, Y.; Mahmoudi, A.; Feylizadeh, M.R.; Li, D.-F. Ordinal Priority Approach (OPA) in Multiple Attribute Decision-Making. *Appl. Soft. Comput.* **2020**, *86*, 105893. [CrossRef]
45. Mahmoudi, A.; Sadeghi, M.; Naeni, L.M. Blockchain and Supply Chain Finance for Sustainable Construction Industry: Ensemble Ranking Using Ordinal Priority Approach. *Oper. Manag. Res.* **2023**, 1–24. [CrossRef]
46. Si, S.-L.; You, X.-Y.; Liu, H.-C.; Zhang, P. DEMATEL Technique: A Systematic Review of the State-of-the-Art Literature on Methodologies and Applications. *Math. Probl. Eng.* **2018**, *2018*, 3696457. [CrossRef]
47. Singh, R.; Khan, S.; Dsilva, J.; Centobelli, P. Blockchain Integrated IoT for Food Supply Chain: A Grey Based Delphi-DEMATEL Approach. *Appl. Sci.-Basel* **2023**, *13*, 1079. [CrossRef]
48. Ganguly, A.; Kumar, C.; Wood, L.C. Evaluating Barriers to CSR in Indian Service Organizations: A Fuzzy Dematel Based Approach. *FIIB Bus. Rev.* **2023**, *15*, 635–661. [CrossRef]
49. Gonzales, G.; Costan, F.; Suladay, D.; Gonzales, R.; Enriquez, L.; Costan, E.; Atibing, N.; Aro, J.; Evangelista, S.; Maturan, F.; et al. Fermatean Fuzzy DEMATEL and MMDE Algorithm for Modelling the Barriers of Implementing Education 4.0: Insights from the Philippines. *Appl. Sci.* **2022**, *12*, 689. [CrossRef]
50. Si, S.-L.; You, X.-Y.; Liu, H.-C.; Huang, J. Identifying Key Performance Indicators for Holistic Hospital Management with a Modified DEMATEL Approach. *Int. J. Environ. Res. Public Health* **2017**, *14*, 934. [CrossRef]
51. Sharma, M.; Patidar, A.; Anchliya, N.; Prabhu, N.; Asok, A.; Jhajhriya, A. Blockchain Adoption in Food Supply Chain for New Business Opportunities: An Integrated Approach. *Oper. Manag. Res.* **2023**, 1–19. [CrossRef]
52. Agarwal, V.; Malhotra, S.; Dagar, V.; Pavithra, M.R. Coping with Public-Private Partnership Issues: A Path Forward to Sustainable Agriculture. *Socio-Econ. Plan. Sci.* **2023**, *89*, 101703. [CrossRef]
53. Pellicer, M.R.; Tungekar, M.Y.; Carpitella, S. Where to Place Monitoring Sensors for Improving Complex Manufacturing Systems? Discussing a Real Case in the Food Industry. *Sensors* **2023**, *23*, 3768. [CrossRef]
54. Zadeh, L.A. Fuzzy Sets. *Inf. Control* **1965**, *8*, 338–353. [CrossRef]
55. Herrera, F.; Martinez, L. A 2-Tuple Fuzzy Linguistic Representation Model for Computing with Words. *IEEE Trans. Fuzzy Syst.* **2000**, *8*, 746–752.
56. Quader, M.A.; Ahmed, S.; Raja Ghazilla, R.A.; Ahmed, S.; Dahari, M. Evaluation of Criteria for CO2 Capture and Storage in the Iron and Steel Industry Using the 2-Tuple DEMATEL Technique. *J. Clean. Prod.* **2016**, *120*, 207–220. [CrossRef]
57. Tzeng, G.; Chiang, C.; Li, C. Evaluating Intertwined Effects in E-Learning Programs: A Novel Hybrid MCDM Model Based on Factor Analysis and DEMATEL. *Expert Syst. Appl.* **2007**, *32*, 1028–1044. [CrossRef]
58. Keskin, G. A Research of Determinants of Structural Transformation in Agriculture in Turkey. *Pak. J. Agri. Sci* **2021**, *58*, 1107–1214.

59. Santarius, T.; Dencik, L.; Diez, T.; Ferreboeuf, H.; Jankowski, P.; Hankey, S.; Hilbeck, A.; Hilty, L.M.; Höjer, M.; Kleine, D.; et al. Digitalization and Sustainability: A Call for a Digital Green Deal. *Environ. Sci. Policy* **2023**, *147*, 11–14. [CrossRef]
60. Yılmaz, H.; Lauwers, L.; Buysse, J.; Van Huylenbroeck, G. Economic Aspects of Manure Management and Practices for Sustainable Agriculture in Turkey. *Present Environ. Sustain. Dev.* **2019**, *13*, 249–263. [CrossRef]
61. Şinasi Akdemir, Elpidio Antonio KOUGNIGAN, Fersin KESKİN, Handan Vuruş AKÇAÖZ, İsmet BOZ, İlkay KUTLAR, Yann Emmanuel MIASSI, Gürsel KÜSEK, Metin TÜRKER Aging Population and Agricultural Sustainability Issues: Case of Turkey. *New Medit* **2021**, *20*, 49–62.
62. dongusel.csb.gov.tr Turkey Green Deal Action Plan—Technical Assistance for Assessment of Turkey's Potential on Transition to Circular Economy. Available online: https://dongusel.csb.gov.tr/en/turkiye-green-deal-action-plan-i-106993 (accessed on 23 October 2023).
63. Sarica, K.; Dellal, İ.; Kollugil, E.T.; Ersoy, E. GHG Emission Mitigation of Turkish Agriculture Sector: Potential and Cost Assessment. *Mitig. Adapt. Strateg. Glob. Chang.* **2023**, *28*, 36. [CrossRef]
64. Nizam, D.; Yenal, Z. Seed Politics in Turkey: The Awakening of a Landrace Wheat and Its Prospects. *J. Peasant. Stud.* **2020**, *47*, 741–766. [CrossRef]
65. Basak, E.; Cetin, N.I.; Vatandaslar, C.; Pamukcu-Albers, P.; Karabulut, A.A.; Caglayan, S.D.; Besen, T.; Erpul, G.; Balkiz, O.; Cokcaliskan, B.A.; et al. Ecosystem Services Studies in Turkey: A National-Scale Review. *Sci. Total Environ.* **2022**, *844*, 157068. [CrossRef] [PubMed]
66. Adalet, B. Agricultural Infrastructures: Land, Race, and Statecraft in Turkey. *Environ. Plan D* **2022**, *40*, 975–993. [CrossRef]
67. Kaya, E.; Kadanalı, E. The Nexus between Agricultural Production and Agricultural Loans for Banking Sector Groups in Turkey. *Agric. Financ. Rev.* **2021**, *82*, 151–168. [CrossRef]
68. Yeni, O.; Teoman, Ö. The Agriculture–Environment Relationship and Environment-Based Agricultural Support Instruments in Turkey. *Eur. Rev.* **2022**, *30*, 194–218. [CrossRef]
69. Bakirci, K.; Kirtiloglu, Y. Effect of Climate Change to Solar Energy Potential: A Case Study in the Eastern Anatolia Region of Turkey. *Environ. Sci. Pollut. Res.* **2022**, *29*, 2839–2852. [CrossRef]
70. Zhu, Q.; Sarkis, J.; Lai, K. Supply Chain-Based Barriers for Truck-Engine Remanufacturing in China. *Transp. Res. Part E: Logist. Transp. Rev.* **2014**, *68*, 103–117. [CrossRef]
71. Berry, E.M.; Dernini, S.; Burlingame, B.; Meybeck, A.; Conforti, P. Food Security and Sustainability: Can One Exist without the Other? *Public Health Nutr.* **2015**, *18*, 2293–2302. [CrossRef] [PubMed]
72. Aydoğdu, M.; Atasoy, A.; Eren, M.; Mutlu, N. The Consumers' Behaviors Towards to a Regional Agricultural Product in Turkey. *IOSR J. Agric. Vet. Sci.* **2016**, *9*, 25–30.
73. Anderson, R.; Böhme, R.; Clayton, R.; Moore, T. The Economics of Cybersecurity. In *Handbook on the Economics of the Internet*; Edward Elgar Publishing: Cheltenham, UK, 2016; pp. 11–40.
74. Gunduz, O.; Korkmaz, O.; Ceyhan, V. The Link among Energy Consumption, Growth and Globalization in Turkish Agriculture. *IJESM* **2023**, *17*, 531–551. [CrossRef]
75. Campbell, B.M.; Hansen, J.; Rioux, J.; Stirling, C.M.; Twomlow, S.; (Lini) Wollenberg, E. Urgent Action to Combat Climate Change and Its Impacts (SDG 13): Transforming Agriculture and Food Systems. *Curr. Opin. Environ. Sustain.* **2018**, *34*, 13–20. [CrossRef]
76. Makate, C.; Makate, M.; Mango, N.; Siziba, S. Increasing Resilience of Smallholder Farmers to Climate Change through Multiple Adoption of Proven Climate-Smart Agriculture Innovations. Lessons from Southern Africa. *J. Environ. Manage.* **2019**, *231*, 858–868. [CrossRef] [PubMed]
77. Michler, J.D.; Baylis, K.; Arends-Kuenning, M.; Mazvimavi, K. Conservation Agriculture and Climate Resilience. *J. Environ. Econ. Manage.* **2019**, *93*, 148–169. [CrossRef]
78. De Boni, A.; D'Amico, A.; Acciani, C.; Roma, R. Crop Diversification and Resilience of Drought-Resistant Species in Semi-Arid Areas: An Economic and Environmental Analysis. *Sustainability* **2022**, *14*, 9552. [CrossRef]
79. Alahmadi, A.; Rehman, S.; Alhazmi, H.; Glynn, D.; Shoaib, H.; Sole, P. Cyber-Security Threats and Side-Channel Attacks for Digital Agriculture. *Sensors* **2022**, *22*, 3520. [CrossRef] [PubMed]
80. McKinsey and Co., Ltd. Agriculture's Technology Future: How Connectivity Can Yield New Growth | McKinsey. 2020. Available online: https://www.mckinsey.com/industries/agriculture/our-insights/agricultures-connected-future-how-technology-can-yield-new-growth (accessed on 12 December 2023).
81. Rezaei, J.; Wang, J.; Tavasszy, L. Linking Supplier Development to Supplier Segmentation Using Best Worst Method. *Expert Syst. Appl.* **2015**, *42*, 9152–9164. [CrossRef]
82. Kumar, G.; Bhujel, R.C.; Aggarwal, A.; Gupta, D.; Yadav, A.; Asjad, M. Analyzing the Barriers for Aquaponics Adoption Using Integrated BWM and Fuzzy DEMATEL Approach in Indian Context. *Environ. Sci. Pollut. Res. Int.* **2023**, *30*, 47800–47821. [CrossRef] [PubMed]