DELIVERABLE 3.2

Report on proposed citrus supply chain scenarios (public)

Report on proposed citrus supply chain scenarios

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Author:

Denis Daus, University of Duisburg-Essen (Germany)

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List of Abbreviations

ADSS	Analytics and Decision Support System
CWR	Crop water requirements
CSC	Citrus supply chain
FSC	Food supply chain
SCM	Supply chain management
STEEP	Social, Technological, Environmental, Economic, Political

Abstract

Citrus supply chains (CSC) in the Mediterranean region are characterised by intransparency, information asymmetry as well as numerous efficiency and sustainability issues. These circumstances together with an uncertain geopolitical environment and accelerating impacts of climate change, significantly influence stakeholders in the citrus sector, making it difficult to make profound operational decisions. To ease decision making process for farmers, food processors, food distributors and policies, an integration of Mediterranean citrus production and distribution systems within a circular economy can be promoted by means of scenario planning. Therefore, the objective of this task is to design scenarios based on the citrus production, logistics solutions, implementation of advanced technologies across the supply chains, regulations, economic viability, climate vulnerability, and consumer perceptions on citrus by-products usage. Scenarios will provide a clear understanding on the key involved stakeholders and the required information, aligning the stakeholders' visions, ensuring sustainable citrus by-products supply chain concepts, and eventually fostering resilience throughout the supply chain.

The Gausemeier scenario planning method was applied to guide the scenario development process. Results from previous work packages were analysed to identify trends in the Mediterranean CSCs. Literature analysis and workshops were conducted to validate, enrich, and challenge these trends. STEEP method was applied to describe and structure the results. Eventually, three alternative scenarios were developed, will serve as a basis for development of innovative business models and further simulations of supply chain processes.

1 Introduction

Business model transformation is a major lever that will have a significant impact on the food supply chain (FSC) and overall business operation, e.g. in terms of increased agricultural output, higher environmental protection and risk mitigation, and more sustainable farming practices. The ability of food system actors to apply innovation is key to achieving global food security, particularly in the current macroeconomic market volatility and decreasing public sector investments in agriculture (Bragdon and Smith 2015). However, fragmentation of supply chains and a lack of integration among the actors hinder the adoption of innovations. Integration along the supply chain is crucial since competition in our globalised economies is no longer between companies, but between supply chains (Li et al. 2006). Consequently, the goal should be to encourage the uptake of innovation in FSCs to address societal challenges such as food security, regional economic growth and competitiveness, employment and quality of life, or environmental resilience.

Innovation is defined as "adoption of an internally generated or purchased device, system, policy, program, process, product, or service that is new to the adopting organization" (Damanpour 1991, p. 556). To support innovation, the supply chain structure should be organised in a collaborative manner and food strategies should be adopted to avoid inefficient practices and cope with future challenges. Supply chain innovation improves the organisational and supply chain performance as well as sustainability of FSCs (Krishnan et al. 2021). In this view, innovation is a result of collaborative processes involving various stakeholders along supply chains (Soosay et al. 2008; Arlbjørn et al. 2011).
Since innovation is shifting from individual organisations to entire supply chain networks, supply chain management (SCM) becomes a critical success factor. Supply chains with their various tasks and actors play a significant role, e.g. through the enormous consumption of resources and energy in the course of the extraction of raw materials, production and consumption, and the generation of waste along the value creation stages. Thus, supply chain innovation constitutes radical changes manifested in new products, services, production process technologies, structures, administrative systems, plans or programs adopted by all stakeholders in the supply chain network (Damanpour 1991; Gao et al. 2017).
Fostering innovation within citrus supply chains is essential across the Mediterranean region due to the importance of the sector, e.g. in terms of economic, environmental and social impacts. Despite a positive trend of the citrus fruits sector in the Mediterranean region fostered by government regulations, several countries face competitiveness limits manifested in the inability to keep up with the uptrending demand and adapt agricultural policies. Specifically, North-African and Near-East countries being dynamic and competitive in citrus production,

while other countries, mainly EU members, are significantly late in competitiveness (Schimmenti et al. 2013).

To promote innovation adoption and unlock transformation potential in citrus by-products supply chains, scenarios for the citrus industry in the Mediterranean area are developed, considering the socio-economic situation of the actors, driving factors and challenges for citrus production, and digitalization progress. This should be achieved by channelling business priorities of the stakeholders in citrus supply chains and align them with the regional and global citrus industry environment. There are many factors that can affect the future citrus sector, including climate, consumer preferences, market barriers, citrus production, logistics solutions, implementation of advanced technologies, available infrastructure, local strategies, or policy regulations. These factors need to be analysed to estimate the effects on future citrus supply chains with a special focus on by-products valorisation. In addition, KPIs will be defined to make sure that the implementation of scenarios can be adequately monitored.
This deliverable paves the way for the introduction of innovations among citrus by-products supply chain actors and for the integration of the Mediterranean citrus production and distribution system under the umbrella of CE and sustainability principles.

The remainder of the deliverable is structured as follows: Section 2 provides an overview of related literature and a selection of previous findings within the ImPUlSe project to set the groundwork for scenario generation by synthesising the conditions in citrus by-products supply chains. In section 3, the methodology for scenario generation is presented. Section 4 presents the results of the different steps in the scenario generation process as well as the final scenarios for the citrus industry in the Mediterranean. A conclusion and further outlook are provided in section 5.

2 Citrus Supply Chains

The advancement of citrus supply chains (CSC) is attracting the attention of researchers as a topic of study due to its potential uses in a variety of industries (Ashraf and Daus 2022). Citrus belongs to the most frequently discarded foods across multi-tier supply networks (Mena et al. 2014). The primary causes associated with waste in retail include failures related to temperature control (transport and storage), store management, inventory management, product life, handling inside the store (by both staff and consumers), access to retail flow information, order variability, forecast accuracy, when repacking products, as well as the inflexibility of retailers to promote special offers.

By implementing different approaches for citrus waste valorisation, process efficiency can be improved, profitability increased, and environmental pollution reduced. Utilising citrus by-products as secondary raw materials for other processes and other industries like pharmaceuticals or cosmetics additionally promotes the idea of industrial symbiosis. For example, flavonoids, pectin, essential oils, and sugars are utilised in pharmaceutical applications and as natural additives for functional food. For a transition like this, however, several requirements like having an efficient infrastructure, identifying suitable alternatives for waste streams, and deploying quantitative analytical tools must be addressed (Sharma et al. 2017). Based on a study in South Italy, citrus waste is difficult to use as a resource for sustainable growth (Raimondo et al. 2018). The distance between processors and plants is one of the most important things to consider when picking between different valorisation pathways. Entrepreneurs and co-investors are more likely to work together to build a multipurpose plant if the contract scheme has features like guaranteed capital, a short term, and less risk.

2.1 Citrus Production Conditions

Citrus production in the Mediterranean region represents about 20% of the total world production. This production is mostly made up of oranges and mandarins-like fruits that are used for fresh consumption and for agro-industry. This sector constitutes a major income source for many people in the Mediterranean. However, farmers struggle with environmental conditions such as drought, pests and diseases. Despite being a driving force for the economy in the Mediterranean, traditional citrus cultivation practices are labour-intensive (Duarte et al. 2016). The citrus sector is diversified, with citrus fruits cultivated on small, medium, big, and extremely large farms (FAO 2021).

The Mediterranean region is considered as a so-called climate change hotspot, threatened by drought episodes that result in variable production and conflicts over irrigation water. These are areas where strong physical and ecological effects of climate change come together notably impacting agriculture (Cos et al. 2021). Climatic conditions have drastic impacts on crop production and crop water requirements (CWR). Hence, the quantity and quality of citrus production is tightly linked with climatic aspects (Albrigo 2019). Geographical citrus cultivation is restricted by low temperatures to coastal regions. Temperature affects plant growth, blooming, fruit set, and quality. Flowers, fruits, and plants suffer greatly at temperatures below -3 degrees Celsius.

Besides climate conditions, soil texture has a strong effect on CWR. Citrus grows best in deep, light, sandy loam, loam, or clay loam soils with adequate drainage and aeration, and a pH range from 4 to 9, although the optimal range is 5.5 to 6 (AZUD 2023). A sustainable citrus cropping system requires increased efficiency of water use and enhanced knowledge of crop water use.
Due to their tropical and sub-tropical origins, citrus fruits require a suitable climate where the risk of prolonged freezing temperatures is low (Sarwar Khan and Ahmad Khan 2021).

However, the North African regions are dispersed in terms of climate differences, which leads to varying CWR and significant water deficits in different regions. In the coming decades, the Mediterranean is likely to be drier during the winter rainy season, potentially seeing 40% less precipitation in the western region and 20% to 30% in the eastern region. Projections into the future show that an increase in CWR from 6% to 22% is possible, while Egypt seems to be the most affected country. Also the summer months are estimated to be warmer by 3 to 4 degrees Celsius (Tuel and Eltahir 2020).
Due to droughts in several regions agricultural stress is evident, e.g. manifested in the threat of the flowering stage. Drought is an increasing issue for agriculture, which puts a large part of the world's population at risk of food insecurity and hunger (Rojas 2021).

A better understanding of the ecology of citrus trees and fruit production may improve agricultural efficiency in the context of sustainability.
A detailed elaboration on citrus production conditions in the Mediterranean region and calculations based on local specificities can be studied in Deliverable D2.1, which is available for download on the project website: https://impulse-sustainable-supply-chains.net

2.2 Market Conditions

The food processing stage accounts for 38% of the total waste, which generally possesses a consistent and stable composition. Food waste with these properties constitutes a valuable raw material for extracting high-value goods or being used as functional products. Since approximately 44% of the whole citrus yield is used for industrial processing, it has the potential to be utilised as a valuable resource for valorisation. For example, innovative drinks can be enriched with functional probiotics that are created from citrus processing waste. Changing consumption patterns and the introduction of healthier and sustainable drinks underpin the increasing health awareness of consumers and their willingness to pay more for sustainable and healthy products compared to existing conventional products on the market, which offers many opportunities but also challenges for the stakeholders in the CSC. This change in consumer perspective requires adaptation of the upstream supply chain processes. At the farm stage, for example, these conditions demand the avoidance of pesticides to ensure that no residues of chemicals used to protect citrus fruits against pests can be transferred to the final juice product. Farmers who lack knowledge in sustainable and organic farming practices are at risk of not being able to provide the fruits required by the market.

Valorising waste to produce sustainable and high-quality products that can compete on the market is a promising approach. However, it is crucial to implement a suitable pricing strategy and assess the economic viability of this endeavour as well as understand the consumers' willingness to pay for specific product types, their price sensitivity, and demand variability between different demographic regions before implementing circular processes to produce these kinds of by-products.

A detailed market analysis for valorisation paths and by-products in CSCs, considering the socioeconomic situation of stakeholders and organizational innovation within a circular economy is available for download on the project website: https://impulse-sustainable-supply-chains.net.

3 Methodological Background

Companies need to be prepared for the future by developing robust strategies. Scenario planning can be an effective way to help make decisions in situations where we don't know what will happen. Scenario method is a suitable approach for a long-term planning to support decision making in uncertain situations (Gaspars-Wieloch 2019).

To foster innovation adoption in citrus supply chains and unlock business transformation potential, we followed the scenario planning and management method from Gausemeier and Plass (2014), which consists of five stages: (i) preparation, (ii) scenario field analysis, (iii) projections development, (iv) scenario development, (v) scenario transfer.

We combined this approach with STEEP (Social, Technological, Environmental, Economic, Political) and CIB (Cross-Impact Balances) methods to develop scenarios for the citrus sector in the Mediterranean area. The results of the first four phases are described in this document. In the preparation phase, the system boundaries and the goals of the scenario project were determined. Citrus supply chains in the Mediterranean were defined as the subject to be investigated with the goal to foster innovation and by-product valorisation. In the **second phase**, key influencing factors (so called descriptors) for the development of the scenario field were identified and structured using the STEEP method (section 4.1). Due to the large amount of potential descriptors under consideration and to avoid complexity, subsequent influence analysis (section 4.1.1) and relevance analysis (section 4.1.2) were applied by means of cross-impact matrices (CIM). For every descriptor, potential development paths (so called projections) were developed in phase three (section 4.2). The actual scenarios were developed in phase four, where the evaluation of interdependencies between projections, which constitute possible development paths, lead to combinations of projections which fit together well, forming a scenario (section 4.3).

Scenarios hence consists of several sets of projections. Each of these sets constitutes a scenario. Depending on the number of descriptors and projections per descriptor, many scenarios can be created. However, scenarios can have a low credibility, which means that the interrelationships between projections are inconsistent and contradict each other (Gausemeier and Plass 2014).

Therefore, it is important to evaluate the consistency of each scenario to decide on its credibility. A powerful technique is the Cross-Impact Balance (CIB), which evaluates how two projections are related to each other in terms of the direct effect that one future projection has on the other. The CIB uses causal information to construct images of the behaviour of the network as a whole, using qualitative insights into the individual relationships between the factors of the network (Weimer-Jehle 2008). The ScenarioWizard software is applied to perform CIB analysis as well as generate and visualise the resulting consistent scenarios.

4 Results

This chapter describes the results obtained from the four stages of the scenario planning and management method.

4.1 Descriptors

In a first step, influencing factors (descriptors) were collected from every project partner to create a comprehensive list structured by the STEEP dimensions. A first synthesis of this collection resulted in 32 descriptors. The aim is to obtain 10-20 key descriptors to ensure the scenario planning process to be manageable. For this reason, influence and relevance analyses were conducted. The results were then visualised in a system grid to obtain the final selection of key descriptors.

4.1.1 Influence Analysis

In a so-called influence matrix, the direct relationships and influences between descriptors are analysed. For every descriptor pair, the analysis shows how strongly (or quickly) one descriptor changes due to the direct influence of the other descriptor - and vice versa.

Question:
How strong does descriptor i (row) influence descriptor j (column)

0 = no influence
1 = weak influence
2 = moderate influence
3 = strong influence

		Social						Technological					Environmental										Economic								Political			
		Consumer preferences for products	Labor availability	Working conditions	Sustainability awareness along the SC	Action for sustainability qualification	Consumer health and well-being	Transparency along the SC	Technology adoption	Forecasting capabilities	Digitalisation in the supply chain	Technology Finance	Packaging recovery	Water salinity	Fruit and by-product waste	Production footprint	Renewable source of energy	Impact of climate change	Natural desasters	Water resources	Pesticide use	Soil quality	Yield development at farm and processor	Market access (distribution channels)	Efficiency of resources	Profit margin	(Operational) costs (raw materials, packaging, fertiliser, processing, energy)	Circular practices adoption	Stakeholder integration (collaboration)	Logistics processes	Trade barriers (foreign policy)	Regulations	(Geo-)Political environment	Active sum
Social	Consumer preferences for products		3	2	1	2	3	2	1	3	1	3	1	0	1	3	1	0	0	0	3	0	1	0	1	3	3	1	0	1	0	1	0	41
	Labor availability	0		2	0	1	0	0	2	1	2	2	1	0	1	1	1	0	0	0	1	0	3	1	2	2	1	1	1	2	0	1	1	30
	Working conditions	1	3		2	3	1	0	2	0	2	1	0	0	1	2	1	0	0	1	0	0	2	1	2	2	2	1	1	1	2	3	1	38
	Sustainability awareness along the SC	2	1	3		3	3	2	3	1	2	2	3	1	3	3	3	0	0	1	3	0	2	2	3	2	2	3	1	2	2	3	1	62
	Action for sustainability qualification	1	2	3	3		3	2	2	1	2	3	3	0	3	2	2	1	0	2	3	1	1	1	3	2	3	3	2	2	1	2	0	59
	Consumer health and well-being	3	1	1	2	2		0	1	0	1	1	0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	1	0	2	3	1	23
Technological	Transparency along the SC	2	1	1	3	1	0		2	2	1	1	2	0	1	1	1	1	0	0	2	0	1	2	2	2	1	3	3	2	1	3	1	43
	Technology adoption	1	1	2	2	1	2	3		3	3	1	3	1	2	3	3	1	0	2	2	1	3	2	3	2	3	3	3	3	1	2	0	62
	Forecasting capabilities	0	2	1	0	0	0	2	1		1	2	1	0	3	2	1	0	0	1	2	0	2	1	2	2	1	3	2	3	0	2	1	38
	Digitalisation in the supply chain	2	1	2	1	2	1	3	3	3		1	3	1	3	3	2	1	0	2	3	0	3	3	3	2	3	3	3	3	1	2	1	64
	Technology Finance	0	0	1	0	1	2	3	3	3	3		2	1	3	2	2	0	0	0	1	0	2	1	2	1	1	1	2	2	0	0	0	39
Environmental	Packaging recovery	1	0	0	1	1	0	0	1	0	0	1		0	0	2	0	0	0	0	0	0	0	0	2	1	3	3	2	3	0	0	0	21
	Water salinity	1	0	0	1	1	2	0	1	0	0	1	0		0	0	0	0	0	2	1	3	1	0	0	0	1	0	0	0	0	0	0	15
	Fruit and by-product waste	0	0	0	2	3	0	0	2	0	1	2	0	0		3	1	0	0	0	0	0	3	0	3	3	2	3	2	3	2	2	0	37
	Production footprint	0	0	0	2	2	0	0	1	0	0	1	1	0	0		2	0	1	0	0	0	0	0	0	0	0	2	1	0	0	1	0	14
	Renewable source of energy	1	0	0	2	1	0	0	0	0	0	0	0	0	0	3		0	0	0	0	0	0	0	1	2	3	0	0	0	0	1	0	14
	Impact of climate change	1	1	0	2	3	1	0	1	0	1	1	1	0	0	0	2		3	2	2	1	3	0	0	0	1	2	0	0	1	2	0	31
	Natural desasters	0	1	0	0	1	1	0	0	0	0	0	0	0	2	0	0	0		1	0	0	1	0	0	0	0	0	0	1	0	1	0	9
	Water resources	0	0	0	1	1	0	0	2	0	1	2	0	1	1	0	0	0	0		1	1	2	0	1	1	1	1	0	0	0	1	0	18
	Pesticide use	3	0	2	2	2	3	0	1	0	1	1	0	1	2	3	0	0	0	1		3	3	3	2	2	1	1	0	0	3	3	0	43
	Soil quality	0	0	0	0	0	2	0	1	0	0	1	0	1	1	0	0	0	0	1	2		3	1	0	2	2	0	0	0	1	1	0	19
Economic	Yield development at farm and processor	0	0	0	0	1	0	0	2	0	1	2	0	0	2	3	0	0	0	0	1	0		0	0	2	3	1	0	3	0	0	1	22
	Market access (distribution channels)	0	0	0	1	2	0	1	0	0	1	0	0	0	1	2	1	0	0	0	3	0	1		0	3	2	2	2	3	1	1	2	29
	Efficiency of resources	0	0	0	2	3	0	0	2	0	1	2	1	0	2	3	2	0	0	1	1	0	3	0		3	3	1	0	1	0	1	0	32
	Profit margin	0	0	0	0	1	0	0	1	0	1	2	0	0	0	0	1	0	0	0	1	0	0	0	0		0	1	0	0	0	0	0	8
	(Operational) costs (raw materials, packaging, fertiliser, processing, energy, labor)	0	0	1	0	1	0	0	2	0	2	2	1	0	0	0	1	0	0	0	1	0	0	0	1	3		1	0	2	0	0	0	18
	Circular practices adoption	2	0	2	1	1	2	2	3	1	2	3	3	0	3	3	3	1	1	2	3	1	3	3	3	3	3		3	3	3	1	0	64
	Stakeholder integration (collaboration)	1	1	2	1	1	0	3	1	3	2	1	3	0	3	1	1	0	0	0	2	0	1	3	1	1	1	2		3	0	0	0	38
	Logistics processes	0	0	0	1	1	0	1	1	1	1	0	3	0	2	3	1	0	0	0	0	0	2	3	2	3	3	1	2		0	0	0	31
Political	Trade barriers (foreign policy)	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	3	0	2	0	0	1	2		2	3	18
	Regulations	0	1	3	3	3	3	1	0	0	0	2	2	0	1	1	2	0	0	0	3	0	0	2	0	1	1	3	0	1	3		2	38
	(Geo-)Political environment	0	0	0	0	0	1	0	2	0	2	1	0	0	0	0	2	0	0	0	1	0	1	3	0	1	0	0	2	1	3	2		22
	Passive sum	22	19	28	36	47	30	25	44	22	35	42	34	7	42	50	37	5	5	19	45	11	47	35	39	54	50	46	34	47	27	41	15	

Figure 1: Influence Matrix

The active sum shows how strong a descriptor influences the other descriptors. The passive sum shows how strong a descriptor is influenced by the other descriptors. The influence analysis provides information about the systemic behaviour of the descriptors. But it doesn't provide information about the strength with which the descriptors impact the investigated field. This gap is filled with the relevance analysis.

4.1.2 Relevance Analysis

In contrast to the influence matrix, the relevance matrix performs the pairwise comparison of descriptors in one direction only. For the second direction (area under the black diagonal separation line), inverted values are taken. In addition, evaluation of the descriptors is done by providing only *yes* (1) and *no* (0) answers.

Question:
Is descriptor i (row) more important than descriptor j (column)

0 = no (i is less important than j)
1 = yes (i is more important than j)

		Social						Technological					Environmental										Economic								Political			
		Consumer preferences for products	Labor availability	Working conditions	Sustainability awareness along the SC	Action for sustainability qualification	Consumer health and well-being	Transparency along the SC	Technology adoption	Forecasting capabilities	Digitalisation in the supply chain	Technology Finance	Packaging recovery	Water salinity	Fruit and by-product waste	Production footprint	Renewable source of energy	Impact of climate change	Natural desasters	Water resources	Pesticide use	Soil quality	Yield development at farm and processor	Market access (distribution channels)	Efficiency of resources	Profit margin	(Operational) costs (raw m., packaging, fertiliser etc.)	Circular practices adoption	Stakeholder integration (collaboration)	Logistics processes	Trade barriers (foreign policy)	Regulations	(Geo-)Political environment	Relevance sum
Social	Consumer preferences for products		0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0	0	12
	Labor availability	1		0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	15
	Working conditions	1	1		1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	25
	Sustainability awareness along the SC	1	1	0		0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	0	0	15
	Action for sustainability qualification	1	1	0	1		0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	0	1	17
	Consumer health and well-being	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	30
Technological	Transparency along the SC	0	0	0	0	0	0		1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	8
	Technology adoption	0	0	0	0	0	0	0		1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	5
	Forecasting capabilities	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Digitalisation in the supply chain	0	0	0	0	0	0	0	0	1		1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	5
	Technology Finance	0	0	0	0	0	0	0	1	1	0		1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1	8
Environmental	Packaging recovery	1	0	0	0	0	0	1	0	1	0	0		0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	7
	Water salinity	1	1	0	1	1	0	1	1	1	1	1	1		0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	19
	Fruit and by-product waste	1	1	0	1	1	0	1	1	1	1	1	1	1		0	0	0	0	0	0	1	1	1	0	1	1	0	1	1	1	1	1	21
	Production footprint	1	1	0	1	1	0	1	1	1	1	1	1	1	1		1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	26
	Renewable source of energy	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0		0	1	0	1	0	1	1	1	1	1	0	1	1	1	1	1	25
	Impact of climate change	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	29
	Natural desasters	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0		0	1	0	1	1	1	1	1	1	1	1	1	1	1	26
	Water resources	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	31
	Pesticide use	1	1	0	1	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0		0	1	1	1	1	1	1	1	1	1	1	1	23
	Soil quality	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	0	1	0	1		1	1	1	0	0	0	1	1	0	1	1	22
Economic	Yield development at farm and processor	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	1	0	0	0	1	8
	Market access (distribution channels)	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1		0	0	0	0	1	0	0	0	1	7
	Efficiency of resources	0	0	0	1	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1		1	1	1	1	1	1	1	1	20
	Profit margin	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0		1	0	1	1	1	0	0	10
	(Operational) costs (raw materials, packaging, fertiliser, processing, energy)	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0		0	1	1	1	0	1	10
	Circular practices adoption	1	0	0	1	1	0	1	1	1	1	1	1	1	1	0	1	0	0	0	0	1	1	1	0	1	1		1	1	1	1	1	22
	Stakeholder integration (collaboration)	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	1	0	0	3
	Logistics processes	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1		1	1	1	12
Political	Trade barriers (foreign policy)	1	1	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0		0	1	12
	Regulations	1	1	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1		1	17
	(Geo-)Political environment	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0		5

Figure 2: Relevance Matrix

The result of this analysis is a ranking of descriptors in terms of their importance for Mediterranean citrus supply chains. The relevance sum shows how important (or significant) a descriptor is for the design field.

4.1.3 System Grid

To identify key descriptors that have the greatest impact on the future of citrus supply chains in the Mediterranean, the active sum and passive sum from the influence analysis as well as the relevance sum from the relevance analysis can be presented in a system grid. Both axes are scaled according to ranks to allow a clear presentation. The sizes of the bubbles represent the result of the relevance analysis. The larger the bubble, the greater the influence on the citrus supply chains.

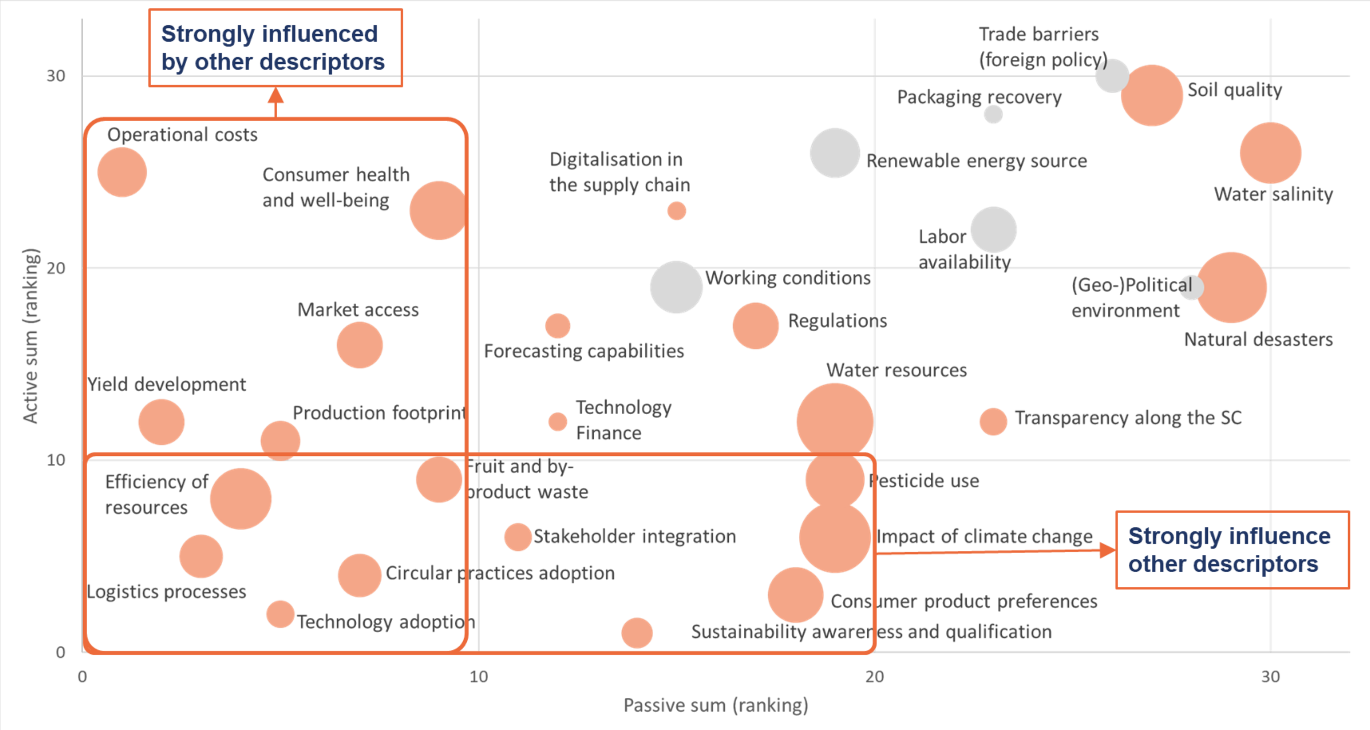

Figure 3: System Grid (selection of key descriptors)

The key influencing factors are the descriptors that have a large bubble size (i.e. a high relevance for the citrus supply chain) and a high ranking position (i.e. a strong activity in the system network of descriptors). The ranking range of 1-10 is chosen to represent the fulfilment of these criteria. A total of 15 descriptors fall within this range. However, a few descriptors are close to this range or also large, suggesting that they are relevant as well. The project consortium decided in a workshop to include 9 more descriptors in the further scenario development, leading to a total of 24 key descriptors. To avoid complexity and eventually obtain the desired 10-20 descriptors, the collection was reduced through consolidation of similar key descriptors and provision of reasoning (Table 1).

Table 1: Consolidation of key descriptors

STEEP	Key descriptor	Consolidation	Reasoning
Social	Consumer product preferences	Sustainability awareness along the CSC	Preference for sustainable products and willingness to pay for it generally comes from sustainability awareness.
	Sustainability awareness		
	Consumer health and well-being	Social health and well-being	Includes not only consumers, but also labour along the CSC.
Technological	Transparency in the SC	Digitalisation in the CSC	Digitalisation drives responsiveness (real-time data), collaboration, traceability (logistics, inventory, materials), predictive analytics of internal and external data.
	Forecasting capabilities		
	Digitalisation in the SC		
	Technology adoption	Technology adoption capabilities	Capabilities to adopt technologies include financing possibilities, capacities, competences.
	Technology Finance		
Environmental	Fruit and by-product waste	Valorisation of secondary resources	Includes fruit and by-product waste, wastewater, energy.
	Production footprint	Environmental performance	Efficient use of resources and capacities along the SC.
	Pesticide use		
	Impact of climate change	Natural citrus growing conditions	Given surrounding conditions and impacts of it. High relevance (bubble size) based on relevance matrix.
	Natural disasters		
	Water resources		
	Water salinity		
	Soil quality		
Economic	Fruit and by-product waste	Efficiency of production means	Resource-related: All describe the use of land, labour, capital etc. that can be used to produce products, which also effects the profit margin.
	Efficiency of resources		
	Circular practices adoption		
	Operational costs	Logistical order fulfilment	Process-related: describes the 6Rs – product, time, place, quantity, quality, cost. Also integrating stakeholders in the processes fosters collaboration and industrial symbiosis.
	Stakeholder integration		
	Logistics processes		
Political	Fruit and by-product waste	Regulations	Regulations are the state's attempt to intervene in private activities and protect domestic industries (policy rules, enforcement of compliance, economic controls, taxation.
	Regulations		

Eventually, ten key descriptors are obtained through the consolidation process. In addition, *geopolitical environment* is considered as another important factor since it affects trade policies, transportation routes, and overall stability in the Mediterranean. Political decisions can affect cross-border movements, tariffs, and market access, which can have an influence on the reliability and cost-effectiveness of the CSC. It's essential to monitor geopolitical dynamics to anticipate potential disruptions and make informed decisions. Eventually, eleven key descriptors are considered for further analysis in the scenario development process.

Table 2: Final key descriptors

STEEP	Consolidation
Social	Sustainability awareness along the CSC
	Social health and well-being
Technological	Digitalisation in the SC
	Technology adoption capabilities
Environmental	Valorisation of secondary resources
	Environmental performance
	Natural citrus growing conditions
Economic	Efficiency of production means
	Logistical order fulfilment
Political	Regulations
	Geopolitical environment

4.2 Projections

Projections describe potential future development paths and should be developed for every descriptor. This is the actual look into the future based on the descriptors that describe the scenario field (i.e. citrus supply chains in the Mediterranean). The time horizon for which the projections are valid should be ca. 10 years. The projections were developed based on literature review and insights from workshops. All projections were subsequently validated by the project consortium.
Every key descriptor is briefly introduced first. Then, the respective projections are described.

Social dimension

4.2.1 Social health and well-being

The citrus industry contributes to the livelihoods of people in the Mediterranean region and influences a sustainable and inclusive economic development. Production, processing, and distribution along the CSC need to be carried out in a manner that prioritizes health and safety standards. By considering social well-being, exploitation of workers, income disparities, negative health consequences, or an unfair distribution of benefits and opportunities among stakeholders can be avoided. The projections for this descriptor address key social challenges faced by the Mediterranean CSCs and focus on different aspects of social well-being offering unique approaches for improvement.

4.2.1.1 Harmony Initiative

The Citrus Harmony Initiative focuses on promoting social cohesion and well-being within the Mediterranean CSCs. It envisions the establishment of collaborative platforms, such as farmer cooperatives and industry associations, that foster dialogue and cooperation among stakeholders. Through these platforms, stakeholders can collectively address challenges related to fair trade practices, labour rights, and social welfare. The initiative ensures that citrus farmers, distributors, retailers, and consumers work together towards sustainable development and equitable outcomes. By fostering a sense of solidarity and shared responsibility, this development path contributes to the overall social well-being of the Mediterranean citrus community. (Bennett et al. 2016; Fonte and Cucco 2017; Prima Dania et al. 2016)

4.2.1.2 Resilience Alliance

The citrus industry is a major employer in many Mediterranean countries, but is also characterized by poor working conditions. The Resilience Alliance emphasizes building resilience within the Mediterranean CSCs to address social challenges effectively. This alliance brings together industry stakeholders, research institutions, and local communities to develop innovative solutions for social issues in the citrus sector. It focuses on promoting adaptive capacity, community engagement, and knowledge sharing (Dai et al. 2020). The alliance addresses various factors, including climate change impacts, labour rights, and social inequalities, to ensure a socially sustainable future for the citrus industry as well as to improve the social conditions of their workers. By building resilience, this development path enhances the social well-being of all stakeholders and contributes to the long-term viability of citrus supply chains. The citrus industry becomes more flexible and adaptive to changing consumer preferences, such as the demand for organic and locally grown food. It becomes a driver of economic growth and social development in the Mediterranean.

4.2.2 Sustainability awareness along the citrus supply chain

The CSC involves multiple stakeholders. Considering sustainability awareness from a social perspective means actively engaging with these stakeholders to understand their needs, concerns, and aspirations. This engagement allows for future developments that align with the social values of the different actors along the CSC and fulfilment of social responsibilities.

4.2.2.1 Eco-Educators

This projection involves the establishment of a network of sustainability educators who specialize in the CSC. It builds upon the increasing emphasis on sustainability education and knowledge dissemination in agricultural sectors (Adnan et al. 2018) as well as focuses on training and empowering individuals within the CSC to become sustainability ambassadors. Stakeholders at various levels are targeted, including farmers, workers, distributors, and consumers, fostering a comprehensive understanding and adoption of sustainable practices and their implications, including organic farming, water and energy conservation, waste reduction, and responsible packaging (Pretty 2008). The projection encompasses initiatives such as sustainability training workshops, certification programs, awareness campaigns, and the integration of sustainability metrics into SCM systems. With increasing sustainability awareness among consumers of the environmental and social impacts of their food choices, their willingness to pay for sustainable food as well as their demands for sustainable products, this projection addresses the need to raise awareness regarding food waste (Huang et al. 2020) and promote sustainable behaviours along the CSC to ensure long-term environmental, social, and economic viability (Trienekens et al. 2012). It focuses on enhancing the capabilities of individuals through skill development programs, access to modern agricultural practices, and entrepreneurship training.

4.2.2.2 Sustainable Empowerment Network

The Sustainable Empowerment Network aims to empower citrus farmers and workers, particularly those in marginalized communities, by providing them with the necessary resources and support. This initiative acknowledges the importance of social equity and inclusivity within CSCs. By encouraging social farming, the network contributes to improving their social and economic prosperity, reducing inequalities, and fostering sustainable livelihoods (Musolino et al. 2020).

This projection focuses on achieving food security within the CSC, aligning with global sustainability goals and initiatives. The citrus industry in the Mediterranean can provide a valuable source of food and income for people in the region. It addresses the increasing urgency to mitigate climate change and carbon emissions (FAO 2016; Masson-Delmotte 2022) by emphasizing the development and implementation of strategies for renewable energy adoption and the promotion of sustainable agricultural practices (Voora et al. 2022), e.g. using less pesticides and fertilizers, or recycling water (FAO et al. 2020; HLPE 2012; Musolino et al. 2020).

Technological dimension

4.2.3 Technology adoption capabilities

The adoption of new technologies is often a complex process that is influenced by a variety of factors, such as the cost of new technologies, the lack of infrastructure, the availability of skilled labor, the fear of change, or the potential benefits. However, the adoption of new technologies can be accelerated, e.g. by governmental support, the availability of financing, and the development of new business models, but it will require a concerted effort by all stakeholders (Gausemeier & Plass, 2014).
Adoption of technologies has the potential to revolutionize the citrus industry. These technologies could make citrus production more efficient, sustainable, and profitable. As a result, CSCs can become more resilient and competitive, and could better meet the challenges of the future.

4.2.3.1 Tech Integration Hub

In this projection, a Tech Integration Hub is established to enhance technology adoption capabilities and digital training networks throughout the CSC. The hub serves as a central platform for knowledge sharing to enhance the technology literacy and skills of citrus growers, workers, and other stakeholders. Collaboration and capacity building initiatives are implemented to foster a culture of continuous learning, especially in rural areas, ensuring equitable access to digital resources and connectivity (F. Ghisi and A. L. da Silva 2001). The projection includes a comprehensive set of selective technologies, ranging from the integration of IoT sensors, to the adoption of precision agriculture techniques for optimized resource management (Ruzzante et al. 2021). For example, precision agriculture can be used to target fertilizer and pesticide applications more precisely, which can help to reduce water pollution (Yokamo 2020). Stakeholders choose technologies that are most suited to their specific needs, local agricultural and cultural contexts (Ruzzante et al. 2021). This leads to a more gradual and sustainable adoption of new technologies, which helps to minimize the risks and maximize the benefits. These developments overcome common technology adoption barriers like scalability, interoperability, lack of expertise, and regulations. (Mohammed et al. 2023; Salemink et al. 2017)

4.2.3.2 Innovation Sandbox

This projection fosters technology adoption capabilities by creating an Innovation Sandbox as a digital innovation ecosystem. The sandbox provides a multi-actor supportive environment for experimentation, collaboration, and the development of a multidisciplinary innovation culture within the CSC. Stakeholders are encouraged to adopt an agile mindset, explore new technologies through scouting initiatives, and take calculated risks to drive technological advancements (Wolfert et al. 2023). This development accelerates the adoption of new technologies, ranging from the implementation of pilot projects for emerging technologies like artificial intelligence and robotics, to the promotion of entrepreneurship and start-ups within the citrus industry. This leads to increased efficiency and productivity, as well as improved quality and safety of citrus products. As a result, CSCs become more resilient to shocks and disruptions. This development path emphasizes the importance of innovation and risk-taking in technology adoption processes, fostering technology-driven capabilities and the creation of an innovation ecosystem within the CSC. (Masi et al. 2022; Nature food 2022; Pierpaoli et al. 2013) Within this development path, the citrus industry is on the brink of a gradual technological revolution and innovation. New technologies have the potential to improve the sustainability and profitability of citrus production. As these technologies become more widely adopted, the citrus industry will be transformed.

4.2.3.3 Slow Adopters

In this projection, citrus growers and processors are slow to adopt technologies. This is due to several barriers in the agricultural sector. The perception of farmers towards new technologies can be a major barrier, as some farmers may be reluctant to adopt new technologies that they are unfamiliar with (Margaret Mwangi and S. Kariuki 2015). High cost of new technologies can be a major obstacle, especially for small farmers. A lack of required skills can also be a problem, as new technologies often require specialized training and technical skills. Government policies or the complexity of agricultural technologies might furthermore hinder technology adoption. (S. Kumari et al. 2018)

As a result, CSCs become less efficient and productive, and are more vulnerable to shocks and disruptions. This leads to increased prices for citrus products, and a decline in the competitiveness of the Mediterranean citrus industry. The developments in this projection assume that new technologies will continue to play an increasingly important role in the agricultural sector. However, their adoption includes several barriers and requires farmers to have a good understanding of their own operations and the potential benefits of new technologies. This would lead to a slower adoption rate for some farmers, as it requires them to take the time to learn about new technologies and to assess their potential benefits. This more pessimistic view states that, if citrus growers and processors are unable to adopt new technologies rapidly, they will be at a competitive disadvantage and may struggle to remain profitable.

4.2.4 Digitalisation in the citrus supply chain

There are a number of potential impacts of digitalisation on the CSC. Digital technologies can help to streamline operations and reduce costs, track products from farm to fork, improve customer service by providing real-time information and support, or enable new forms of innovation and collaboration throughout the supply chain. The extent to which these benefits can be realized depends on different factors, such as the speed of establishing digital ecosystems, investments in digital infrastructure, or the willingness of and incentives for businesses to modify their operations.

4.2.4.1 Digital Citrus Network

A Digital Citrus Network enhances transparency and traceability throughout the CSC. Blockchain technology is utilized to track environmental and social impacts of citrus production, enhancing transparency and credibility of traceability information (Mohammed et al. 2023; Yang et al. 2021). It allows to securely record and share information, ensuring the integrity of data and enhancing supply chain visibility, especially in complex FSCs (Kshetri 2018; van Hilten et al. 2020). The integration of data from various stakeholders across business activities enables effective business analytics, allowing for improved quality control and timely responses to issues such as food safety incidents (Li et al. 2023). The access to data allows predictive analytics of various data sources, including historical sales data, weather patterns, and customer buying patterns, to generate accurate demand forecasts in the CSC. These forecasts enable supply chain optimization, leading to improved inventory management, reduced waste, and enhanced market responsiveness (Wang et al. 2016). With real-time data integration stakeholders can make data-driven decisions and adapt to changing market conditions. Digital technologies increase efficiency and productivity, as well as improve quality and safety of citrus products. As a result, CSCs become more resilient to shocks and disruptions, and are better able to meet customer demands.

4.2.4.2 Citrus E-commerce Platform

This projection focuses on the establishment of a Citrus E-Commerce Platform to enable direct sales to consumers and digitise the supply chain. Online marketplaces and e-commerce platforms provide a digital platform for citrus growers to connect with consumers, eliminating intermediaries and reducing distribution costs. This facilitates efficient order fulfilment and logistics management (Yi Jiang et al. 2021). The platform also allows for direct customer engagement, providing valuable feedback and building brand loyalty. This projection emphasizes the potential of e-commerce in expanding market reach and enhancing the digitalization of the CSC.

Environmental dimension

4.2.5 Valorisation of secondary resources

This descriptor focuses on the benefits of valorising secondary resources and citrus waste, which could lead to new businesses and industries that are based on the CE principles. These businesses would collect and process citrus waste, and then sell the resulting products to other businesses or the local market, which in turn could boost the local economy. However, the development of new businesses and industries can be risky. There is also a need to raise awareness of the economic benefits of valorising secondary resources and wastes among businesses.

4.2.5.1 Circular Citrus Bioeconomy

Since the idea of circular FSCs is gaining traction globally (Ellen MacArthur Foundation 2019; Malhotra et al. 2022), the focus of this projection is on transitioning the Mediterranean CSC towards a CE model. A Circular Citrus Bioeconomy is established to promote the valorisation of secondary resources in the CSC. It aligns with the increasing recognition of the need to reuse products, promote resource efficiency, and create value-added by-products from citrus waste (Hamam et al. 2021). Waste or by-products generated during citrus processing, such as peels and pulp, are utilised to develop high-value bioproducts, such as essential oils, pectin, animal feed, and bioplastics. Furthermore, nutrients derived from citrus waste and by-products in a circular agriculture approach are recovered and utilised for fertilizer production, reducing dependence on chemical fertilizers, promoting sustainable farming practices, and improving soil health.
The vision is to create a closed-loop system that integrates various stages of the supply chain, where waste materials are transformed into valuable resources (FAO 2019) to support a sustainable regional development. Besides a closed-loop system, the principles of industrial symbiosis are applied to create new products for other industries, such as cosmetics or detergents. This can help to reduce the environmental impact of citrus production, by reducing the need for conventional materials amount and waste that goes to landfills and incinerators. The circular bioeconomy approach focuses on resource recovery, reducing waste, and

creating sustainable practices. Collaboration among stakeholders, including citrus processors, researchers, and policymakers, fosters innovation and knowledge exchange to identify new value-added applications for secondary resources.

4.2.5.2 Wate-to-Energy Initiatives

This projection focuses on the valorisation of citrus waste through biomass conversion technologies, such as anaerobic digestion, which are employed to generate renewable energy (Malhotra et al. 2022). The initiatives aim to improve energy efficiency, reduce the carbon footprint, and contribute to the transition to a sustainable low-carbon citrus industry (Singh et al. 2022; Zema et al. 2018). Renewable energy infrastructure projects such as the establishment of biogas and biodiesel plants reduce the reliance on fossil fuels and contribute to sustainability by reducing the environmental impact of the citrus industry. With this approach, barriers for valorisation of citrus waste for biomethane or bioethanol production can be overcome, resulting in better energy efficiency and less environmental impacts (Zema et al. 2018). The biomass sector plays a major strategic role in energy renewables policy and investment since it provides a huge energy potential (Di Fraia et al. 2020).

4.2.6 Environmental performance

Processes in the citrus industry have an ecological impact due to cultivating, harvesting, processing, and distributing citrus fruits and by-products. It encompasses aspects like water and pesticide usage, energy consumption, and waste management. To reduce the negative effects on the environmental impact, and to promote conservation and biodiversity, sustainable practices can be implemented. Improving environmental performance is crucial for the citrus sector since it not only addresses ecological concerns but also helps to adapt to climate change, reduce resource depletion, and meet consumer demand for environmentally friendly products.

4.2.6.1 Sustainable Farming Certification

Sustainable agricultural practices are vital for the long-term viability of the citrus sector, ensuring the production of safe and environmentally friendly food. Sustainable farming programs are established to improve environmental performance across the CSC. These initiatives set sustainability standards and define environmental indicators for citrus farms, moving away from unquantifiable informal sectors (Parrott et al. 2006). Participating farmers adopt sustainable best practices that promote soil health, water conservation, biodiversity conservation, reduced pesticide use, and renewable energy. Environmental performance assessments are conducted, and farms meeting the criteria are awarded the certification.

Continuous improvement and stakeholder engagement are emphasized to drive further enhancements in environmental practices.

Water scarcity is a major concern in citrus-producing regions, and sustainable water management is crucial for long-term citrus farming. Therefore, water-saving techniques, such as drip irrigation, precision agriculture practices, and water recycling systems are adopted to maintain and improve crop productivity. Irrigation techniques are applied to improve irrigation management, optimize water resources, and maintain sustainable production levels under drought conditions (Martínez-Gimeno et al. 2018; Shui Lee 2012). Water footprints are assessed to identify areas of high water consumption and potential efficiency improvements. In addition, the focus is on soil and crop management options for farmers, adoption of conservation agriculture principles (minimum soil disturbance, maintenance of a permanent soil cover, diversification of plant species), and sustainable technologies, such as integrated pest management (Giller et al. 2015; Dreistadt 2012).

4.2.6.2 Production Footprint Reduction

This projection focuses on reducing the carbon footprint of CSC through various measures. For example, carbon footprint assessments are performed to identify emission sources and hotspots within the supply chain. Energy efficiency measures are implemented in citrus processing facilities and transportation systems to reduce greenhouse gas emissions. Techniques for optimizing logistics are adopted and alternative fuels or electric vehicles are promoted to minimize carbon emissions. Additionally, carbon offset initiatives, such as reforestation or investment in renewable energy projects are pursued. These initiatives simplify for Mediterranean countries the entrance into international markets by means of increasing integration of their sustainable processes into global value chains (Wang et al. 2022).

4.2.7 Natural citrus growing conditions

Citrus cultivation and growing conditions are influenced by various natural factors, including temperature change, precipitation, soil characteristics, and resilience against pests or diseases. To ensure the long-term sustainability and productivity of citrus farming, it is crucial to develop future strategies that effectively address these natural growing conditions.

4.2.7.1 Climate-resilient Citrus Cultivation

Climate change poses significant challenges to citriculture, including irregular rainfall, and increased occurrence of extreme weather events, especially at higher levels of warming and at low latitudes (Rosenzweig et al. 2014). Rising temperatures, drought, soil salinity and other adverse climate events are changing the environment where citrus varieties grow, which jeopardizes crop production and even the survival of plants in extreme cases (Balfagón et al. 2021). Negative impacts of climate change and natural disasters are especially evident in poor African countries compared to middle-income and more developed countries (Coulibaly et al. 2020). In this projection, efforts are made to implement risk management strategies to mitigate the impacts of extreme weather events, so that citrus crops and trees are resilient to climate change impacts. Resilient and heat-tolerant citrus varieties are developed or selected to withstand changing climatic conditions, such as heatwaves, droughts, and pest pressures, which helps farmers in vulnerable areas adopt these varieties for enhancing food production (Maheswari et al. 2019).

4.2.7.2 Organic Citrus Farming

To maintain favourable growing conditions, organic farming practices, such as the use of organic fertilizers, biological pest control, and crop rotation, are adopted to preserve soil health, ensure nutritional value, and enhance biodiversity. With a growing organic market worldwide (Reganold and Wachter 2016), compliance with organic certification standards ensures the integrity of organic citrus products. Soil management under organic farming is an effective strategy to maintain organic soil carbon content in Mediterranean citrus agriculture (Novara et al. 2019). Composting, erosion control and organic matter enhancement are employed to maintain soil health, fertility, and productivity. Increasing market demand for organic products provides incentives for farmers to transition to organic farming. Organically produced citrus fruits lead to a greater ability to synthesize Vitamin C, essential oils or higher seed numbers as well as are acceptable for the market since consumers increasingly associate organic crops with being healthier, tastier, and safer for the environment than conventional crops (Domínguez-Gento et al. 2023). Farmer education and agricultural technical training and incentive programs supported by policymakers concerned with agricultural sustainability issues are implemented to facilitate the adoption of organic practices (Beltrán-Esteve et al. 2012). In contrast to conventional farming, organic farming systems generate lower yields, but are more profitable, environmentally friendly, provide equally or more nutritious foods as well as deliver greater ecosystem services and social benefits. However, policy instruments will be required to facilitate the development and implementation of organic farming systems (Reganold and Wachter 2016).

4.2.7.3 Unfavourable Growing Conditions

Climate change is posing a number of challenges for the Mediterranean growing conditions, which makes it more difficult to grow citrus trees. In this projection, negative impacts on citrus production arise due to unfavourable natural conditions. Land degradation and urbanisation due to a massive increase in population lead to a loss of agricultural land, which threatens food security (Zdruli 2014). A decrease in citrus growing area is likely to have a significant impact on the CSC in the Mediterranean region. In addition, citrus fruits suffer yield loss due to temperature and water stress. A warmer climate, although favourable for the production of citrus, is also making it more difficult to control pests and diseases because it creates more favourable environments for infestation of pests and major diseases in citrus cultivation (Khan et al. 2023). These stresses cause negative changes in plant structure, leading to reduced growth, smaller fruit, and increased acidity. High temperatures can also affect leaf function and reduce photosynthesis. Interventions in farming practices to address these challenges don't show the expected impact (Shafqat et al. 2021).

Economic dimension

4.2.8 Efficiency of production means

The efficiency of production means is crucial for the future of CSC in the Mediterranean region. In addition to increasing yields, it promotes resource efficiency, cuts costs, supports environmental sustainability, and strengthens food security and resilience. By focusing on improving the efficiency of production means, stakeholders can foster a thriving and sustainable citrus industry in the Mediterranean.

4.2.8.1 Technology-driven Efficiency Gains

In this projection, the focus is on leveraging advanced technologies and practices to improve the efficiency of production means in the CSC. Farmers and processors can implement precision agriculture techniques to improve crop monitoring and enhance decision-making processes, which can lead to increased yield development at both farm and processor levels. Despite small margins and the growing concerns of the environmental impact of farming, precision agriculture techniques, such as remote sensing, big data analytics, automated machines, and real-time monitoring systems provide the means to optimise citrus yields and a better resource allocation (Duncan et al. 2021). Analysing data throughout the production process, enables informed decision-making and proactive management. Supply chain integration is enhanced through digital platforms, facilitating seamless communication and coordination among stakeholders.

By applying better agricultural practices, such as drip irrigation, water-efficient technologies, and robotic harvesting and sorting, the production of citrus fruits and farm incomes can be increased, while costs of production can be decreased. Automation and robotics in agriculture have the potential to significantly improve production resources and ensure sustainable agricultural production by efficiently harvesting, sorting, and packing fruits, which can help to reduce labour costs, improve product quality, and increase productivity. The notion of minimizing environmental impact while maximizing agricultural outputs offers a high potential for autonomous agricultural robotic systems to be widely implemented (Saiful Azimi et al. 2020).

4.2.8.2 Circular Gains and Collaboration

This projection focuses on enhancing the efficiency of resources in citrus production by implementing circular principles and adopting sustainable resource management practices in order to keep materials valuable. Resource mapping and optimization assessments can be employed to identify areas of resource inefficiencies and develop strategies to optimize resource utilisation. Applying circular practices, such as valorising agricultural waste for compost or the utilisation of by-products for bioenergy production or other products, can contribute to resource efficiency. The valorisation of citrus by-products offers great potential to enhance the value in the citrus processing chain since recovered bioactive compounds are useful for several industrial applications, such as in cosmetics, medicines, packaging, and bio-fuels (Panwar et al. 2021; Suri et al. 2022). Collaboration among stakeholders is crucial for knowledge sharing and establishing circular supply chain networks to optimize the use of production means, such as machinery, storage facilities, and transportation assets. Efficient coordination enables stakeholders to pool resources, share costs, and streamline operations, leading to reduced waste and downtime, while improving yield development and overall productivity in the supply chain. Energy efficiency measures and resource management strategies are implemented to optimize resource consumption. An economical and sustainable energy consumption can be achieved either by increasing productivity with the existing amount of energy inputs or by saving energy without affecting productivity (Oğuz and Oğuz 2022).

4.2.9 Logistical order fulfilment

Logistical order fulfilment plays an important role in the future of CSC. It impacts operational costs by optimizing logistics expenses, facilitates stakeholder integration through improved collaboration, enhances logistics processes for timely and accurate delivery, contributes to customer satisfaction by meeting expectations, and improves market competitiveness by adapting to market demands. Focusing on effective logistical order fulfilment enables the Mediterranean citrus industry to achieve operational efficiency, customer-centricity, and sustainable growth.

4.2.9.1 Smart Logistics and Traceability

This projection focuses on leveraging smart logistics and remote real-time tracking technologies to monitor the condition of goods and to optimize logistical order fulfilment within CSCs. IoT technology enables the collection of real-time data throughout the supply chain with end-to-end security, allowing stakeholders to trace the location and condition of fresh food shipments (Sergi et al. 2021) and ensure that it is delivered on time and in good condition. With this data, innovative predictive analytics can be implemented to enable supply chain managers to predict citrus yield (Moussaid et al. 2023) or anticipate and address potential disruptions, ensuring on-time delivery and customer satisfaction.

Supply chain and product visibility is improved through real-time process, and temperature and humidity tracking, enabling stakeholders to proactively address any bottlenecks, delays, or issues related to cold chain disruptions (Khumalo et al. 2023).

4.2.9.2 Collaborative Supply Chain Networks

This projection focuses on establishing collaborative supply chain networks to improve logistical order fulfilment within CSCs. Collaborative planning, innovation, forecasting, and product development are aspects of supply chain collaboration (Chauhan et al. 2022). Sharing of demand and supply information among stakeholders and establishing partnerships foster trust, coordination, and collaboration, leading to more accurate order fulfilment and inventory management. Efficient order management and collaborative process improvements, including order consolidation and batch processing, optimize order fulfilment and reduce lead times. Techniques such as collaborative planning, forecasting, and replenishment (CPFR) lead to increased financial and operational performance of the stakeholders (Hill et al. 2018).

A collaborative delivery network design involves strategically located hubs to minimise distances and enable faster deliveries. Cross-docking and collaborative distribution centres enable seamless transfer and consolidation of products, minimising handling and transportation costs.

4.2.9.3 Last-mile Delivery Optimisation

This projection focuses on optimizing last-mile delivery, the final leg of the supply chain, to enhance logistical order fulfilment within CSCs. Route planning and optimization algorithms enable efficient allocation of delivery resources, reducing travel time and costs as well as improving delivery efficiency.

The integration with vehicle scheduling and routing allows just in time delivery with minimum inventory holding and transportation costs, enhancing food distribution efficiency and providing better delivery services for time-sensitive biomasses at lowest logistics cost (Agustina et al.

2014). Additionally, alternative and sustainable cold storage concepts and delivery methods such as electric cargo bicycles, or drones are explored to overcome traffic congestion, reduce costs, and shorten last mile distances (Borghetti et al. 2022; Max Leyerer et al. 2020). Autonomous vehicles provide the means to transform food distribution systems (Heard et al. 2018), e.g. to deliver citrus products to retailers and consumers. The adoption of autonomous vehicles could help to improve the efficiency and safety of logistical order fulfilment as well as reduce the environmental impact of transportation. Customer-centric approaches, like flexible delivery time windows, real-time delivery tracking, and delivery preferences, enhance the overall customer experience and satisfaction. Integrating supply chain information with on-demand delivery platforms provides additional flexibility and scalability to meet changing customer demand patterns and increase service efficiency (Dai et al. 2020).

Political dimension

4.2.10 Regulations

Regulations for CSCs describe government policies and rules to be followed throughout the supply chain, from cultivation to distribution, to ensure environmental sustainability, fair trade, and quality standards. These policies play an important role in the future of the citrus industry since they can promote or hinder industry-wide adoption of sustainable practices, impacting the environmental, economic, and social dimensions. Excessive or poorly implemented regulations can also pose challenges for the citrus industry, leading to overregulated markets and decreased competitiveness of the Mediterranean citrus industry.

4.2.10.1 Sustainable Agricultural Policies

This projection focuses on the development and implementation of sustainable agricultural policies and environmental laws to regulate CSCs from a political perspective. Governments can introduce regulations that encourage farmers to adopt sustainable farming techniques, such as integrated pest management, proper water usage, and soil conservation techniques. Environmental impacts on the agricultural system, particularly in terms of output properties, yield losses and barriers for export can be consequences of such policies (Soliman 2013). Environmental regulations and restriction of substances can be enforced to ensure compliance with sustainability standards and reduce the environmental impact of production processes, while securing farmers’ profits (Picazo-Tadeo and Reig-Martínez 2007). Governments can also promote organic farming by providing incentives and support to farmers transitioning to organic practices. Water resource management policies can be implemented to safeguard water availability, avoid negative impacts of climate change on irrigation activities, and promote responsible water usage within CSCs. To ensure a balanced distribution of benefits among farmers and water institutions, the government takes a strong coordination role, which supports the farmers' adaptation to efficient irrigation activities (Kahil et al. 2015; Bartolini et al. 2010).

4.2.10.2 Food Safety and Quality Standards

Food safety and quality is a significant matter internationally. This projection focuses on political regulations aimed at ensuring food safety and maintaining high-quality standards within CSCs. Governments can establish and enforce food safety regulations to avoid low-quality and hazardous food products and protect consumers from health risks associated with citrus products (D. Krysanov 2010).

Quality control measures, including inspections and testing, can be adopted to maintain product quality throughout the supply chain (Gu Xue-zhu 2008). Certification and labeling requirements can be enforced to provide transparency and assurance to consumers regarding the origin, production methods, and quality of citrus products (Ibanez and Stenger 2000). Traceability systems can be mandated to track the movement of citrus products, enabling the recall of cargo or unsafe products, and ensuring quality and safety of organic products (Ji-yuan 2012). Additionally, consumer protection laws can be in place to safeguard consumer rights and ensure fair trade practices within CSCs.

4.2.10.3 Trade Agreements and Market Access

This projection focuses on political regulations related to trade agreements and market access for CSCs. Governments can align domestic political economy considerations with global trade partners and engage in negotiations to establish favourable trade agreements that promote the export and import of citrus products, ensuring market access for producers and reducing trade barriers such as tariffs and quotas (Jouanjean et al. 2016). Harmonization of regulations across countries can simplify compliance procedures for citrus producers and enhance trade flows. Governments can work towards aligning standards and technical measures as well as labelling requirements to minimise trade barriers, enhance market access for citrus products, but also restrict imports for certain substances (Devadason et al. 2018). Additionally, efforts can be made to improve trade facilitation measures such as streamlined customs procedures, reduced administrative burdens, and efficient logistics infrastructure to enhance the efficiency of cross-border citrus trade.

4.2.11 Geopolitical environment

This descriptor relates to the influence of political relationships and power dynamics between the Mediterranean and other countries. Diplomatic relations and geopolitical tensions can significantly influence the citrus industry.

4.2.11.1 Favourable Political Conditions

A stable geopolitical environment is favourable for a smooth functioning of the CSC in the Mediterranean since it supports consistent trade and cooperation between countries. Harmonised political conditions promote economic growth and stability in the Mediterranean region. Collaborative efforts among Mediterranean countries can lead to more resilient and interconnected CSCs, benefiting the citrus industry.

4.2.11.2 Unfavourable Political Conditions

Geopolitical uncertainties and conflicts may disrupt established CSCs or hinder the establishment of collaborative supply networks, which affects production, distribution, and market access for citrus products.

4.3 Scenario Building

The projections describing alternative future development paths are summarised in Table 3. To better distinguish between the projections in terms of their focus, descriptive keywords are provided.

Table 3: Summary of projections

STEEP	Key descriptor	Projection	Focus
Social	Social health and well-being	Harmony Initiative	social cohesion
			collaborative platforms
			solidarity
			shared responsibility
		Resilience Alliance	resilience through innovation
			adaptive capacity
			community engagement
			improved working conditions
	Sustainability awareness in the citrus supply chain	Eco-Educators	sustainability education and training
			knowledge dissemination
			stakeholder engagement
			sustainable practices
			fulfilment of consumer demands
		Sustainable Empowerment Network	marginalized stakeholders
			sustainable livelihoods
			social equity and inclusivity
			food security through sustainability
Technological	Technology adoption capabilities	Tech Integration Hub	digital training networks
			capacity building
			access to digital resources and technologies
		Innovation Sandbox	experimentation
			agile mindset
			technology scouting
			entrepreneurship
			digital innovation ecosystem
		Slow Adopters	adoption barriers
			fear of change
			lack of skilled labour
	Digitalisation in the supply chain	Digital Citrus Network	transparency and traceability
			data integration
			predictive analytics
			supply chain optimization
		Citrus E-Commerce Platform	online marketplaces
			customer engagement
			efficient order fulfilment
Environmental	Valorisation of secondary resources	Circular Citrus Bioeconomy	waste and byproducts valorisation
			resource recovery
			bioproducts
			closed-loop systems
			industrial symbiosis
		Waste-to-Energy Initiatives	renewable energy projects
			biomass conversion plants
	Environmental performance	Sustainable Farming Certification	sustainability standards
			best practices

			continuous improvement
			conservation agriculture
		Production Footprint Reduction	identification of emission hotspots
			logistics optimization
			carbon offset
	Natural citrus growing conditions	Climate-Resilient Citrus Cultivation	risk management strategies
			resilient citrus varieties
			precision agriculture
		Organic Citrus Farming	pest control
			soil and nutrition management
			increased organic market
			incentive programs
		Unfavourable Growing Conditions	severe climate change impacts
			less agricultural land
			decreased citrus yield
			pests and diseases
Economic	Efficiency of production means	Technology-Driven Efficiency Gains	advanced technologies
			optimised citrus yield
			resource allocation and productivity
			supply chain integration
			automation and robotics
		Circular Gains and Collaboration	resource management practices
			by-products valorisation
			collaborative resource pooling
	Logistical order fulfilment	Smart Logistics and Real-time Tracking	collection of real-time data
			supply chain and product visibility
		Collaborative Supply Chain Networks	sharing supply chain information
			collaborative process improvement
			cross-docking and product consolidation
		Last-Mile Delivery Optimization	route optimisation
			alternative delivery methods
			customer-centric approaches
Political	Regulations	Sustainable Agricultural Policies	sustainable farming policies
			environmental regulations
			water management regulations
		Food Safety and Quality Standards	quality control measures
			certification and labelling
			traceability requirements
			consumer protection laws
		Trade Agreements and Market Access	reduce trade barriers
			harmonize product compliance
			streamlined customs procedures
	Geopolitical environment	Favourable Political Conditions	stability and growth
			collaborative environment
		Unfavourable Political Conditions	uncertainties
			conflicts

A scenario consists of the selection of one projection for each descriptor. The 26 projections of the 11 descriptors theoretically can be combined into a total of 10.368 potential scenarios. However, the decisive factor for the credibility of possible future scenarios is their consistency, i.e. the absence of contradictions between the individual projections.

The main challenges in scenario building are assessing the credibility of different combinations of projections and aggregating coherent combinations of projections into a scenario. This approach is referred to as *consistency analysis*.

4.3.1 Pairwise Consistency Analysis

The evaluation of the consistency for each pair of projections is made by the members of the of the scenario project team. This is a subjective approach. However, the discussions around synchronization of the alternative projections are in themselves an added value of a scenario project (Gausemeier and Plass 2014). Every projection is evaluated with every other projection in terms of their compatibility. Values between -2 (inconsistent) and +2 (consistent) were assigned by the project consortium in a workshop.

Question:
How compatible (consistent) is projection i (row) with projection j (column)?

-2: strongly restricting influence (inconsistency)
-1: restricting influence
0: no influence (independent of each other)
+1: promoting influence
+2: strongly promoting influence (consistency)

Dimension	Key descriptors	Projections	Key descriptors	Social health and well-being		Sustainability awareness along the citrus supply chain		Technology adoption capabilities			Digitalisation in the supply chain		Valorisation of secondary resources		Environmental performance		Natural citrus growing conditions			Efficiency of production means		Logistical order fulfilment			Regulations			Geopolitical environment	
			Projections	Harmony Initiative	Resilience Alliance	Eco-Educators	Sustainable Empowerment Network	Tech Integration Hub	Innovation Sandbox	Slow adopters	Digital Citrus Network	Citrus E-Commerce Platform	Circular Citrus Bioeconomy	Waste-to-Energy Initiatives	Sustainable Farming Certification	Production Footprint Reduction	Climate-Resilient Citrus Cultivation	Organic Citrus Farming	Unfavourable growing conditions	Technology-Driven Efficiency Gains	Circular Gains and Collaboration	Smart Logistics and Traceability	Collaborative SC Networks	Last-Mile Delivery Optimization	Sustainable Agricultural Policies	Food Safety and Quality Standards	Trade Agreements and Market	Favourable	Unfavourable
Dimension	Key descriptors	Projections	Nr.	A1	A2	B1	B2	C1	C2	C3	D1	D2	E1	E2	F1	F2	G1	G2	G3	H1	H2	I1	I2	I3	J1	J2	J3	K1	K2
Social	Social health and well-being	Harmony Initiative	A1			2	1	2	0	0	1	1	2	2	1	1	0	0	-1	0	1	2	2	1	1	1	0	0	0
		Resilience Alliance	A2			2	2	1	1	-2	2	2	2	2	2	2	2	1	-1	1	2	1	2	1	1	1	0	0	0
	Sustainability awareness along the citrus supply chain	Eco-Educators	B1	2	2			2	1	-1	0	0	2	2	2	2	2	1	-1	1	2	2	2	2	1	1	0	1	-1
		Sustainable Empowerment Network	B2	2	2			1	1	-1	0	0	2	2	2	2	2	1	-1	1	2	2	2	1	1	1	1	0	0
Technological	Technology adoption capabilities	Tech Integration Hub	C1	2	2	1	1				2	1	2	2	1	2	2	1	0	2	1	2	2	1	0	1	0	0	0
		Innovation Sandbox	C2	0	1	1	1				2	1	2	2	1	1	1	1	-2	2	2	1	1	1	1	0	0	0	0
		Slow adopters	C3	-1	-1	0	0				-2	-1	-2	-2	0	-1	-1	0	0	-2	-2	-2	-2	-1	0	0	0	0	0
	Digitalisation in the supply chain	Digital Citrus Network	D1	1	2	0	1	1	1	-2			1	0	0	2	0	0	0	2	1	2	2	1	0	1	2	1	-1
		Citrus E-Commerce Platform	D2	0	0	1	1	2	0	-1			1	0	1	1	0	1	-1	1	1	1	1	2	0	1	2	0	0
Environmental	Valorisation of secondary resources	Circular Citrus Bioeconomy	E1	0	1	2	2	2	2	-2	2	2			2	2	0	2	-1	1	2	2	2	0	2	2	2	0	0
		Waste-to-Energy Initiatives	E2	1	1	2	2	2	2	-1	1	1			0	2	0	0	0	1	2	0	0	0	1	0	0	0	0
	Environmental performance	Sustainable Farming Certification	F1	2	2	2	2	2	2	-2	2	2	2	1			2	2	-2	1	2	1	1	0	0	1	1	0	0
		Production Footprint Reduction	F2	2	0	2	2	2	2	-2	2	2	2	2			1	1	-1	2	2	2	1	2	0	0	1	0	0
	Natural citrus growing conditions	Climate-Resilient Citrus Cultivation	G1	0	1	2	2	2	2	-1	2	0	2	2	2	1				0	0	0	0	0	1	0	0	0	0
		Organic Citrus Farming	G2	2	1	2	2	1	2	-2	0	0	1	0	2	2				1	2	1	1	0	0	1	1	0	0
		Unfavourable growing conditions	G3	-1	-2	2	-1	2	2	-2	1	0	2	1	2	1				-1	-1	-1	-1	-1	2	2	2	0	0
Economic	Efficiency of production means	Technology-Driven Efficiency Gains	H1	0	1	0	0	0	1	0	0	0	2	2	1	2	1	1	0			2	2	2	0	0	0	0	0
		Circular Gains and Collaboration	H2	2	1	1	2	1	1	0	1	1	1	1	1	1	1	1	-1			1	2	2	1	1	1	0	0
	Logistical order fulfilment	Smart Logistics and Traceability	I1	0	0	0	0	1	2	-2	2	2	2	1	0	2	0	0	0	2	1				1	2	2	0	0
		Collaborative Supply Chain Networks	I2	2	2	1	1	1	1	-2	2	2	2	2	2	1	1	1	-1	2	2				0	0	1	0	0
		Last-Mile Delivery Optimization	I3	0	0	1	1	1	1	-1	1	1	0	0	0	2	0	0	0	1	1				0	0	0	0	0
Political	Regulations	Sustainable Agricultural Policies	J1	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	0	0	2	1	1	0				1	1
		Food Safety and Quality Standards	J2	2	2	2	2	1	2	-1	2	0	2	2	2	1	1	2	0	0	1	1	2	0				1	1
		Trade Agreements and Market Access	J3	2	2	2	2	1	1	-2	2	2	2	0	2	1	1	2	0	0	1	2	2	0				2	2
	Geopolitical environment	Favourable	K1	2	2	1	1	2	2	-2	2	2	2	2	2	2	1	2	0	2	2	2	2	0	2	2	2		
		Unfavourable (wars, demographical changes, immigration...)	K2	-2	-2	-2	-2	-2	-2	1	-2	-2	-1	1	-1	1	0	0	0	1	-1	0	-1	0	-1	-1	-2		

Figure 4: Consistency Analysis Matrix

4.3.2 Scenarios

To handle the complexity (10.368 potential scenarios), the ScenarioWizard software was used. The values from the consistency analysis matrix were transferred to the software, which has identified 5 scenarios.

Szenario Nr. 1	Szenario Nr. 2	Szenario Nr. 3	Szenario Nr. 4	Szenario Nr. 5
Soc: Social health and well-being: Resilience Alliance	Soc: Social health and well-being: Harmony Initiative	Soc: Social health and well-being: Resilience Alliance	Soc: Social health and well-being: Harmony Initiative	
Soc: Sustainability awareness along citrus supply chains: Sustainable Empowerment Network			Soc: Sustainability awareness along citrus supply chains: Eco-Educators	
Tec: Technology adoption capabilites: Tech Integration Hub	Tec: Technology adoption capabilites: Innovation Sandbox	Tec: Technology adoption capabilites: Tech Integration Hub	Tec: Technology adoption capabilites: Slow Adopters	
Tec: Digitalisation in the citrus supply chain: Digital Citrus Network	Tec: Digitalisation in the citrus supply chain: Citrus E-Commerce Platform	Tec: Digitalisation in the citrus supply chain: Digital Citrus Network	Tec: Digitalisation in the citrus supply chain: Citrus E-Commerce Platform	
Env: Valorisation of secondary resources: Circular Citrus Bioeconomy			Env: Valorisation of secondary resources: Waste-to-Energy Initiatives	
Env: Environmental performance: Sustainable Farming Certification	Env: Environmental performance: Production Footprint Reduction	Env: Environmental performance: Sustainable Farming Certification		
Env: Natural citrus growing conditions: Climate-Resilient Citrus Cultivation	Env: Natural citrus growing conditions: Unfavourable Growing Conditions	Env: Natural citrus growing conditions: Organic Citrus Farming	Env: Natural citrus growing conditions: Unfavourable Growing Conditions	
Econ: Efficiency of production means: Circular Gains and Collaboration	Econ: Efficiency of production means: Technology-Driven Efficiency Gains	Econ: Efficiency of production means: Circular Gains and Collaboration		
Econ: Logistical order fulfilment: Last-Mile Delivery Optimisation	Econ: Logistical order fulfilment: Collaborative Supply Chain Networks	Econ: Logistical order fulfilment: Last-Mile Delivery Optimisation		Econ: Logistical order fulfilment: Smart Logistics and Traceability
Pol: Regulations: Trade Agreements and Market Access			Pol: Regulations: Food Safety and Quality Standards	Pol: Regulations: Sustainable Agricultural Policies
Pol: Geopolitical environment: Favourable			Pol: Geopolitical environment: Unfavourable	

Figure 5: Scenarios (obtained from ScenarioWizard software)

However, when comparing the scenarios, it is obvious that some scenarios are very similar to each other and differ only in one or two projections. Therefore, scenarios 1 and 3 as well as scenarios 4 and 5 were merged, resulting in three distinguishable final scenarios – an optimistic (green), a pessimistic (red), and a neutral (orange) scenario.

4.4 Performance Indicators

To adequately monitor the future implementation of the scenarios, key performance indicators (KPIs) were assigned to the key descriptors.

STEEP	Key descriptor	Monitoring KPIs
Social	Social health and well-being	• % of female personnel • employment rate • working hours (on farm)
	Sustainability awareness in the citrus supply chain	• % of qualified personnel • % of training hours per worker
Technological	Technology adoption capabilities	
	Digitalisation in the supply chain	
Environmental	Valorisation of secondary resources	• loss rate (% or tonnes) • generation of waste in kg • % of vertical/horizontal integration of stakeholders (industrial symbiosis)
	Environmental performance	• change in water use (%) • amount of water (m^3ha) • CO_2eq/kg citrus
	Natural citrus growing conditions	
Economic	Efficiency of production means	• output value of citrus production (e.g. fresh fruits and valorised by-products) • operational efficiency (%, decrease of resource use and/or increase of yield)
	Logistical order fulfilment	• operational costs (for conventional and organic citrus processing) • cost increase (%)
Political	Regulations	• consumption increase (%) • ratio of local and abroad customers (%) • market share growth
	Geopolitical environment	

These KPIs are proposed for the purpose of the ImPUISe project. There are plenty of other potential KPIs that could be used. However, not all key descriptors require KPIs in order to be able to track the progress of the implementation of a scenario. Instead, only a few KPIs should be selected for this purpose to avoid complexity and make data collection manageable.

5 Conclusion and Outlook

This deliverable introduces scenarios for the citrus industry, considering socio-economic factors, driving forces, environmental challenges, and digitalisation possibilities in CSCs. Literature analysis and insights from the ImPUlSe project were used to identify trends and potential development paths. The scenarios aim to align business priorities with the regional and global citrus industry environment, fostering innovation adoption and unlocking transformation potential in citrus by-products supply chains. Three alternative scenarios were generated following the Gausemeier scenario planning method – a positive scenario, a negative scenario, and a neutral scenario. They offer a detailed exploration of the challenges and opportunities in CSCs, emphasizing the need for innovation, collaboration, and strategic planning under the principles of circular economy and sustainability.

Subsequent analysis will include the development of sustainable business models for the Mediterranean citrus sector based on the developed scenarios. Furthermore, these scenarios will be evaluated in the terms of benefits and challenges as well as probability of occurrence and impacts in the fifth phase of the scenario planning process.

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