# RATIONALISATION OF TRANSPORT OF PERISHABLE GOODS AND FOODSTUFFS, THROUGH EFFICIENT TRANSPORT SUPPLY CHAINS

*Dimitrios Tsamboulas, Professor (Corresponding author)*

*National Technical University of Athens, School of Civil Engineering, Department of Transportation Planning and Engineering.*

*5, Heroon Polytechniou Str., Zographou, Athens, GR-15773, Greece, Tel.: +30 2107721367, Fax: +30 2107722404, E-mail: dtsamb@central.ntua.gr*

*Anna-Maria Lekka, Research Associate*

*National Technical University of Athens, School of Civil Engineering, Department of Transportation Planning and Engineering.*

*5, Heroon Polytechniou Str., Zographou, Athens, GR-15773, Greece, Tel.: +30 2107721155, Fax: +30 2107722404, E-mail: alekka@central.ntua.gr*

*Aikaterini Rentziou, PhD candidate*

*National Technical University of Athens, School of Civil Engineering, Department of Transportation Planning and Engineering.*

*5, Heroon Polytechniou Str., Zographou, Athens, GR-15773, Greece, Tel.: +30 2107721155, Fax: +30 2107722404, E-mail: krentz@central.ntua.gr*

# ABSTRACT

The economies of the Mediterranean Countries are very much dependent on agriculture; therefore, the trade liberalization process is a significant stimulus for them, while the efficiency and effectiveness of the supply chain of perishable goods and foodstuff constitute substantial elements for the regions' competitiveness and economic growth. In addition, the supply of fresh produce is becoming increasingly competitive with latest market trends indicating that competition between individual firms is being replaced by competition between supply chains. In light of the above, the objective of the paper is to propose a procedural framework for the rationalization of perishable goods and foodstuffs transport systems in the Mediterranean. The framework presents a viable, efficient and competitive transport supply chain for perishable goods and foodstuffs, ensuring product quality and sustainability, particularly for the transport within EU member states. The latter is achieved through an evaluation by use of a Multi-Criteria Analysis, which will ultimately provide valuable benchmarks for improved supply chains compared to those existing. The development of such efficient supply chains would result in enhancing the trade among EU and Mediterranean countries, contributing, thus, ultimately to the economic growth of the Mediterranean countries.

*Keywords: transport supply chain, perishable goods and foodstuffs, multi-criteria analysis, Mediterranean region*

# INTRODUCTION

Perishable goods and foodstuffs have the unique characteristic that they lose their value with time. On the other hand, the consumers' preferences for perishable goods and foodstuffs are influenced by price and quality (freshness/expiration date). In addition, they are characterized by a high level of type differentiation, seasonality and spatial dispersion of flows, caused by the variety of production areas and bodies. Market data has shown that the demand for such products in Europe is more segmented than elsewhere, leading to a greater necessity to import goods from abroad.

At the same time, Mediterranean countries are gaining momentum with regard to the production of agro-food perishables goods. Nevertheless, fragmentation of logistic chains, small size operators and lack of intermodality are the key issues characterizing the transportation of perishable goods and foodstuff between South Mediterranean countries (the producers) and Central Europe (the consumers). The need arises, therefore, for a unified approach in terms of concentrating and integrating perishable goods flows in the area in order to avoid diseconomies and negative impacts.

Based on the above, the present paper aims at the rationalization of the transport of perishable goods and foodstuffs supply chain systems in the Mediterranean region, through the development of a viable, efficient and competitive transport supply chain and related logistics services, ensuring product quality, safety and sustainability. The proposed methodology makes use of a multi-criteria analysis for evaluating(and benchmarking) potential

perishable goods and foodstuffs supply chains in the Mediterranean area with the scope to determine the most viable and efficient ones. For demonstration purposes, the methodology is applied to two transport corridors operating between South Mediterranean countries and Europe.

# TRENDS AND STRUCTURE OF PERISHABLE GOODS AND SUPPLY CHAIN IN MEDITERRANEAN COUNTRIES

## Background

Perishable goods and foodstuff need, by their very nature, highly efficient supply lines for storage and fast transport through the supply chain so that commodities reach consumers at optimum quality, freshness and shelf-live levels. Although improved refrigeration technology has made the time factor somewhat less critical (Nordtvedt, 2009), perishable goods continue to be particularly sensitive with regard to on-time reliability (Patterson et al., 2008). In addition, the market requires product homogeneity, continuous deliveries, quality upgrading and stable shelf-life. The most relevant critical aspects affecting fresh-food products are the following (Bruzzone et al., 2009):

- Perishability, which implies the need for very rapid logistics processes.
- The very high level of organoleptic quality and freshness, which implies hard constraints for cost reductions.
- Traceability, required among the goods to be distributed, as well as controls for guaranteeing supply chain safety and security.
- Special processes required for preparing food along the supply chain: slaughtering, meat cutting, packaging or modified atmosphere packaging (MAP).
- Strong seasonal behaviour of demand and production, which introduces a continuous evolution in the product mix, as well as the necessity to organise a robust and flexible logistics network.
- Difficulty in creating an efficient and optimised platform due the interaction of many logistics flows.
- Presence of direct distribution flows from producer to final consumer (stores).

Food and agribusiness supply chains and networks are now rapidly moving towards globally interconnected systems with a large variety of complex relationships; this also affects the ways in which food is produced, processed and delivered to the market (Gustafsson *et al.*, 2006).

In the Mediterranean area, trade has been an on-going activity for centuries, while Mediterranean countries' economies are very much dependent on agriculture. Therefore, the trade liberalization process is a significant stimulus for them (Petit, 2006). In addition, South Mediterranean countries (which are not EU member states) have comparative advantages over the southern EU countries, especially in the perishable goods and foodstuff trade. Despite a slight decreasing trend in the last years in exports, South Mediterranean countries constitute a significant trading partner of the European Union in the fruit and vegetables sector with a 9% share of imports to EU (Kalaitzis *et al.*, 2007).

In addition, a Euro-Mediterranean policy is taking form to build a Euro-Mediterranean logistics area of effective and sustainable growth. Numerous related programmes and initiatives have

been developed , such as the Regional Transport Action Plan (RTAP) and the Mediterranean Sea Basin Programme, together with regional projects, such as the AGRO-ENVIRONMED, MEDNET - Mediterranean Network for Custom Procedures and Simplification of Clearance in Ports, FREEMED - Free Trade Zones in the Mediterranean Basin, MEDA TEN-T - Mediterranean Trans-European Networks for Transport, VEG-i-TRADE - Impact of climate change and globalisation on safety of fresh produce governing a supply chain of uncompromised food sovereignty, SFECT - Supervising of food during European-wide cool transport and the SUSFOOD - food supply chain with main focus on food chain sustainability, etc.

Despite the above, the South Mediterranean countries' industry of perishable goods and foodstuff is typically characterized by small scale producers, while the Euro-Mediterranean trade of related products is small, asymmetrical and fragmented (Garcia *et al.*, 2008). The production structures and control systems that exist in the Mediterranean countries (especially non-EU countries) are rather unsophisticated and, consequently, the perishable goods and foodstuffs imports from South Mediterranean countries play a less important or niche role in the European markets, where the majority of the related products originate from Southern European Mediterranean countries. Another cause of fragmentation is linked to the bilateral nature of the trade arrangements between South Mediterranean countries and the EU and International standards. More specifically, knowledge of evolving standards is often lacking (Busch *et al.*, 2000), and South Mediterranean countries lag in their capacity for effective certification and accreditation of testing facilities (Stephenson, 1997).

An additional problem affecting the perishable goods industry of the Mediterranean countries is the transport-related bottlenecks, at infrastructure, operational and administrative level, as well as lack of harmonisation of procedures and cross-border cooperation.

Such conditions endanger the quality of fresh produce, which is one of the most essential food product characteristics throughout the supply chain (Smith and Sparks, 2004), since due to its perishable nature, the industry must operate at a faster pace. To this end, quality and safety control of perishable goods is a formidable challenge for the South Mediterranean countries, and differences in technical requirements and/or conformity assessment procedures make often the process of quality certification very difficult , influencing trade relations with European countries. Trienekens and Zuurbier (2008) claim that quality assurance is expected to dominate the process of production and distribution in food chains in the future.

## Supply and Consumer Trends

Suppliers of fresh produce are less able to differentiate their products at the consumer level. They are in a weak bargaining position as price differentiation is almost the only available strategy. Suppliers are also often forced to accept low prices in order to get volume growth, which does little to improve their immediate and long-term financial performance (Garcia, 2007). These trends are common to most countries, but are more severe in South Mediterranean countries, where small suppliers are mainly dealing with middle-men having no direct contact with the consumers and their preferences.

On the other hand, consumers ask for a variety of products, while also changing references, food preferences, buying habits, and lifestyle pushing for easy to prepare products. All these

changes in the marketplace present significant challenges to retailers and manufacturers to project demand, plan manufacturing and also meet supply in a timely manner (Kumar and Nigmatullin, 2001). Seasonality adds even more complexity to the food supply chain through fluctuating consumer demand and availability of raw products (Georgiadis *et al*. 2005). These are requirements that producers in South Mediterranean countries simply cannot meet with their current structure and supply chain processes.

## Supply Chain Structure

The critical components of fruit and vegetable supply chains include supply, demand, and price for supply chain members including farmers, wholesalers, and retailers. Price variability at all levels of supply chain occurs due to dynamic factors, such as substitute goods price, inflation, import, export, production costs, customer demands (Teimoury *et al.,* 2013). Ahumada and Villalobos (2009) identify two main types of agricultural supply chains: fresh agri-foods supply chain and non-perishable agri-foods supply chain. They review fresh products owing to their logistical complexity, their limited shelf life, and the renewed interest of the public on the safety of these products.

Food systems in developing countries are not always as well organised and developed as in the industrialised world, and moreover, knowledge of standards is often lacking (Briz *et al.* 2005). This is the case in most South Mediterranean Countries. Food safety is more likely to be a concern in fresh food products destined for international trade than in other types of agricultural trade (Unnevehr, 2000). The latter constitutes a key concern for the fragmented and dispersed producers of fresh produce in South Mediterranean countries.

In most countries of the region, supply chain structures in the fruit and vegetable sector are in a stage of shifting from government controlled institutions towards increased participation of private structures. Exports are handled mainly through independent commissioners who work on the basis of consignments and operate on spot markets (central wholesale markets), or through larger buying/packing houses, which are focusing on supplying either wholesalers in importing countries or buying centres of retail chains and other large institutional buyers that apply modern supply chain management methods (Kalaitzis *et al.*, 2007).

A typical supply chain for fresh agricultural products in developing countries, as is the case of South Mediterranean countries, is presented in Figure 1 (Vanany *et al,* 2010).

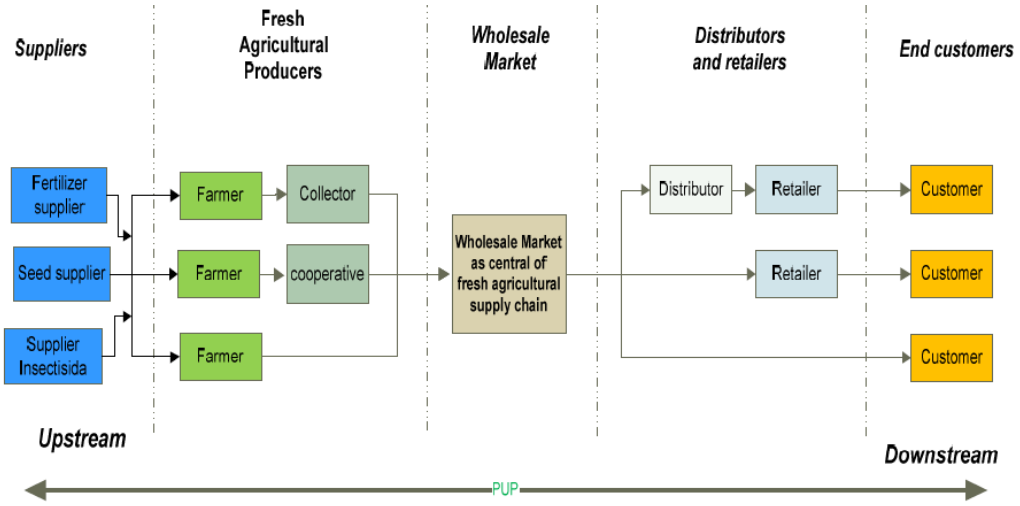


Figure 1: Structure of fresh agriculture produce supply chain

Despite what was described in this section, the identification of a sustainable supply chain developed for perishable and foodstuffs in the Mediterranean area has yet to be accomplished. On the other hand, most of the related literature is dealing with sophisticated supply chains, including the domain of perishable goods and foodstuffs. In addition, in developing an optimum supply chain, all transport systems are assumed to operate efficiently, while the focus is shifted towards logistics operations. Nevertheless, this is not a common scenario for South Mediterranean countries, where a targeted approach is required.
In light of the above, the specific characteristics of this type of commodity in combination with its requirements render the development of a supply chain suitable for these goods transported between South Mediterranean area and central Europe essential. The present analysis focuses, therefore, on the development of a methodology for the identification of the most viable and efficient supply chain for transport of perishable goods and foodstuffs for these specific origin-destination corridors.

# METHODOLOGY

The methodology developed focuses on the identification of an improved -as it concerns its performance-supply chain for the transport of the perishable goods and foodstuffs between the South Mediterranean area and central Europe. It consists first of the identification of all existing perishable good supply chains in a specific region of the Mediterranean, followed by a multi-criteria analysis, which, based on appropriate indicators/criteria, will evaluate the effectiveness of each selected supply chain in terms of viability, efficiency and competitiveness. The key objective of the methodology is the selection of the best performance supply chains in terms of viability and efficiency, by measuring the benefits and costs of the system's operation with regard to economies of scale and added value.
A multi-criteria analysis (MCA) was employed due to its distinct advantages of dealing with discretionary or intangible impacts that cannot be directly translated to monetary units. A

qualitative rather than quantitative approach is, therefore, followed, due to the difficulty in assigning quantitative measures to the supply chain characteristic criteria that will be examined in this paper. Another main advantage of the multi-criteria analysis is that the different criteria included can be combined to determine a single deciding value (as in cost-effectiveness analysis), or can be treated individually without aggregation (as in compatibility analysis). To this end, the proposed MCA comprises of five distinct steps, described in detail in the following.

## Step 1: Criteria Selection

The first step includes the identification of the assessment objectives, that is, the selection of appropriate criteria and sub-criteria together with their way of measurement. Several types of criteria exist to measure supply chain and logistics activities. For the purpose of this analysis, four main categories of criteria have been selected by the authors to cover all aspects of the perishable food supply chain in the area under study, as per the related literature. In particular, the criteria chosen are the ones that bear more relevance to the Mediterranean region and the types of transport supply chains that are currently operating or proposed to be operational in the area. In addition, they are easy to be measured, given the limited availability of data in the region. These are the following:

- Quality: These criteria are often the simplest to implement and measure. They usually indicate the level of performance of a specific activity.
- Time: These criteria focus on the time it takes to complete specific activities in comparison to the overall supply chain performance.
- Financial: These criteria assist in the determination of costs and the development of more efficiently managed supply chains.
- Productivity: These criteria examine the level of use of human resources.

Related sub-criteria under the above categories were also selected. The criteria and related sub-criteria are presented in Table 1, together with their units of measurement.

Table 1-Supply Chain Evaluation Criteria

| ***Criteria Category*** | ***Sub-Criteria*** | ***Sub-Criterion Number*** | ***Unit of Measurement*** |
|---|---|---|---|
| Quality | Produced Products that meet standards of fresh food products Regulations | $C_1$ | tons/year |
| | Fresh food products registered in country | $C_2$ | No of different products |
| | Shipping Accuracy | $C_3$ | % |
| | Order Compliance | $C_4$ | -1(not satisfactory) to+1(very good) |
| | Picking Accuracy | $C_5$ | -1(not satisfactory) to+1(very good) |
| | Security Measures | $C_6$ | yes/no |
| | Adequate Shelf Life | $C_7$ | yes/no |
| | Stock Rate | $C_8$ | % (with 100% maximum) |
| | On time arrivals | $C_9$ | % |
| | Shipments arriving in good conditions | $C_{10}$ | % |
| | Traceability (traceability systems) | | Yes/no |
| Response Time | Purchase Order Issue | $C_{11}$ | Hrs |
| | On-time delivery | $C_{12}$ | yes/no |
| | Supplier lead-time variability | $C_{13}$ | low-medium-high |
| | Loading/ unloading time | $C_{14}$ | Hrs |
| | Warehouse order processing time | $C_{15}$ | Hrs |
| | Customs clearance cycle | $C_{16}$ | Days |
| | Order Entry Time | $C_{17}$ | Hrs |
| Cost/ Financial | Total supply cost | $C_{18}$ | Euro |
| | Total warehousing cost | $C_{19}$ | Euro |
| | Value of product not damaged | $C_{20}$ | Euro |
| | Average transportation cost per km/ ton | $C_{21}$ | euro/km/tons |
| | Ratio of transportation cost to value of product per ton | $C_{22}$ | ratio (%, with the lowest better) |
| Productivity | Average number of products processed | $C_{23}$ | No of products |
| | Storage space utilization | $C_{24}$ | Sqm |
| | Vehicle use availability | $C_{25}$ | No of vehicles |
| | Container capacity utilization | $C_{26}$ | % |
| | Average number of stops per route | $C_{27}$ | No of stops |

## Step 2-Weighting of criteria

The weighting technique includes the estimation of criteria related weights (criteria will be weighted against each other). For the purpose of this application, the Paired Comparison Approach was chosen. This is a scaling approach (Lootsma, 1988), and is employed in order to derive criteria weights by answering the question "is this criterion more important than the other?". This allows for a paired comparison matrix (see for example Table 2) to be filled with zero's (0) and one's (1), where one represents "is more important".
The elements Aij where $i \neq j$ will be completed in columns according to the paired comparison method- with 1 if *i* is more important than *j* or else with 0. In the absence of any specific instruction given by the method, the value 0.5 is set for the elements Aij where *i=j*.
By adding these values over a matrix column, a measure is obtained for the degree to which a criterion is important compared to all other criteria. Finally, these measures are standardised, and a set of criteria weights is created. For the purpose of the present analysis, the following standardization equation was used:

$$\text{Standardised score } w_i = \frac{'raw'\ score..w_i}{\sum 'raw'\ scores} \qquad (1)$$

To this end, each 'raw' score is divided by the sum of all 'raw' scores. This type of transformation is particularly appropriate for standardising various sets of different criterion weights, since the application of equation (1) implies that all weights will add up to unity.

Table 2-Pair Comparison Matrix (* $W_i$: Weight/ Importance of Criterion i)

| | $W^*_1$ | $W_2$ | $W_3$ |
|---|---|---|---|
| $W_1$ | $A_{11}$ | $A_{12}$ | $A_{13}$ |
| $W_2$ | $A_{21}$ | $A_{22}$ | $A_{23}$ |
| $W_3$ | $A_{31}$ | $A_{32}$ | $A_{33}$ |

## Step 3- Estimation of criteria levels in physical scale.

At this stage the scores (degree of performance) for each criterion are estimated, according to the data collection process carried out for the purpose of the current analysis. For the quantitative criteria, the physical scale of performance is measured as a change in comparison with the reference case and not as an absolute value. For the qualitative criteria, the physical scale of performance is measured in a "verbal" scale with 2 or more discrete points, i.e. yes/no or very good/good/satisfactory/not satisfactory, etc.

## Step 4-Estimation of criteria/impact levels in artificial scale

To make the various criterion scores compatible in order to facilitate their aggregation, it is necessary to transform these into one common measurement unit, for example forcing each

criterion score to take values between [-1,1], by making use of the so called utility functions of the following form:

$$UCj = \begin{cases} +PCj/A, & \text{if } P > 0 \\ 0, & \text{if } P = 0 \\ -PCj/B, & \text{if } P < 0 \end{cases} \quad (2)$$

where:
j: criterion number
Cj: criterion j
PCj: Physical (real) performance of criterion j (measured as a change in comparison with the reference case or as an absolute value)
UCj: Artificial (after transformation) performance of criterion j
A, B: Constant variables that either depend on measurement thresholds or are set by the relevant decision makers

The qualitative criteria scores are derived by ranking the "verbal" physical performances from the "worst " to the "best", and then assigning the values of artificial scale from the lowest to the highest values, respectively, as in the following example:

-1 No
+1 Yes
or
-1 Not satisfactory
+0,25 Satisfactory
+0.5 Good
+1 Very Good

## Step 5- Aggregation

The final step includes the aggregation of all weighted criterion scores to estimate the total score of the system's overall performance. Weighted summation of criterion scores takes place by applying Multiple Attribute Utility Theory (MAUT). The final score is calculated by equation (3), using the results of Steps 2 and 4.

$$T.P. = \sum_{j=1}^{J} W_j * U_j \quad (3)$$

where:
j: criterion number
Wj: criterion weight
Uj: Artificial performance of criterion j

T.P. : Total performance score

### Final Result

The main output of the proposed methodology will be the evaluation of one or more proposed supply chains for the exports/imports of perishable goods and foodstuffs from/to the South Mediterranean countries. In addition, the proposed methodology can render a ranking/prioritized list of selected supply chains, based on their respective scores, providing thus a sound basis for rationalization of the fresh food supply chain transport system of a particular area. This analysis can also act a valuable tool for benchmarking best practices in the development of similar perishable goods and foodstuffs transport corridors in other regions.

## APPLICATION

The proposed methodology was applied to two different supply chains in two countries in the Mediterranean region. In order to ensure comparable results, the two supply chains were selected in terms of type of perishable good transported and origin/destination. The perishable good was selected based on the percentage of export of the specific country, in order to ensure that the specific supply chain is indicative for the region under study. To this end, the application focused on the analysis of two transport corridors between two Mediterranean countries, that is, Morocco and Tunisia and an EU country, France. The key perishable good transported between these countries is citrus. A desk research survey of available statistics, related studies and papers was carried out in order to measure selected criteria, whereas criteria weights were selected based on preferences expressed by experts (transport operators, merchants, export and import institutions, food manufactures, food retailers) from the countries under study.

### Case 1: Morocco - France

Citriculture represents an important branch of the Moroccan economy, while the citrus production is mostly based on export. Export quantities are close to 500 000 Mt/ year and they somewhat vary from year to year, representing 40 to 50 % of the total production. From the authors' survey, it is clear that most citrus growers try to export as much of their crop as possible because of the greater returns obtained on the export market than on the domestic market. However, with Morocco's population increasing, the production being relatively stagnant, and the power of buying of the consumer increasing, the prices in the domestic market will continue to improve unless export prices drop suddenly for some unexpected reason or the production increases so dramatically. Citrus export is based on quality standards, and products that do not meet these standards are sold in the domestic market. Rotten or broken fruit is destroyed, while very little quantity goes to juicing. One of the main reasons is that the cost of production cannot be offset by the prices offered by juice

processing. The destinations of Morocco citrus exports have also changed over the years. Among the EU countries, France, the Netherlands and Great Britain constitute the main importers (El-Otmani et. al., 2007).

## Case 2: Tunisia - France

The major part of the production of citrus in Tunisia is sold in the domestic market (80 to 90%) where prices are determined by competition. However, high prices on the domestic market can discourage producers to look at export, in spite of the incentive measures taken by the government towards the product's export. Citrus fruit exports hold a share ranging between 2 and 3% in the total agro-food exports. Approximately, 90% of citrus in the fresh form are exported to the French market (Laajimi and Mimoun ,2007)

## Evaluation Results

The evaluation was carried out for the two supply chains and results are presented in Tables 3 and 4, for Morocco-France and Tunisia-France corridors, respectively. According to the evaluation results, the estimated total score for corridor 1 is slightly higher than the one estimated for corridor 2, thus indicating that the supply chain for citrus between Morocco and France is the most viable and efficient, at least marginally. This is also validated by the fact that Morocco has acquired significant expertise in the exporting of the citrus over the years. Statistically, Morocco is the 3rd largest exporter of citrus over the region in contrast to Tunisia, which is at the 6th place of exporting countries (EuroMedCitrusNet, 2007). To this end, the Morocco-France citrus supply chain can be used as a benchmark case/ "best practice" for all countries transporting this particular commodity in the region. This will provide valuable guidance for decisions with regard to loading/unloading times, warehouse order processing times, and the ratio of transportation cost to value of product, etc.

Table 3- Case 1 Evaluation Results

| ***Criteria Category*** | ***Sub-Criterion Number*** | ***Sub-Criterion Value*** | ***Weight of Criterion*** | ***Weight of Sub-Criterion*** | ***Weighted Score per Sub-Criterion*** |
|---|---|---|---|---|---|
| Quality | $C_1$ | 0.25 | 0.2 | 0.03 | 0.0075 |
| | $C_2$ | 1 | | 0.01 | 0.01 |
| | $C_3$ | 0.25 | | 0.02 | 0,005 |
| | $C_4$ | 1 | | 0.01 | 0,01 |
| | $C_5$ | 0.5 | | 0.02 | 0.01 |
| | $C_6$ | 1 | | 0.03 | 0.03 |
| | $C_7$ | 0.25 | | 0.02 | 0.005 |
| | $C_8$ | 0.5 | | 0.02 | 0.01 |
| | $C_9$ | 0.25 | | 0.02 | 0.005 |
| | $C_{10}$ | 1 | | 0.02 | 0.02 |
| Response Time | $C_{11}$ | 0.25 | 0.4 | 0.04 | 0.02 |
| | $C_{12}$ | 1 | | 0.06 | 0.06 |
| | $C_{13}$ | 0.5 | | 0.08 | 0.04 |
| | $C_{14}$ | 0.5 | | 0.07 | 0.035 |
| | $C_{15}$ | 1 | | 0.04 | 0.04 |
| | $C_{16}$ | 0.25 | | 0.05 | 0.0125 |
| | $C_{17}$ | 0.25 | | 0.06 | 0.015 |
| Cost/ Financial | $C_{18}$ | 1 | 0.3 | 0.08 | 0.08 |
| | $C_{19}$ | 0.5 | | 0.04 | 0.02 |
| | $C_{20}$ | 0,6 | | 0.07 | 0.042 |
| | $C_{21}$ | 0.25 | | 0.06 | 0.015 |
| | $C_{22}$ | 1 | | 0.05 | 0.05 |
| Productivity | $C_{23}$ | 0.5 | 0.1 | 0.03 | 0.015 |
| | $C_{24}$ | 0.25 | | 0.01 | 0.0025 |
| | $C_{25}$ | 0.25 | | 0.02 | 0.005 |
| | $C_{26}$ | 0.5 | | 0.03 | 0.015 |
| | $C_{27}$ | 1 | | 0.01 | 0.01 |
| | | | | **Total Score** | **0.5895** |

Table 4-Case 2 Evaluation Results

| ***Criteria Category*** | ***Sub-Criterion Number*** | ***Sub-Criterion Value*** | ***Weight of Criterion*** | ***Weight of Sub-Criterion*** | ***Score per Sub-Criterion*** |
|---|---|---|---|---|---|
| Quality | $C_1$ | 0.25 | 0.2 | 0.03 | 0.0075 |
| | $C_2$ | 1 | | 0.01 | 0.01 |
| | $C_3$ | 0.25 | | 0.02 | 0.005 |
| | $C_4$ | 1 | | 0.01 | 0.01 |
| | $C_5$ | 0.5 | | 0.02 | 0.01 |
| | $C_6$ | 1 | | 0.03 | 0.03 |
| | $C_7$ | 0.25 | | 0.02 | 0.005 |
| | $C_8$ | 0.5 | | 0.02 | 0.01 |
| | $C_9$ | 0.25 | | 0.02 | 0.005 |
| | $C_{10}$ | 1 | | 0.02 | 0.02 |
| Response Time | $C_{11}$ | 0.25 | 0.4 | 0.04 | 0.01 |
| | $C_{12}$ | 1 | | 0.06 | 0.06 |
| | $C_{13}$ | 0.5 | | 0.08 | 0.04 |
| | $C_{14}$ | 0.25 | | 0.07 | 0.0175 |
| | $C_{15}$ | 0.5 | | 0.04 | 0.02 |
| | $C_{16}$ | 0.25 | | 0.05 | 0.0125 |
| | $C_{17}$ | 0.25 | | 0.06 | 0.015 |
| Cost/ Financial | $C_{18}$ | 1 | 0.3 | 0.08 | 0.08 |
| | $C_{19}$ | 0.5 | | 0.04 | 0.02 |
| | $C_{20}$ | 1 | | 0.07 | 0.07 |
| | $C_{21}$ | 0.25 | | 0.06 | 0.015 |
| | $C_{22}$ | 0.9 | | 0.05 | 0.045 |
| Productivity | $C_{23}$ | 0.5 | 0.1 | 0.03 | 0.015 |
| | $C_{24}$ | 0.25 | | 0.01 | 0.0025 |
| | $C_{25}$ | 0.25 | | 0.02 | 0.005 |
| | $C_{26}$ | 0.5 | | 0.03 | 0.015 |
| | $C_{27}$ | 1 | | 0.01 | 0.01 |
| **Total Score** | | | | | **0.565** |

# CONCLUSIONS

One of the main economic sectors of developing countries in the South Mediterranean area is agriculture, rendering the transport of perishable goods and foodstuffs an indispensible activity for the region's growth. Nevertheless, the operation of fresh food supply chains in these countries is lagging far behind due to lack of sophistication, while being hindered by considerable bottlenecks, significantly compromising the products' quality.

Current research in the sector of perishable goods and foodstuffs transport is mainly focused on the analysis of sophisticated and optimized supply chains, which are hardly applicable to those currently operating in the countries of the South Mediterranean. To this end, the present paper aimed at proposing a procedural framework for the rationalization of perishable goods and foodstuffs transport systems in this specific region. The analysis included the development of a methodology for the identification of the most viable and efficient supply chain corridor for the transport of perishable goods and foodstuffs through an evaluation by use of a Multi-Criteria Analysis, with criteria related to the critical components of the region's supply chains, as well as the specificities and supply chain operating conditions of the South Mediterranean. For the purpose of demonstrating its added value, the methodology was applied to two real case studies of citrus transport between two South Mediterranean countries with an EU Member State.

The proposed evaluation framework can ultimately provide valuable benchmarks for improved supply chains compared to existing ones, and will, therefore allow for the creation of an efficient and sustainable perishable goods and foodstuffs transport system network in the South Mediterranean region that could ultimately contribute to its countries' sustainable development and economic growth. In addition, the proposed framework provides a benchmarking tool for effective strategic planning and decision-making for both the demand and supply side of the perishable goods and foodstuffs transport market.

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