Economic Evaluation of a Hydroponic Tomato Greenhouse Farm in Greece

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Abstract

The feasibility assessment of a hydroponic greenhouse, based in the Regional Unity of Preveza in Western Greece and focusing on tomato production, is the main research subject of the study. In particular, the study aims at the presentation of an investment plan that has been developed for a greenhouse farm of a total area of 0.2 hectares, where tomato plants will be cultivated by implementing hydroponic methods. The investment plan is evaluated for a 5-year period, while the Internal Rate of Return (IRR) is used as the criterion of feasibility and performance assessment. For the needs of the main analysis of the study, secondary data regarding all costs and benefits deriving from the annual operation of the greenhouse farm are used. The analysis shows that the economic viability of the farm is achieved after 4 years from the beginning of its operation and is ensured mainly due to the innovative and environmental-friendly hydroponic production methods, but also due to the favorable pedoclimatic conditions of the region. Although the greenhouse sector has a high potential in countries such as Greece, further research is required and should examine the extent to which farmers are willing and capable to adopt new technologies and innovation, in order to overcome challenges mainly associated with the limited use of hydroponic systems.

Keywords

Hydroponics, sustainable crop production, feasibility assessment, cost-benefit analysis, Internal Rate of Return (IRR)

1. Introduction

The study investigates the economic feasibility of a hydroponic greenhouse farm producing tomato, which is located in a close distance from the town of Preveza and covers a total owned land of 0.2 hectares. The Regional Unit of Preveza belongs to the Region of Epirus - located in the Western part of Greece - and occupies a total area of 1036 km^2. The climate of the Regional Unit is coastal Mediterranean, characterized by hot and dry summers and mild winters, while the whole area is the least mountainous part of the Region of Epirus. The particular pedoclimatic conditions render the region ideal for the development of greenhouse farms, specialized in vegetable production.

Greece's vegetable production accounts for almost 20% of the total value of the domestic food production [1] and thus ranks first among all agricultural sectors. Tomato is the most important vegetable crop from both economic and commercial aspect in Greece, as, in 2014, about 17000 hectares (Table 1) were cultivated and 550000 tons were produced [2]. The demand for tomato has been increasing rapidly worldwide. In European countries, fresh tomato and tomato-based products attract even greater consumer interest, especially when their production is based on sustainable methods, such

Proceedings of HAICTA 2022, September 22–25, 2022, Athens, Greece
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as hydroponics, while the quality of vegetable products is another important factor affecting consumers' decision making [3].

Hydroponics is a technique of growing plants out of soil. The plants grow in an artificial substrate instead, with presence of water, which includes all the necessary nutrition ingredients [4]. Controlling irrigation water provision is the most important advantage of hydroponic methods, as the used water can be recycled. A study by [5] proved that vegetable crops can be produced in a hydroponic system of delivering water and nutrients by reusing 33% of drainage water. Another study conducted by [6], revealed that the hydroponic production of lettuce in Arizona required 13 times less water compared to conventional production. As a result, hydroponic systems can guarantee not only higher production, but also lower environmental footprints.

Table 1

Cultivated land of tomato in Greece (thousand hectares)

Year	2011	2012	2013	2014	2015	2016	2017	2018
Total cultivated land	3566,6	3560,1	3628,5	3334,1	3285,9	3225,7	3220,9	3221,7
Tomato (total)	**28,1**	**27,6**	**26,6**	**17,4**	**17,5**	**15,7**	**14,9**	**14,7**
Industrial	*10,6*	*10,1*	*9,4*	*6,2*	*6,4*	*6,1*	*5,9*	*5,6*
Open field	*14,1*	*14,2*	*13,9*	*8,6*	*8,4*	*7,1*	*6,7*	*6,7*
Greenhouse	*3,4*	*3,3*	*3,3*	*2,6*	*2,7*	*2,5*	*2,3*	*2,4*

Source: [2]

The purpose of the study is the feasibility assessment of a hydroponic greenhouse farm oriented to tomato production, established on owned land in Preveza Regional Unit. The feasibility assessment is based on a cost-benefit analysis, for which the Internal Rate of Return (IRR) is used as a criterion of performance.

2. Methods

The main research question of the study is whether the investment on a hydroponic tomato greenhouse farm can be feasible and cost-effective.

A feasibility analysis can provide essential information for decision making. It requires detailed and reliable data of all costs and benefits for the whole assessment period in order to adequately address uncertainty. It needs to anticipate the possible outcomes based on the understanding of the current market conditions [7]. As part of a feasibility analysis, a cost-benefit analysis highlights the extent to which an investment on a particular domain is beneficial at the socioeconomic level. It is used to estimate and weigh costs and benefits in an investment plan. The method can be applied to both private and public projects that may have a significant economic impact, as it reflects the importance of all costs and benefits associated with the operation of the project at the social level and tries to determine if the proposed benefits justify the cost and other implications that may occur for the society [8]. By calculating the IRR - the discount rate which equates the present value of the flow of benefits of an investment with the present value of its flow of costs [9] - the feasibility analysis examines the possibility of the farm to respond to the actual conditions in a profitable and competitive manner. The IRR as a decision criterion, suggests to accept a project if and only if the IRR is greater than the cost of capital and to rank projects via their IRRs.

Secondary data related to all costs and benefits deriving from the annual operation of the greenhouse farm were collected from the Directorate of Agricultural Development of the Regional Unit of Preveza. Particularly, the study was provided with detailed technical and economic data, primarily collected by the Directorate through the conduction of an in-person questionnaire survey which involved visits to typical hydroponic tomato greenhouse farms of the region. For the purposes of the main analysis, data were recorded in a Microsoft Excel spreadsheet and the cost-benefit analysis (calculation of the IRR) was performed via the use of dedicated equations of MS Excel.

3. Results – Discussion

Greenhouse facilities provide a controlled environment with preferable conditions, the most significant of which are temperature, humidity, CO_2 concentration and light intensity [10]. The purpose of cultivating agricultural products in greenhouse facilities is none other than the modification and control of all these environmental factors which affect plant growth. As a result, production can be increased, programmed on time and improved in quality, while diseases and pests can be reduced in a significant level [11] and damages caused by wind, rain, snow and hailstone can be avoided.

3.1. Description of the Greenhouse Facility

The greenhouse farm occupies a total area of 0.2 hectares, nearby the town of Preveza, characterized by a slight slope. The orientation of the farm and the planting lines have the "East-West" direction. The facility is certified by the Ministry of Rural Development and Foods of Greece, while the constructor is certified by ISO 9001:2008. The selection of the materials and the technical characteristics of the greenhouse has taken into account the pedoclimatic conditions of the region and the special requirements of tomato cultivation. The production is based on multi-level growing system and the facility is constructed with the technical characteristics listed below: Height 4.5m; width of pyramid 9.6m; length of basic structure unit 4m; roof slope 22°. Plastic sheet of long-lasting polyethylene (total permeability to solar radiation 88%) is used as a cover, while the greenhouse is equipped with natural ventilation system (roof windows). The prevention of external contamination and invasion from insects is achieved via the use of a special net.

For the heating requirements of the greenhouse, the meteorological data of the region have been taken into consideration. The greenhouse is equipped with system of air recirculation of 10 axial fans and heating system with air-boilers functioning on pomace wood, which is a type of biomass that constitutes an alternative to fossil fuels and renewable source of energy [12]. The rest of the electric-mechanical equipment includes a refrigerator chamber, an electricity generator, a meteorological station, and an irrigation system. Auto-regulated water drippers, placed on polyethylene pipe of diameter of 20mm and providing 2L/hour, contribute to the irrigation needs of the plants. Drip irrigation method is selected, as it can guarantee a good balance between high yield and superior quality of tomato fruits while reducing the environmental impact caused by horticultural production and saving water [13]. Liquid fertilization takes place through a modern fertilization injector controlled by microcomputer, which adjusts the parameters of the nutrient solution, such as pH, conductivity and concentration of inorganic and organic nutrients.

The hydroponic system selected for the greenhouse is the Nutrient Film Technique (NFT). According to this method, a shallow steam of nutrient solution recirculates in a closed circuit over the roots of crop plants [14]. The plants grow, without the use of a substrate, inside channels of appropriate slope [15]. The width of channels varies based on the root system that each plant develops. For tomato and pepper, a width of 15cm is needed [15], as these crops have the ability to develop a big root system and require side support, while for lettuce 8cm are sufficient [15]. The low cost of installation as well as the relative ease of construction are distinctive characteristics of the NFT system [14]. Water consumption is lower in the NFT compared to other types of hydroponic systems, while the control, adjustment and renewal of nutrient solution is more accurate, as a greatly reduced volume of solution is required [14]. Studies have shown that NFT-based hydroponics can reduce irrigation water usage by 70% to 90%, by recycling the run-off water [16]. In the NFT system also, the nutrient solution requires less time to heat up during winter and cool up during summer. In overall, NFT is a commonly used system for successful tomato production. The cultivation of tomato in NFT system with regular recycling of nutrient solutions improves growth, productivity and mineral composition [16].

3.2. Economic Performance of the Greenhouse Farm

The economic performance of the greenhouse farm is highly associated with the specific technical characteristics described above. The operation of the greenhouse farm requires two types of operating expenses, which are the labor costs and the costs of circulating capital. The main analysis of the study is based on data valid for the year 2021 (Year 0) in hydroponic tomato greenhouse sector in Greece and especially in the Regional Unit of Preveza and the Region of Epirus. In addition, the study takes for granted that the level of prices in the estimations of future net cash flows remains steady. Based on these assumptions, the total of labor and circulating capital costs come up to 32500€ per year. The annual revenue of the farm, which results from product sales, is 63000€. As a result, the farm achieves annual net cash flows of 30500€ (Table 2), which implies its profitability and cost-effectiveness in each of the 5 years of operation.

Installation costs are not included in the annual cash flows, as long as they are related to the initial foundation and not to the operation of the farm (i.e. the construction and installation of the greenhouse facility takes place in Year 0 of the investment). The analysis does not take into account any depreciation expenses that may occur over the course of the 5-year assessment period, as maintenance costs are considered negligible during this short period of time.

Table 2
Annual cost-benefit analysis

A) Installation Costs (€)		B) Labor Costs (€)		C) Costs of Circulating Capital (€)	
Greenhouse structure, Plastic roof and side walls cover, Truck	54000	Owner's labor	3,4 €/hour × 1200 hours/year = 4080	Plants, Fertilization, Plant protection	9640
Refrigerator chamber, Heating system, Axial fans, Electricity generator, Irrigation system, Hydroponic system, Meteorological station	45700	Specialized personnel's labor	5,0 €/hour × 2400 hours/year = 12000	Energy and Water consumption	1700
Installation labor and Other expenses	10300	Non-specialized personnel's labor	3,4 €/hour × 1200 hours/year = 4080	Certifications and Other expenses	1000
Sum	110000	**Sum**	20160	**Sum**	12340
D) Annual Revenue (€)		70000 kg × 0.9 €/kg = 63000			
E) Annual Net Cash Flows (€)		D – (B+C) = 30500			

The outcome of the feasibility analysis confirms the economic viability of the greenhouse farm during the 5 years of operation. The IRR is positive in the 4th year, in fact exceeding 4%, which is almost equal to bank interest rates. At this specific time, the initial invested capital of 110000€ as well as the annual operating costs are fully compensated by the revenues of the farm, when future benefits and costs are discounted to current values by using a discount rate equal to the value of IRR (4%). In the 5th year particularly, the IRR indicator is 12%, which reflects the high profitability and cost-effectiveness of the investment, comparing the value of IRR with the prevailing bank interest rate. Therefore, the installation of the greenhouse farm is an economically viable investment option, as presented in Table 3.

Table 3
Results of feasibility analysis

Year	2021 (Year 0)	2022 (Year 1)	2023 (Year 2)	2024 (Year 3)	2025 (Year 4)	2026 (Year 5)
Initial Invested Capital (€)	110000					
Annual Net Cash Flows (€)		30500	30500	30500	30500	30500
Internal Rate of Return (IRR)	<0	<0	<0	<0	4%	12%

The result proves that the perspectives of agricultural facilities and enterprises that use innovative techniques such as hydroponics, are really promising. Economic feasibility is ensured and is also connected with other benefits, such as the socioeconomic development of the area (e.g. support for processing facilities, labor supply), the creation of viable and profitable farms, the efficient use of natural resources with lower environmental footprints and high quality production.

4. Conclusion

The implementation of modern hydroponic systems guarantees the achievement of high yields and the production of vegetables of excellent quality with high market prices. The investment plan evaluated in the study could encourage the development of similar activities in the agricultural sector. It could also contribute to the improvement of the socioeconomic and environmental conditions of the region through more efficient use of capital, labor and water resources. Hydroponics, however, is not yet widespread in Greece. The main reason is none other than the high initial invested capital required to purchase and install hydroponic systems, in combination with a significant lack of know-how and real-life data regarding the efficiency of input use. Further research should investigate the willingness and ability of farmers to adopt innovative production practices and methods, considering that investing in greenhouse facilities could contribute positively to the commercialization and competitiveness of the final product, through cost savings, quality improvement and product promotion. The aspect of innovation is a very important factor for the agri-food industry at both farm and production system levels, although innovative systems along with modern technological equipment imply high installation costs. In a next step, the study will also focus on assessing different scenarios of economic feasibility of the investment plan, taking into consideration any possible changes of input, energy and product prices, especially under the current volatile conditions existing in agricultural markets worldwide.

5. Acknowledgements

We would like to show our gratitude for the Directorate of Agricultural Development of the Regional Unity of Preveza for providing the study with necessary data.

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