Structural Characteristics of Protected Cultivation Enterprises and Production Systems in the Famagusta Region

Yasin MERCAN*[*1], Esma Nur DÖLEK [2]

[1] *Adnan Menderes University, Faculty of Agriculture, Department of Biosystems Engineering, South Campus, Aydın, TURKIYE*

[2]*Independent Researcher. TRNC*

Abstract: This study aims to characterize the structural and technical features of greenhouse enterprises in the Famagusta (Gazimağusa) region of the Turkish Republic of Northern Cyprus (TRNC) and to identify the main factors constraining production. Within the scope of the research, on-site observations, technical measurements, and structured surveys were carried out in 10 representative greenhouse enterprises (n = 10), and the collected data were analyzed using descriptive statistical methods. The results indicate that 50.0% of the enterprise owners have primary-level education, 70.0% operate on areas smaller than 0.5 hectares, and greenhouse cultivation constitutes their primary source of income. The majority of the enterprises were identified as family-operated, low-technology systems, predominantly using polyethylene-covered structures without active heating facilities. Moreover, water scarcity, elevated salinity levels, and socio-economic limitations were found to adversely affect input availability and the adoption of modern technologies. By reflecting the current structural status of protected cultivation in the Famagusta region, this study emphasizes the necessity of greenhouse modernization and the integration of regionally adapted smart agricultural technologies as strategic priorities for sustainable production. The study contributes an original and region-specific dataset to the literature by providing a holistic evaluation of the technical and economic constraints affecting greenhouse production systems.

Keywords: Famagusta, Protected cultivation, Structural characteristics, Climate control, TRNC

Gazimağusa Bölgesinde Örtüaltı İşletmelerin ve Üretim Sistemlerinin Yapısal Özellikleri

Öz: *Bu çalışma, Kuzey Kıbrıs Türk Cumhuriyeti'nin (KKTC) Gazimağusa (Famagusta) bölgesindeki sera işletmelerinin yapısal ve teknik özelliklerini belirlemek ve üretimi sınırlandıran temel faktörleri ortaya koymak amacıyla yürütülmüştür. Araştırma kapsamında, bölgede faaliyet gösteren 10 temsilî sera işletmesinde (n = 10) yerinde gözlemler, teknik ölçümler ve yapılandırılmış anket çalışmaları gerçekleştirilmiş; elde edilen veriler tanımlayıcı istatistiksel yöntemler kullanılarak analiz edilmiştir. Bulgular, işletme sahiplerinin %50.0'sinin ilkokul mezunu olduğunu, işletmelerin %70.0'inin 0.5 hektardan küçük alanlarda üretim yaptığını ve sera yetiştiriciliğinin temel geçim kaynağı olduğunu göstermiştir. İşletmelerin büyük çoğunluğunun, aktif ısıtma sistemi bulunmayan, polietilen örtülü, düşük teknolojili ve aile işletmesi niteliğinde olduğu belirlenmiştir. Ayrıca, su kıtlığı, yüksek tuzluluk düzeyleri ve sosyo-ekonomik kısıtların girdi temini ile modern teknolojilerin benimsenmesini olumsuz yönde etkilediği tespit edilmiştir. Gazimağusa bölgesindeki örtüaltı yetiştiriciliğinin mevcut yapısal durumunu ortaya koyan bu çalışma, sürdürülebilir üretim açısından sera modernizasyonunun ve bölgesel koşullara uyumlu akıllı tarım teknolojilerinin entegrasyonunun stratejik bir gereklilik olduğunu vurgulamaktadır. Çalışma, sera üretim sistemlerini etkileyen teknik ve ekonomik kısıtları bütüncül bir yaklaşımla ele alarak literatüre özgün ve bölgeye özgü bir veri seti sunmaktadır.*

Anahtar Kelimeler: Gazimağusa, Örtüaltı yetiştiriciliği, Yapısal özellikler, İklimlendirme, KKTC

INTRODUCTION

According to United Nations estimates, approximately 735 million people experienced hunger worldwide in 2022. Projections indicating that the global population will reach 9.2 billion by 2050 render food security an increasingly critical strategic challenge (UNICEF Turkey, 2023). In parallel with rising food demand, global freshwater use has increased at an average annual rate of approximately 1% since the 1980s, with an additional 20–30% increase in water demand anticipated by 2050. Currently, nearly half of the world's population is affected by severe water scarcity, underscoring the urgent need to maximize the efficiency of existing water resources in agricultural production and to accelerate the integration of advanced and resource-efficient technologies (UNESCO World Water Assessment Programme [WWAP], 2024).

Protected cultivation is widely recognized as one of the most effective approaches for achieving high yields per unit area in agricultural production. It represents a production system

***Corresponding Author:** yasin.mercan@adu.edu.tr.*
*A summary of this work was presented at the "*15th international conference on agriculture, animal science & rural development*" (12-14 July 2024, Aydın). This study is the product of a thesis.*
***The submitted date:** Mach 4, 2026*
***The accepted date:** June 22, 2026*

that encompasses both low- and high-technology structures designed to optimize crop growth by partially or fully mitigating the adverse effects of unfavorable climatic and environmental conditions. Low-technology systems include practices such as mulching, surface plastic covers, and low tunnels, whereas high-technology systems comprise high tunnels and greenhouses (Turkish Standards Institute, 2001). By providing a controlled growing environment, protected cultivation enables significantly higher yields and improved product quality compared to open-field cultivation, primarily through enhanced protection against pests, diseases, and extreme weather events (Askalan, 2022).

Located in the eastern part of the Turkish Republic of Northern Cyprus (TRNC), the Famagusta (Gazimağusa) region is characterized by a semi-arid Mediterranean climate and faces structural constraints on agricultural production primarily due to limited water resources. Despite these limitations, the region remains predominantly agricultural and ranks first in terms of greenhouse cultivation activities within the TRNC (Figure 1). Owing to its long sunshine duration and relatively mild winter temperatures, Famagusta possesses considerable potential for the development and expansion of modern, controlled greenhouse production systems (Kaykı, 2010).

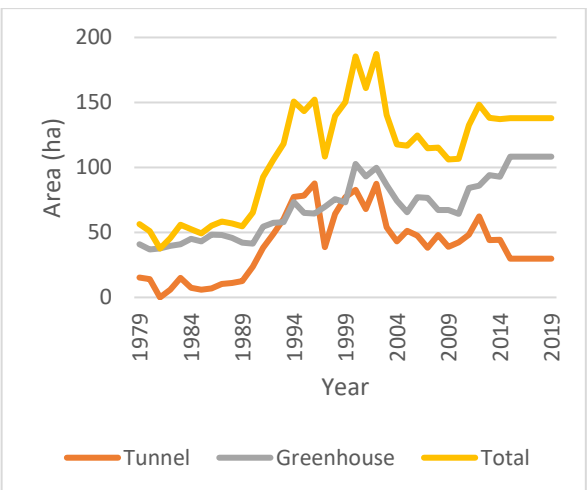

Figure 1. Temporal development of protected cultivation in the Turkish Republic of Northern Cyprus between 1979 and 2019 (TRNC Ministry of Agriculture and Natural Resources).

Data on protected cultivation activities between 1979 and 2019 indicate that the sector has been undergoing a structural transformation. Following the expansion surge that began in the 1990s, the total production area peaked at 190 hectares in 2002. In the subsequent years, a qualitative shift in the sector was observed, as low-cost tunnel systems were gradually replaced by more protected and modern greenhouse facilities. By 2019, the area covered by tunnels had decreased to 30 hectares, while greenhouse areas expanded to 110 hectares, becoming the primary driver of total production.

At present, the ongoing reduction of agricultural land resources combined with increasing population pressure necessitates the adoption of productivity-enhancing strategies, including agricultural automation and modern greenhouse systems. Modern greenhouses are technologically advanced production structures that integrate a wide range of technical equipment and operate within a controlled environment, where climate regulation as well as irrigation, spraying, and fertilization processes are carried out through computer-based control systems (Üçışık Erbilen and Şahin, 2011).

Greenhouse cultivation in Turkey plays a pivotal role in the agricultural sector due to its capacity to achieve high productivity per unit area and to enable year-round and off-season production. An examination of the sector's development reveals that, in addition to the long-standing concentration of greenhouse activities in the Mediterranean and Aegean regions, significant efforts toward modernization and spatial expansion have been observed in various provinces in recent years (Akın et al., 2018).

Antalya ranks first in Turkey in terms of greenhouse cultivation, accounting for 38.8% of the country's total greenhouse area. A study conducted in the Kepez district reported that the majority of traditional greenhouses are constructed with iron frames and polyethylene (PE) coverings, with production predominantly based on soil cultivation and focused on single-crop systems, primarily tomatoes, cucumbers, and strawberries (Gale et al., 2014). In the Kumluca district, 82.9% of greenhouse structures were identified as production-oriented greenhouses; however, a substantial proportion were found to be inadequately designed with respect to local ecological conditions and lacking modern technological features (Emekli et al., 2007). Similarly, studies conducted in the Mersin and Adana regions revealed that all surveyed greenhouses were constructed without formal project planning and were built by local craftsmen rather than through engineering-based design approaches (Güllüler, 2007; Solmaz and Kapur, 2019).

In the Aegean Region, studies indicate that approximately 80.0% of greenhouses in the Gediz Basin (Manisa) are characterized by arched and semi-circular roof designs, with multi-layer polyethylene coverings being commonly preferred (Ünal et al., 2015). Furthermore, research by Eltez and Eltez (2005) highlighted that the Bergama and Dikili districts of İzmir possess substantial potential for greenhouse development due to favorable climatic conditions and the availability of geothermal energy resources.

In the Southeastern Anatolia Region, greenhouse cultivation in Diyarbakır has gained considerable momentum through

state-supported incentive and grant programs, with a majority of greenhouses in the region adopting radiator-based heating systems. In Kahramanmaraş, studies have shown that greenhouse enterprises operate with an average production area of 0.7 hectares and that tomato cultivation accounts for 70.1% of total greenhouse production (Kaynakçı Baydar et al., 2024).

A study conducted in the Turkish Republic of Northern Cyprus (TRNC) indicates that greenhouse production activities are predominantly carried out in small-scale family farms ranging from 0.1 to 0.3 hectares, operating within unheated, plastic-covered structures constructed of wood or metal. The prevalence of glass greenhouses in the region remains relatively limited. Moreover, the use of high tunnels for early-season production has increased in recent years, particularly in the Gazimağusa and Güzelyurt regions (Üçışık Erbilen and Şahin, 2011).

Despite the strategic importance of the Gazimağusa region for greenhouse agriculture in the Turkish Republic of Northern Cyprus (TRNC), quantitative and region-specific assessments of the structural and technical characteristics of greenhouse enterprises are still limited. Therefore, this study aims to evaluate the structural and technical features of greenhouse production systems in the Gazimağusa region, identify key constraints affecting production efficiency, and propose feasible improvement strategies. This study provides a comprehensive field-based dataset and a regional-scale technical assessment, offering original contributions to the literature and supporting evidence-based decisions for the modernization and sustainable development of protected cultivation systems in the TRNC.

MATERIALS AND METHODS

Materials

The study was conducted in the Gazimağusa region, a strategically critical agricultural basin representing approximately 49.0% (67.8 ha) of the total greenhouse production potential in the TRNC. The selection of the greenhouse enterprises was based on the official registry of the TRNC Ministry of Agriculture and Natural Resources, with logistical feasibility and ease of access serving as the primary criteria (Table 1). To ensure a holistic characterization of the sector and its structural diversity, ranging from traditional low-technology tunnels to modern block-type systems, purposive sampling was employed to select 10 representative greenhouse enterprises (n = 10). The field studies and data collection process were carried out throughout 2024. Although the sample size was limited to 10 facilities, this deliberate choice facilitated a multi-dimensional and systematic data collection approach that moved beyond subjective questionnaire data. This methodology integrated on-site technical measurements of construction dimensions and ventilation capacities, direct observations of structural integrity and material properties—such as polyethylene degradation—and structured interviews with owners to correlate socio-economic factors with technological adoption. By employing this localized and rigorous technical assessment, the study ensured high precision in evaluating construction types and climate control efficiencies, providing a detailed dataset that accommodates the specific technical and economic constraints of the region.

Table 1. Distribution of greenhouse production facilities in the Turkish Republic of Northern Cyprus according to greenhouse structural systems (TRNC Ministry of Agriculture and Natural Resources, 2019).

Region	Greenhouse		Tunnel		Total	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Lefkoşa	4.6	4.0	0.0	0.0	4.6	3.0
Gazimağusa	52.2	48.0	15.6	52.0	67.8	49.0
Girne	29.2	27.0	7.0	23.0	36.2	26.0
Güzelyurt	17.5	16.0	7.2	24.0	24.7	18.0
İskele	4.9	5.0	0.0	0.0	4.9	4.0
Total	108.4	100.0	29.8	100.0	138.3	100.0

Located on the eastern coast of the TRNC (35°07′ N, 33°55′ E), Gazimağusa is characterized by a typical Mediterranean climate with hot, dry summers (30–35 °C) and mild, rainy winters (10–15 °C). High evapotranspiration rates and winter-concentrated precipitation patterns render controlled environment cultivation a necessity for sustainable production in the area. As the primary center of greenhouse vegetable production in the TRNC, the region hosts a diverse range of systems, from conventional structures to technologically advanced greenhouses. This diversified agricultural structure, which also includes citrus, olive, and cereal cultivation, enables year-round activity independent of seasonal variability and market fluctuations.

Methods

This study employed a two-stage methodological approach to evaluate the structural conditions and technical adequacy of greenhouse enterprises in the Gazimağusa region. The first stage involved comprehensive fieldwork conducted through on-site visits to the selected ten enterprises. During these investigations, data collection integrated three primary instruments: technical measurements of greenhouse dimensions and ventilation areas, direct observations of construction materials and structural integrity, and structured interviews with enterprise owners. The variables recorded during this phase included greenhouse typologies, load-bearing system properties, covering material types, climate control capacities, and specific cultivation practices.

In the second stage, the data obtained from field investigations were digitized and classified to facilitate a systematic technical assessment. The analysis was performed using descriptive statistical methods, including percentages, frequency, and arithmetic means. Given the sample size (n = 10), which focuses on a detailed structural audit rather than parametric modeling, descriptive statistics were utilized as the most accurate method for characterizing existing conditions. The structural performance and technical equipment were evaluated against internationally recognized greenhouse standards and modern cultivation principles. Based on this holistic assessment, region-specific and ecologically compatible improvement strategies were developed to enhance production efficiency and sustainability in the Gazimağusa region.

RESULTS AND DISCUSSION

General Characteristics of Enterprises

An examination of the general characteristics of the greenhouse enterprises surveyed in the Gazimağusa region revealed that the majority were established without formal technical or engineering project designs and have been in operation for extended periods, typically ranging from 15 to 25 years. Production activities are predominantly based on family labor, and the enterprises generally exhibit the profile of small-scale family-operated farms. With respect to production patterns, soil-based cultivation systems are widely adopted, with crop production primarily concentrated in the spring and autumn seasons. The main crops cultivated include tomatoes, peppers, cucumbers, eggplants, and lettuce.

Data on the educational attainment of the greenhouse enterprise owners examined in this study are presented in Table 2, demonstrating that 50.0% of the owners completed primary education, 40.0% attained secondary (high school) education, and only 10.0% hold a university degree. These findings are consistent with previous studies conducted in different regions of Turkey and the TRNC. For instance, Kaynakçı Baydar et al. (2024) reported that 63.2% of greenhouse enterprise owners in Kahramanmaraş were primary school graduates, while Ak (2023) found a similar proportion (52.3%) in the Gazimağusa region. In the Manisa region, Mercan (2013) reported that 80% of greenhouse business owners had primary-level education, and a study conducted in Antalya indicated that 86.7% of owners were primary school graduates (İşbecer, 2010). The generally low level of formal education among greenhouse enterprise owners is considered a critical factor that may limit the rate of adoption of modern agricultural practices and innovative technologies.

Table 2. Distribution of greenhouse enterprise owners by educational level.

Education Level	Number of Enterprises (n)	Percentage (%)
Primary education	5	50.0
High school	4	40.0
University	1	10.0
Total	10	100.0

An analysis of the operational objectives of the surveyed enterprises indicates that greenhouse cultivation plays a crucial economic role for the local community. As presented in Table 3, 70.0% of enterprise owners rely on greenhouse production as their primary source of income, whereas 30.0% engage in greenhouse cultivation as a supplementary income-generating activity. Comparable findings were reported by Mercan (2013), who identified greenhouse production as the main source of income for 45.0% of business owners. These results underscore the economic importance of greenhouse production for enterprises in the region.

Table 3. Income dependency of greenhouse enterprises on cultivation.

Source of livelihood	Number of enterprises (n)	Percentage (%)
Primary source of income	7	70.0
Supplementary source of income	3	30.0
Total	10	100.0

The distribution of greenhouse enterprises in the study area according to land holding size is presented in Table 4. The results indicate that 70.0% of the enterprises operate on areas smaller than 0.5 hectares, while 20.0% fall within the 0.5–1.0 hectares range and only 10% manage production areas larger than 1.0 hectares. Similar patterns have been reported in previous studies conducted in different regions. Emekli et al. (2007) reported that 84.3% of protected cultivation areas in Antalya were smaller than 0.45 hectares, while Mercan (2013) found that 72.5% of protected production areas in the Manisa region were below 0.5 hectares. The consistency between the findings from the Gazimağusa region and those reported in the literature suggests that small farm size represents a widespread structural constraint rather than a region-specific issue. Such limited land holdings constitute a major barrier to the adoption of capital-intensive modern agricultural technologies aimed at increasing productivity per unit area, as well as to the effective implementation of automation systems.

Table 4. Distribution of greenhouse cultivation area sizes among enterprises

Greenhouse Area Size (ha)	Number of Enterprises (n)	Percentage (%)
< 0.5	7	70.0
0.5 – 1.0	2	20.0
> 1.0	1	10.0
Total	10	100.0

The data obtained from official agricultural records demonstrates that greenhouse production activities in the Gazimağusa region are carried out within limited land areas and are largely dependent on intensive family labor. While larger, commercially oriented enterprises operate across the island, local accessibility and logistical criteria confirm that small-scale production structures remain predominant within the examined regional network.

In this context, the small-scale enterprise structure is considered a fundamental structural constraint that limits the feasibility and adoption of advanced technologies and automation systems capable of achieving high yields per unit area.

General Characteristics of Greenhouses

The structural and technical characteristics of the greenhouses examined in the surveyed enterprises have been shaped by the climatic advantages and constraints of the region. The findings related to greenhouse structural type, load-bearing system, and covering material in the Gazimağusa (Maraş) region are presented below.

Structural assessments and field inventories reveal that plastic-covered greenhouses are universally preferred across all enterprises surveyed. With respect to structural configuration, all greenhouses exhibit a gable-roof design and are constructed as block-type (multi-span) structures. Corrosion-resistant galvanized steel pipes were identified as the primary structural material, and the structural joints were predominantly formed using welding techniques. This configuration suggests that greenhouse construction in the region follows a cost-oriented approach, while also reflecting the influence of local construction practices and available craftsmanship on structural design choices.

The findings revealed that polyethylene (PE) plastic was used as the covering material in all of the greenhouses examined. The distinctive climatic conditions of the Gazimağusa region—characterized by high solar radiation, extreme temperatures during the summer months, and strong winds in winter—lead to the gradual deterioration of the physical and optical properties of the covering material, thereby directly reducing its economic service life. Interviews with greenhouse owners indicated that, as a consequence of these climatic stresses, the replacement interval of the covering material typically ranges between 3 and 5 years.

This regional situation is consistent with findings reported in other studies conducted in comparable climatic zones. Saltuk (2005) reported that plastic (PE) coverings were used in all greenhouse enterprises in the Mersin region, while Güllüler (2007) found that 98.4% of greenhouse enterprises in Adana consisted of plastic-covered structures. Similarly, Mercan (2013) noted that PE covering material was preferred in all greenhouses and tunnels in the Manisa region. The widespread adoption of PE-covered greenhouses in Mediterranean climate regions is primarily attributed to their lower investment costs compared to glass-covered structures and their ability to provide flexible and adaptive solutions to region-specific climatic conditions.

Summer vegetable cultivation with high economic returns predominates in the region. Among these crops, tomato production ranks first, accounting for 32.2% of total production, owing to its year-round market demand and high adaptability to the regional climatic conditions. Nevertheless, as reported by Üçışık Erbilen and Şahin (2011), the progressive reduction in cultivated areas over time has resulted in a declining trend in overall vegetable output.

The analysis further highlights that drip irrigation systems are employed in all of the surveyed enterprises, reflecting a strong commitment to water conservation and irrigation efficiency. Comparable results have been reported in previous studies: Coşkun (2000) found that 40.7% of greenhouse enterprises in İzmir adopted drip irrigation systems; Mercan (2013) reported a 90.0% adoption rate; and Güllüler (2007) observed that drip irrigation was used in all greenhouse enterprises in the Adana region. Studies conducted across different regions of Türkiye (Coşkun, 2000; Güllüler, 2007; Mercan, 2013) similarly indicate that irrigation technologies tend to be adopted more rapidly than other innovations, whereas climate control systems and structural modernization remain relatively limited.

In this context, the Gazimağusa case demonstrates that a certain level of technical awareness and capacity has been achieved in water management practices. However, it also highlights that the comprehensive integration of greenhouse design standards, climate control technologies, and advanced technical equipment into the production system remains constrained by a combination of economic, climatic, and socio-political factors.

Greenhouse Climate Control Characteristics

Cyprus's temperate climate plays a decisive role in shaping greenhouse climate control strategies. Accordingly, the heating and ventilation practices applied in greenhouses reflect both the climatic conditions and the economic structure of production systems in the region.

In the Gazimağusa region, greenhouses generally lack continuous or centralized heating systems. Heating is

applied only during periods of extreme cold in winter, primarily to prevent frost damage to crops, and is therefore limited to so-called “frost protection heating.” For this purpose, coal-fired stoves are commonly used, with high-calorific Siberian coal being the preferred fuel. Similar practices have been reported in the literature; Önge (2002) noted that greenhouse and high-tunnel structures are typically heated using stoves or auxiliary heating devices rather than fully integrated heating systems.

Climate control in the studied greenhouses is primarily achieved through natural ventilation. Ventilation is provided by the combined use of side openings that allow fresh air intake and roof vents that facilitate air exhaust, thereby enhancing overall ventilation efficiency. To improve the effectiveness of natural ventilation, the prevailing wind direction is taken into consideration during greenhouse siting. Given that the dominant wind in the region is westerly, with an average speed of approximately 13.6 km h^{-1}, greenhouses are generally oriented along a north–south axis. This indicates that the longitudinal alignment of block-type greenhouses has been designed in accordance with sound technical principles.

Overall, these findings demonstrate that greenhouse climate control practices in the Gazimağusa region are largely limited to low-cost, passive approaches. Owing to the absence of centralized heating systems, production remains vulnerable to frost risk during the winter period. Although the north–south orientation of greenhouses in line with the prevailing wind direction is technically appropriate, reliance solely on natural ventilation is considered insufficient for effective temperature regulation during the summer months, particularly under conditions of high solar radiation and elevated ambient temperatures.

Structural Analysis of Greenhouses

In the facilities examined, block-type (multi-span) greenhouse construction, which provides a large internal volume and extensive production area, is predominant, together with arched roof forms that offer increased resistance to wind loads. Although galvanized steel profiles are preferred in the load-bearing systems to enhance corrosion resistance, the widespread use of welded joints restricts structural flexibility and limits the potential for modular expansion or modification. As a covering material, UV-stabilized polyethylene (PE) films with an economic lifespan of approximately 3–5 years are utilized, reflecting their suitability for the region’s high solar radiation levels and pronounced temperature extremes.

Climate control within the greenhouses is achieved exclusively through natural ventilation. The north–south orientation of the structures, designed to maximize the use of prevailing westerly winds, demonstrates technical appropriateness in terms of both ventilation efficiency and the uniform distribution of solar radiation. When these structural and technical attributes are considered collectively, it becomes evident that greenhouses in the Gazimağusa region are generally well adapted to local climatic conditions; however, they remain limited with respect to compliance with modern greenhouse standards and advanced technological integration.

Problems Encountered by Greenhouse Enterprises

Greenhouse cultivation in the Gazimağusa region is confronted with a set of persistent ecological, economic, and technical challenges that collectively increase production costs and undermine the competitiveness of local enterprises.

The most critical constraint in the region is water scarcity and declining water quality. Limited natural water resources, reduced precipitation, and the uncontrolled extraction of groundwater have led to increasing salinity levels, which adversely affect plant growth and soil structure (Önge, 2002; Şenol, 2020). Moreover, excessive temperatures during the summer months impose severe thermal stress on crops, resulting in yield reductions, while hot and humid microclimatic conditions accelerate the incidence and spread of pests and diseases.

Political and economic embargoes imposed on the TRNC further exacerbate these challenges by increasing dependency on external sources for essential agricultural inputs, such as fertilizers, pesticides, and technological equipment, thereby significantly raising production costs (Önge, 2002). The reliance on imported greenhouse construction materials also elevates initial investment requirements. Concurrently, the unplanned expansion of the tourism sector has led to the conversion and misuse of agricultural land, reducing the area available for greenhouse production. In addition, the presence of low-priced imported agricultural products in local markets constrains the price competitiveness of domestic producers.

From a technical perspective, the predominance of traditional production practices and the limited technical knowledge of most greenhouse operators slow the adoption of modern agricultural technologies. Insufficient governmental support and inadequate agricultural extension and training services further reinforce this dependence on conventional and low-efficiency practices. As a result, producers continue to rely on rudimentary methods, such as coal-fired stoves for frost protection, particularly during critical risk periods, limiting both productivity and sustainability.

Conclusions and Recommendations

This study quantitatively demonstrates that greenhouse cultivation in the Gazimağusa (Maraş) region is in a transitional phase between traditional production practices

and modern greenhouse technologies. The findings indicate that the adoption of innovative production techniques is hindered by a multifaceted socio-economic barrier. While the relatively low educational level of operators, 50% of whom have only primary education—limits the technical capacity to manage complex systems, this constraint is further exacerbated by the economic structure of the enterprises. The prevalence of small-scale family farms (70% under 0.5 ha) and the reliance on greenhouse cultivation as a primary source of income suggest that limited capital accumulation and low-profit margins significantly restrict the financial ability to invest in high-cost automation and modernization. Consequently, the lack of technological integration in the region appears to be a result of both educational limitations and financial constraints, where low-income levels prevent the transition to capital-intensive smart farming systems. Nevertheless, the sector's role as a primary livelihood for the majority of practitioners highlights its strategic economic importance and the urgent need for targeted financial incentives and technical extension services.

From a structural and technical perspective, although all greenhouses are plastic-covered, arched, and block-type structures, the majority have been constructed without formal engineering projects and independently of recognized technical standards. The absence of central heating and advanced climate control systems renders production particularly vulnerable to frost risk during the winter period. Moreover, despite the region's favorable climatic conditions, production patterns remain largely confined to tomatoes and similar conventional summer vegetables, indicating that market diversification and the development of value-added products are not being adequately utilized.

In this context, the promotion of renewable energy-based heating systems and the support of desalination technologies to mitigate increasing salinity problems are considered essential measures. In parallel, expanding hands-on training programs and strengthening technical consultancy and extension services for producers would facilitate the diffusion of modern greenhouse technologies. Collectively, these interventions would enhance production efficiency, improve competitiveness, and support the sustainable development of predominantly small-scale greenhouse enterprises in the Gazimağusa region.

REFERENCES

Ak D, Öncü E, Demir B, Umarbeyli Ş (2023) Cost Analysis of Tomato Growing Activity in The Turkish Republic of Northern Cyprus (TRNC): Case Of Famagusta. EUL Journal of Social Sciences, 14(I): 52-71.

Akın S, Kara A, Pirinç V, Aktürk Z (2018) Current Situation of Greenhouses in Diyarbakir. Dicle University Journal of the Institute of Natural and Applied Sciences, 7(2): 95-101.

Askalan OA (2022) Sustainable Irrigation Water Management in Drip-Irrigated Tomato Grown Under Greenhouse Conditions: Mogadishu /Somalia Case Study. Master's Thesis, Bursa Uludağ University Graduate School of Natural and Applied Sciences, Bursa.

Coşkun M (2000) A Research on Ascertainment and Development of Greenhouse Construction Characteristics in İzmir and Surroundine, PhD Thesis, Ege University Graduate School of Natural and Applied Sciences, Izmir.

Eltez S, Eltez RZ (2005) A Research on Greenhouse Production Potential and Current Status in Bergama and Dikili Districts (İzmir). Journal of Agriculture Faculty of Ege University, 42(2): 203-214.

Emekli NY, Baştuğ R, Büyüktaş K (2007) Current State, Problems and Suitable Solution Suggestions of The Greenhouses in Kumluca Province of Antalya. Akdeniz University Journal of the Faculty of Agriculture, 20(2): 273-288.

Gale U, Tüzel Y, Öztekin GB (2014) Properties of Conventional Greenhouse Production in Kepez Township of Antalya. Turkish Journal of Agricultural Research, 1(1): 68-77.

Güllüler F (2007) Structural Evaluation of Greenhouses in Adana and Provinces of Adana and Their Assessment in Terms of Compliance with the TSE Standards. Master's Thesis, Çukurova University Graduate School of Natural and Applied Sciences, Adana.

İşbecer ÖB (2010) An Assessment of the Greenhouse Vegetable Production in Antalya; Problems and Suggestions for Solutions, Master's Thesis, Süleyman Demirel University Graduate School of Natural and Applied Sciences, Isparta,

Kaykı A (2010) Geographical and Environmental Study of Famagusta, Master's Thesis, Marmara University, Institute of Turkic Studies, Istanbul.

Kaynakçı Baydar C, Çetinkaya S, Akbay C, Kaya HA, Dalkılınç S (2024) Investigation of Structural Characteristics of Greenhouse Enterprises: The Case of Kahramanmaraş Province, Türkiye. Turkish Journal of Agricultural Research, 11(3): 287-295.

Mercan Y (2013) Structural Analysis and Development of Production Systems and Protected Cultivation Enterprises in Manisa Region. Master's Thesis, Ege University Graduate School of Natural and Applied Sciences, İzmir.

Ministry of Agriculture and Natural Resources of the TRNC. (2015) Data of the Ministry of Agriculture and Natural Resources of the TRNC. (Access date: 05.01.2026) http://tarim.gov.ct.tr

Önge H (2002) The Place of Agricultural and Animal Breeding in the Economy of Northern Cyprus Turkish Republic

Master's Thesis, Marmara University, Institute of Middle East and Islamic Countries, Istanbul.

Saltuk B (2005) A Study on the Structural Analysis and Development of Plastic Greenhouses in Mersin and its Provinces, Master's Thesis, Çukurova University Graduate School of Natural and Applied Sciences, Adana.

Solmaz D, Kapur B (2019) A Research on The Investigation and Development of The Agricultural and Structural Properties of Greenhouses in Adanalıoğlu Region in Mersin. Çukurova University Insitute of Natural and Applied Science, 38(2): 64-74.

Şenol C (2020) The Turkish Republic of Northern Cyprus Hydrographic Structure, Water Problem and Solution Suggestions. Journal of Cyprus Studies, 21(45): 77-98.

Turkish Standards Institution. (2001) Greenhouses – Terms and Definitions (TS 12741).

UNESCO World Water Assessment Programme. (2024). The United Nations World Water Development Report 2024: Water for Prosperity and Peace. UNESCO. https://unesdoc.unesco.org (Access date: 13.01.2026).

UNICEF Türkiye (2023) The State of Food Security and Nutrition in the World 2023. https://www.unicef.org/turkiye/ (Access date: 18.02.2024).

Üçışık Erbilen S, Şahin G (2011) Development Of Greenhouse Cultivation and Its Problems in TRNC Journal of World of Turks, 3(3): 197-219.

Ünal HB, Demir V, Çoban H, Günhan T, Yılmaz Hİ, Öztürk Alkan İ (2015) Evaluation of the Usage of Cover Material in Protected Cultivation in Manisa Region of Gediz Basin. Journal of Agriculture Faculty of Ege University: 52(3): 257-267.