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Why do high-quality olives fail to yield high-value oil? Cultural lag, convention mismatch, and the quality paradox

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Mediterranean smallholder olive oil production exhibits a recurring empirical puzzle: regions endowed with high-quality cultivars, favorable climatic conditions, and substantial cultivation areas systematically underperform their biophysical potential in premium-oriented markets. This study asks under what socio-demographic and structural conditions such high-potential territories fail to convert that potential into sustainable, high-value output, using Bozdoğan (Aydın, Türkiye) as an analytically instructive case. We mobilize a citizen science design—36 farmer citizen scientists conducted 60 in-depth interviews with local producers in 2024, complemented by 15 researcher-led triangulation interviews with key stakeholders. The study develops three interlocking contributions. First, against the standard deficit model of sustainability communication, we show that farmers' economistic framing of sustainability coexists with fine-grained environmental awareness and is best read as a situated coping discourse under livelihood precarity rather than as a symptom of knowledge deficit. Second, we formalize the concept of the "quality paradox"—the chronic disjuncture between quality potential and market-recognized quality—through a dual framework combining cultural lag and convention theory. Third, we reposition the decline of communal harvest practices as a social reproduction crisis whose erosion of intergenerational tacit knowledge is itself a generative mechanism of the quality paradox rather than an supplementary context. A partial resolution pathway emerges in the form of women and young entrepreneurs who are convention-competent though their capacity to scale the transition depends on cooperative institutional platforms largely absent in the present setting. The findings specify the limits of technology and certification-focused interventions and argue for pedagogical, cooperative-institutional, and social-reproductive support for convention-enrolment in Mediterranean smallholder systems undergoing demographic restructuring.

KEYWORDS
citizen science, conventions theory, cultural lag, Mediterranean sustainability, olive oil production, quality paradox, smallholder agriculture, social reproduction

1 Introduction

Olive oil constitutes a fundamental element of the diet and culture of the Mediterranean region. It also represents a substantial source of economic activity and environmental pressures. Türkiye is currently one of the leading olive oil producers in the world (International Olive Council, 2026). Most of this production comes from the Aegean region and the city of Aydın contributes with about 15% of the country's oil production (TURKSTAT, 2026). Olive oil production, however, especially in rain-fed agricultural systems, faces increasing climate pressures that could make production more difficult for Turkish farmers. Research on olives shows that there is a general agreement on the factors affecting production, but that there are differing perspectives on the socio-economic responses to these issues (Simmie and Martin, 2010; Taguas and Gómez, 2015; Rodríguez-Cohard et al., 2020).

Socio-economic problems such as small land fragmentation, demographic aging in the rural areas, and youth migration have eroded labor supply in many places of Mediterranean region, as well as Türkiye and Aydın. While the Turkish agricultural workforce is rapidly shrinking (TURKSTAT, 2026), there is no consensus on what could increase olive productivity and its economic value. Some argue that different olive types should be planted due to challenging geographical conditions (Fraga et al., 2020; Öztürk et al., 2021). Others suggest strong cooperatives value chains (Barrett et al., 2022) and the strong branding in olive marketing (Sayadi et al., 2017; Rodríguez-Cohard et al., 2020). These contradictions are deeply embedded in a small district of Aydın, Bozdoğan, which is a microcosm of contradictions: abandoned orchards on the slopes, the improper treatment of olive mill wastewater (OMW), and socio-demographic changes that are causing olive production to be lower than its potential.

The dominant literature on olive production in Türkiye has been oriented around structural determinants and technological prescriptions—cultivar selection, irrigation technology, cooperative organization, and value chain optimization. Valuable as this body of work is, it tends to treat producers as variables to be acted upon by policy levers rather than as interpretive agents whose perceptions, meanings, and everyday decisions determine whether environmental and market pressures are translated into sustainable or unsustainable outcomes. The result is an interpretive gap: the literature documents in considerable detail the external conditions confronting Mediterranean olive producers, yet supplies comparatively little understanding of the micro-level sense-making through which those conditions are processed and acted upon. Closing this gap is not incidental to sustainability research; it is prerequisite to understanding whether and how transitions toward several Sustainable Development Goals (SDGs)—zero hunger, gender equality, clean water and sanitation, and responsible consumption and production—are actually feasible in rain-fed smallholder contexts where producer adaptation is the ultimate determinant of change. To address this interpretive gap, the present study employs a citizen science approach whose epistemic value, as we develop in the methodology section, lies precisely in surfacing the perceptions, local meanings, and tacit decision-making of producers that structural and quantitative approaches cannot reach. Concretely, this study examines the interplay of sustainable olive oil production with the escalating convergence of environmental, economic, and socio-demographic factors in Bozdoğan, a district whose productivity profile, as we argue below, makes it an especially instructive case.

The structural challenges in agricultural production are linked to contemporary sustainability discussions. Bozdoğan has a traditional and fragile production system that lacks the capacity for social and economic self-reproduction, and emerging restrictions associated with environmental conditions engender significant risks regarding agricultural sustainability within the community. Contemporary work on sustainability, however, exhibits a limited emphasis on the social elements at the micro level that influence production structures and their wider social implications (Wang and Ke, 2024).

As stressed in the SDGs, addressing sustainability through a holistic strategy encompassing social, economic, and environmental dimensions is a theoretical need (Purvis et al., 2019). Understanding agricultural transformation processes and producers' perceptions of this change is only possible through an analytical framework that accounts for the mutual interaction of these three dimensions (Sannou et al., 2023; Saleh and Ehlers, 2025). Particularly in the context of olive production, understanding how sustainability is interpreted by farmers in the field and sustainable production practices by centering on social relationships and demographic transformations in rural areas is of critical importance. The research question is, hence, how sustainability of olive oil production is affected by socio-demographic factors and structural limitations.

To answer this question a new and innovative data method, citizen science approach, will be used. Citizen science is regarded as a multidimensional approach that not only increases the production of scientific data but also enhances scientific literacy and broadens public participation in scientific processes (Bonney et al., 2009; Finger et al., 2023). One of the most significant contributions of this approach, as noted in the literature, is making the production of scientific knowledge more democratic and inclusive. Indeed, citizen science is defined as a mechanism that contributes to the "democratization of science" by enabling the participation of diverse socio-economic and cultural groups in research processes (Paleco et al., 2021). This participation not only increases data production but also enables the diversification of research questions, methods, and interpretations, thereby facilitating the production of scientific knowledge in a more inclusive manner. Furthermore, the inclusion of diverse social groups in the process transforms power dynamics in scientific knowledge production and contributes to reducing epistemic inequalities (Jaeger et al., 2023). In this context, citizen science can be viewed not merely as a methodological tool but as a democratic model of scientific production that reshapes the science-society relationship.

Adopting a participatory citizen science approach, this study uses Bozdoğan as a case study to address these complex questions by treating the farmers themselves as co-researchers and drawing on their in-depth interviews, observations, and experiences to present grounded assessment of the challenges and emergent adaptive responses for sustainable food production.

The article is organized as follows. First, sustainability and socio-economic determinants of production will be disused in the next part. In the second part, after a brief description of olive and olive oil production in Türkiye and Bozdoğan, the key points on sustainable olive oil production will be given. Third, a detailed description of research methodology and data collection procedures will be provided. Lastly, research findings and discussions on sustainable olive oil production, social solidarity, and demographic challenges will be presented.

2 Sustainable production and socio-economic determinants of olive oil production in Türkiye

2.1 Environmental concerns

The need for sustainable agriculture is making the system change so that the planet's ecological limits are in line with its socio-economic resilience. Contemporary agricultural production and food systems are at a crucial stage, as global climate stressors—such as alterations in water cycles, resource depletion, and extreme temperatures—pose an immediate threat to the environment and human beings (Zagaria et al., 2023). Scientists are no longer just talking about how to get the most crops from sustainable farming. Now they are also talking about the "triple bottom line," which means protecting the environment, making sure the economy is strong, and keeping rural communities safe. The Mediterranean basin has been greatly harmed by climate change. It is facing major sustainability problems that show how weak traditional farming systems are and require quick, context-specific adaptation plans (Pausas and Millán, 2019; Zagaria et al., 2023). This important point where changes in the environment around the world meet social and economic factors in a certain area is what lets us look at some staple crops in that area.

Olive cultivation is also under increasing pressure due to contemporary socio-economic problems and environmental constraints in Türkiye. The sector is dominated by small, fragmented family-run orchards with low economic capacity and productivity (Adigüzel and Kizilaslan, 2019; Noman and Uclés, 2024). These structural vulnerabilities are worsened by climate variability in the Mediterranean region, where rising temperatures, unpredictable rainfall, and ongoing water shortages endanger agricultural sustainability. Climate change particularly affects the phenology, yield, and geographical viability of olive trees. Temperature increases of up to 6 °C can disturb the essential vernalization needs, ultimately reducing production and negatively influencing fruit ripening and total oil content, even if global warming may cause flowering sooner and lengthen the growth season (Türkeş and Şahin, 2024).

Moreover, extensive environmental externalities are also produced by intensive olive farming and processing operations. According to a Life Cycle Assessment (LCA) of Turkish extra virgin olive oil, each kilogram of oil has a climate change impact of 3.04 kg CO2 equivalent (Ruiz-Carrasco et al., 2023). The agricultural phase is responsible for 83% of this footprint, mostly from fertilizer (51%) and irrigation (19%). This, along with the use of pesticides, puts a significant strain on soil and water resources (Ruiz-Carrasco et al., 2023; Leal Filho et al., 2025). Additionally, olive pomace and olive mill wastewater have a lot of organic matter and polyphenols in them. If these materials are not thrown away properly, they can do a lot of damage to ecosystems nearby (Bas and Killi, 2024; Enaime et al., 2024). However, waste products like olive pomace can be repurposed as safe agricultural fertilizer with efficient industrial treatment, reducing some of these ecological effects (Černe et al., 2023).

Taken together, this literature provides a detailed portrait of the environmental pressures that constrain Turkish and Mediterranean olive production as measured from above—through downscaled climate projections, Life Cycle Assessment accounting, water-balance modeling, and pollution-load characterization. What it has left largely untheorized is a corresponding question from below: how producers themselves perceive, interpret, and respond to these pressures in the practical conduct of cultivation and processing. This inequality is important for real reasons, not just rhetorical ones. It is the small decisions that individual producers make, like when to water, what chemicals to use, whether and how to properly dispose of mill wastewater, and whether to accept the costs of conversion to a less polluting two-phase extraction method that affects the environment. The absence of this interpretive dimension in the existing literature constitutes a specific epistemic gap (Sumane et al., 2018; Carolan, 2006) that the present study is designed to address, and it is one of the two principal gaps that motivate our research design.

2.2 Socio-economic challenges for sustainable olive production

There are several structural threats to the long-term viability of olive growing and processing in Türkiye. These concerns stem from the basic structures of farms, how they are managed and worked, the economic system they are embedded in and their marketing position. Barriers identified include the high proportion of small scale, traditional farming operations, cultivation on marginal land and low productivity levels as well as problems with market development and labor (Adigüzel and Kizilaslan, 2019). Almost 400,000 small scale families are responsible for olive production in Türkiye (Ligvani and Artukoğlu, 2015). The focus of many farmers with primary to no education is still on sustenance economics than increasing productivity and quality.

Such structural disintegration stands in the way of economies of scale in production being realized. Consequently, the cost is high and efficiency is low (Adigüzel and Kizilaslan, 2019). Therefore, improvements in current irrigation, more machinery or better processing technologies are hard to realize. The current small, weak, and fragmented producer structure does not allow for the formation of strong cooperatives and marketing strategies. It increases the price volatility and erodes the bargaining position of producers (Ligvani and Artukoğlu, 2015). All of these factors prevent the olive oil sector from fully realizing its potential in both national and international markets. Furthermore, the aging of the farmers themselves makes it more difficult to spread new production methods and slows down the updating of technologies in the sector (Tok et al., 2022). The migration of young and middle-aged workers from villages is leading to labor shortages in agriculture and harvesting. This labor shortage can have adverse effects on the quality and quantity of the olive harvest.

As with the environmental literature reviewed above, however, the existing work on these socio-economic challenges has proceeded largely at the aggregate level—documenting structural fragmentation, demographic aging, and market exposure through statistical and sectoral analysis—without systematic investigation of how these pressures are experienced, narrated, and negotiated by producers in their daily practice. This second interpretive gap, complementary to the environmental one, reinforces the need for a qualitative, micro-level approach and frames the research question that this study pursues: under what socio-demographic and structural conditions do high-potential olive-producing territories fail to convert that potential into sustainable, high-value output?

3 Olive oil production in Türkiye

Tagging with the average of 2020–2025, with 319,000 tons Türkiye occupies the second place for olive oil production in the world production after Spain (International Olive Council, 2026). Turkish olive

production is quite dispersed geographically, a total of 903,061 hectares were recorded in the year of 2023 (FAO (Food and Agriculture Organization of the United Nations), n.d.) and about 204 million olive trees in the country were identified in 2024 (Aydın Ticaret Borsası, 2024).

Figure 1 shows the global olive production since 2000. Türkiye is among the leading olive-producing countries after the European Union (EU), comprised of Southern European countries such as Spain, Italy, and Greece. Olive oil production in Türkiye has fluctuated but generally shown an upward trend. While world production has fluctuated between approximately 2.4 and 3.5 million tons during this period, EU production continues to constitute the majority of the total, although exhibiting significant volatility over the years. Spain's dominant role in production and its sharp increases and declines over the years are the main determinants of fluctuations in both EU and global totals. Türkiye, on the other hand, has shown remarkable growth performance during this period, starting from a lower level. Production, which fluctuated between 100 and 200 thousand tons in the early 2000s, began to increase, notably after 2016, topping 400 thousand tons in some years and reaching roughly 500 thousand tons in the 2024/25 period. Olive and olive oil production in Türkiye, like in other Mediterranean countries, exhibits a fluctuating production structure due to periodicity. An analysis of overall production trends shows that the share of Türkiye has been steadily increasing and that it is one of the most significant producers outside the EU. In recent years, in particular, its production capacity has come close to being on par with more established producers like Italy.

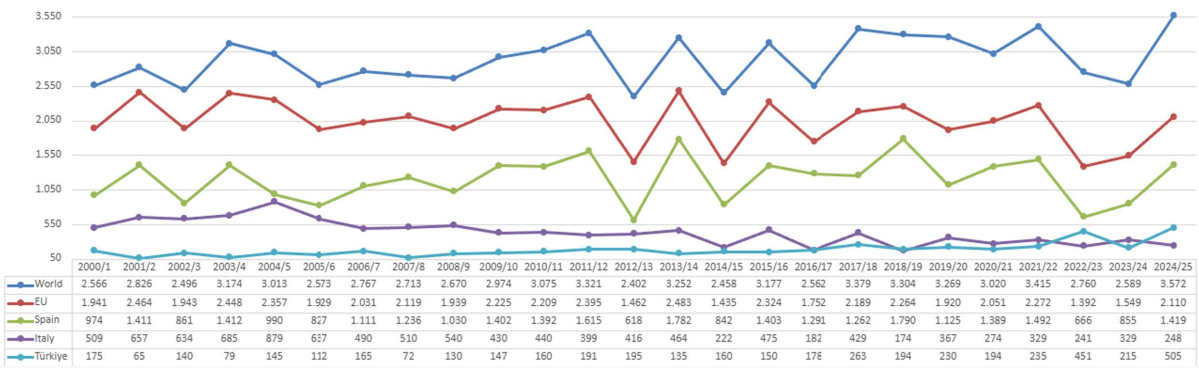
In the Aegean, Marmara, Mediterranean, and Southeastern Anatolia regions, where typical Mediterranean climate dynamics (dry-hot summers and mild-rainy winters) predominate, as well as in the narrow microclimate areas of the Black Sea, olive cultivation is primarily practiced in Türkiye (see Figure 2). With 49% of all olive trees and over half of the country's olive production, the Aegean area has a highly concentrated geographical pattern of olive agriculture. With 24% of the tree stock and 27% of total production, the Mediterranean region comes in second. While the Southeastern Anatolia region holds 10% of the olive trees, just 3% of the entire production comes from the Marmara region, which has 16% of the trees and produces about 20% of the country's output (Özdel et al., 2024).

Six major regions influence the country's production patterns, such as the Southern Aegean's emphasis on olive oil production, the Gulf's (Ayvalık, Edremit, and Burhaniye) boutique quality, and Marmara's expertise in table olives. Sectoral superiority is held by Manisa in Western Anatolia, with its intensive olive production methods, and its southern neighbor Aydın, with its better-quality standards (Aydın Ticaret Borsası, 2024). In particular, the Aegean Region (Aydın, İzmir, Balıkesir, and Çanakkale) is a leader in production for Türkiye, whereas the Northern Aegean is known for its early harvest and quality-focused output. According to data from the Ministry of Agriculture and Forestry, this tendency is encouraged by geographical indication and cooperative activities (TAGEM, 2022). Three broad patterns emerge when analyzing olive oil production in Türkiye (TEPGE, 2023).

The three-phase continuous system has been widespread for a long time (TAGEM, 2022). It is used in many places, especially in the Aegean Region (Aydın, İzmir, and Balıkesir). It leads to environmental problems due to the significant amount of wastewater it produces. Two-phase continuous systems, on the other hand, have become widespread in recent years, especially due to environmental concerns. This production system is more sustainable due to its reduced water consumption and reduced waste water problems. They are preferred in more organized and systematic production regions such as Çanakkale, Balıkesir, and İzmir.

Another production style is high-quality, cold-pressing and boutique production. This production style is particularly common in the Northern Aegean (Ayvalık, Edremit, and Çanakkale) and some Southern Aegean regions, including Aydın. High value-added, export-oriented products are produced. This production style involves harvesting olives from non-irrigated (dry farming), sloping lands exposed to natural stress during the "early harvest" period and pressing them immediately at temperatures below 27 °C (cold pressing) in modern, waterless (two-phase) machines. This style produces oils with low acidity, high fruitiness, very high antioxidant value, and medicinal/functional food qualities.

Considering olive production basins throughout Türkiye, the southern Aegean basin, including Aydın, stands out in terms of production quantity and product quality. Aydın is one of the provinces with the highest olive production in Türkiye. The geographical structure of this region consists of the fertile alluvial soils and mountainous slopes of the Büyük Menderes River Basin. Olives obtained through dry farming on the mountainous slopes have a high oil and polyphenol content. Aydın, has a significant share in Türkiye's olive production. According to the 2020–2024 averages, Aydın accounts for about 13% of Türkiye's total olive production while Memecik, Gemlik, and



	2000/1	2001/2	2002/3	2003/4	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
World	2.566	2.826	2.496	3.174	3.013	2.573	2.767	2.713	2.670	2.974	3.075	3.321	2.402	3.252	2.458	3.177	2.562	3.379	3.304	3.269	3.020	3.415	2.760	2.589	3.572
EU	1.941	2.464	1.943	2.448	2.357	1.929	2.031	2.119	1.939	2.225	2.209	2.395	1.462	2.483	1.435	2.324	1.752	2.189	2.264	1.920	2.051	2.272	1.392	1.549	2.110
Spain	974	1.411	861	1.412	990	827	1.111	1.236	1.030	1.402	1.392	1.615	618	1.782	842	1.403	1.291	1.262	1.790	1.125	1.389	1.492	666	855	1.419
Italy	509	657	634	685	879	637	490	510	540	430	440	399	416	464	222	475	182	429	174	367	274	329	241	329	248
Türkiye	175	65	140	79	145	112	165	72	130	147	160	191	195	135	160	150	178	263	194	230	194	235	451	215	505

FIGURE 1
Olive oil production between 2000 and 2025 (1,000 tons). Source: International Olive Council (2026).

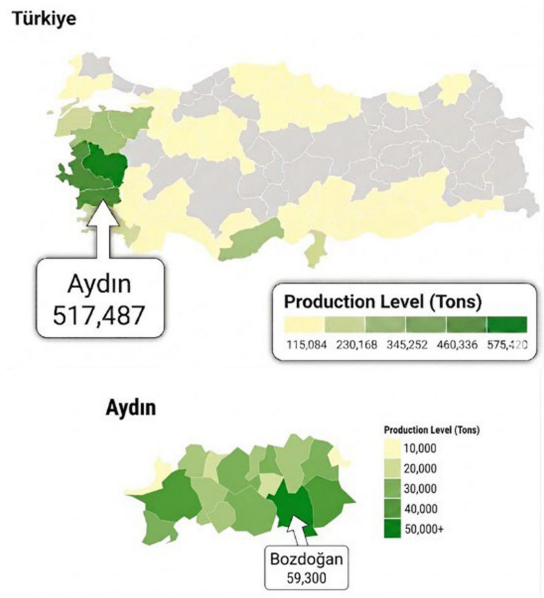


FIGURE 2
Total olive production in Türkiye and Aydın, 2024. Source: TURKSTAT (2026).

Yamalak Sarısı olive types are the dominant olive cultivars (Aydın Ticaret Borsası, 2024).

An examination of the 2020–2024 data presented in Table 1 clearly shows that Aydın holds a strategic importance in Türkiye's olive farming, particularly in the oil olive category. Indeed, according to five-year averages, Aydın alone accounts for 13.6% of national oil olive production and 12.7% of total olive production. When examined by region, it becomes clear that Bozdoğan district constitutes a critical sub-region within the Aydın agricultural ecosystem. Based on average values, Bozdoğan accounts for 12.4% of Aydın's table olive production and 8.5% of its oil olive production, making a stable contribution of 9.5% (an average of 27,300 tons annually) to the province's total production volume.

Despite annual yield fluctuations, Bozdoğan's share of production within Aydın and Aydın's share within Türkiye have maintained structural integrity across two decades, demonstrating the high agricultural capacity and resilient economic potential of this basin. This surface stability, however, conceals an empirical puzzle that has not been adequately theorized in the existing olive production literature. In spite of holding one of the country's largest cultivation areas, Aydın lags behind provinces with considerably smaller cultivation footprints—such as İzmir (18% of national production) and Muğla (16%)—in terms of share of national output (TEPGE, 2023). Translated into yield terms, this means that per-tree productivity in Aydın is systematically below the level that its biophysical conditions and cultivation scale would predict.

We term this the productivity paradox of olive production: a persistent gap between cultivation capacity and realized output that cannot be reduced to any single agronomic, climatic, or demographic factor on its own. Partial explanations advanced in the literature—the biennial bearing cycles of the dominant Memecik cultivar (TAGEM, 2022), the placement of low-yielding groves on unsuitable mountainous terrain, and aging, under-maintained orchards in demographically thinning villages (Tok et al., 2022)—each capture a dimension of the problem. However, none of them accounts for it fully, and their conjoint operation under the contemporary conditions of rural demographic collapse, market integration failures, and climate-induced livelihood insecurity remains poorly understood from the producer's standpoint. It is precisely this conjoint, producer-internal dynamic that the present study is designed to investigate. The productivity paradox, hence, is not treated here as a passing contextual note but as the empirical problem that motivates the core research question of this paper: under what socio-demographic and structural conditions does a region of high agricultural potential fail to realize that potential in actual production? Bozdoğan, whose aggregate share within Aydın is high but whose producer-level realization of quality and value remains constrained, offers an especially instructive vantage point from which to pursue this question.

The primary olive variety is Memecik in the region. It exhibits slightly more pronounced periodicity compared to other common varieties. In addition to the olive type, the topography and farming practices have significant roles in productivity. The presence of low-yielding olive groves on mountainous locations unsuitable for agriculture, as well as the use of machinery, are two factors contributing to the productivity problem. Furthermore, in rural areas where the population is often elderly, agricultural activities cannot be conducted in a modern and efficient manner. Olive groves are either maintained very inaccurately or neglected for a long time, which further degrades their current productivity (TAGEM, 2022; T.C. Sanayi ve Teknoloji Bakanlığı, 2023). The aging and low productivity of existing olive groves make the rehabilitation and regeneration of traditional olive orchards a priority for sustainable yield increases in the region. These issues underscore the necessity of a thorough examination of the causes of the productivity decline in the province that produces the most olives in Türkiye, with a particular emphasis on land, climate, and traditional farming methods.

4 Materials and methods

TURKSTAT (2026) population statistics show that the population of Bozdoğan District stood at around 41,000 in 1945, began a steady decline, particularly after 2006, and had fallen to approximately 31,000 by 2025. The population growth trend seen throughout Türkiye over the past century is at conflict with the demographic collapse in Bozdoğan. Like many rural areas in Türkiye, Bozdoğan's agriculture-based economy has failed to create new economic prospects, and the youthful population's migration to metropolitan areas in pursuit of employment and educational opportunities is the main cause of this problem (Aysan et al., 2022). Additionally, the decline in total fertility is limiting the natural population growth, thereby deepening the overall population loss. In this context, Bozdoğan can be regarded as a typical example of a rural district in Türkiye that has entered a demographic decline process. An analysis of Bozdoğan, hence, is crucial for understanding sustainable food production and local development.

This exploratory study employed a citizen science approach to examine the general characteristics of olive oil production and challenges for sustainability issues in Bozdoğan. This approach has become an important scientific method within contemporary academic research. Citizen science approach actively engages ordinary people in collecting and sometimes analyzing data and acts as a powerful collaborative tool for advancing scientific discovery (Oakden et al., 2021). The scientific benefit is mainly on the potential to generate large scale data sets over broad geographic and temporal ranges that cannot be achieved by professional scientists alone (Downs et al.,

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TABLE 1 Olive production in Bozdoğan, Aydın, and Türkiye between 2000 and 2024.

Year	Region	Olive production for table olive (1,000 tons)	Olive production for olive oil (1,000 tons)	Total olive production
2020	Bozdoğan	6.1	11.6	17.7
	Aydın	45.2	75.5	120.7
	Türkiye	513.1	803.5	1,316.6
	Share of Bozdoğan in Aydın (%)	**13.5**	**15.4**	**14.7**
	Share of Aydın in Türkiye (%)	**8.8**	**9.4**	**9.2**
2021	Bozdoğan	2.5	12.9	15.4
	Aydın	58.9	228.8	287.7
	Türkiye	555.8	1,182.8	1,738.7
	Share of Bozdoğan in Aydın (%)	**4.2**	**5.6**	**5.4**
	Share of Aydın in Türkiye (%)	**10.6**	**19.34**	**16.5**
2022	Bozdoğan	10.0	22.1	32.1
	Aydın	82.9	249.2	332.2
	Türkiye	938.2	2,037.8	2,976.0
	Share of Bozdoğan in Aydın (%)	**12.1**	**8.9**	**9.7**
	Share of Aydın in Türkiye (%)	**8.8**	**12.3**	**11.2**
2023	Bozdoğan	4.2	7.6	11.8
	Aydın	50.1	122.9	173.0
	Türkiye	490.0	1,030.0	1,520.0
	Share of Bozdoğan in Aydın (%)	**8.4**	**6.2**	**6.8**
	Share of Aydın in Türkiye (%)	**10.2**	**11.9**	**11.4**
2024	Bozdoğan	25.3	33.9	59.2
	Aydın	152.4	365.1	517.5
	Türkiye	1,166.3	2,583.7	3,750.0
	Share of Bozdoğan in Aydın (%)	**16.6**	**9.3**	**11.4**
	Share of Aydın in Türkiye (%)	**13.0**	**14.1**	**13.8**
Average	Bozdoğan	9.7	17.6	27.3
	Aydın	77.9	208.3	286.2
	Türkiye	732.7	1,527.6	2,260.3
	Share of Bozdoğan in Aydın (%)	**12.4**	**8.5**	**9.5**
	Share of Aydın in Türkiye (%)	**10.6**	**13.6**	**12.7**

Source: TURKSTAT (2026).
Bold values indicate the share of olive production in Bozdoğan and Aydın.

2021; Finger et al., 2023). Such a wide range of capabilities allows science to address issues in various global challenges in different fields, such as health and environment.

The usefulness of data from citizen science in a particular research setting is in relation to the implementation of their design but shows a clear requirement for standardization in terms of training and

professional factors in relation to data that are inferentially powerful for conservation and management applications (Brown and Williams, 2018). This approach shows a critical dual purpose in terms of being a powerful tool for data collection in a particular setting and a foundational level for creating scientific literacy within a particular society.

Active engagement by citizen scientists democratizes the research process, promotes inclusiveness, and ensures that scientific inquiries align with social priorities. Citizen contributions extend beyond mere data collection, as citizen input often includes complementary local and traditional knowledge, which can lead to innovative problem-solving approaches and improved research strategies (Downs et al., 2021; Coeugnet et al., 2023; Finger et al., 2023). By facilitating co-learning and knowledge integration, citizen science enhances public understanding of science, cultivates a sense of environmental stewardship, and produces socially robust knowledge that is acceptable and trustworthy to the broader public (Mazumdar et al., 2018; Finger et al., 2023).

Citizen science is highly applicable in environmental monitoring and supporting global duties (Fritz et al., 2019). Environmental sciences are a cornerstone of citizen science, in which citizens participate in actively observing phenomena at spatial and temporal scales from water and air quality to changes in biodiversity. Since traditional data sources may fall short for monitoring some SDG targets, citizen-generated data may represent an important source to monitor and report on development goals (Hughes et al., 2022). Citizen science has been successfully transferred towards applied fields, such as agriculture where participatory research initiated by farmers also can help in promoting efforts like crop variety management for the adaptation to climate change (Downs et al., 2021).

To understand sustainable olive oil production, in-depth interviews were conducted by farmer citizen scientists with local villagers, olive oil producers, and cooperative representatives. The citizen science method was chosen to provide a deeper understanding of scientific and locally specific information, especially when dealing with complex socio-ecological issues such as agricultural sustainability (Turrini et al., 2018). Involving citizen scientists directly ensures that the research questions, the interpretation of findings, and consequent knowledge generated are rooted in lived experiences rather than merely theoretical perspectives, which potentially increases the relevance, applicability, and impact of results.

The choice of a peer-to-peer farmer interview design warrants a specifically epistemological rather than solely normative justification. As Strasser et al. (2018) argue, the value of a given citizen science design must be specified in terms of the epistemic function it performs, since participatory research encompasses a heterogeneous set of approaches with quite different knowledge-generating properties. For the present study, the peer-to-peer design was selected not because it is inherently more "authentic" or "democratic," but because it plausibly generates forms of qualitative knowledge that researcher-conducted interviews with the same informants would not have reliably produced. Four dimensions are particularly pertinent.

First, with respect to interview dynamics, peer interviewing takes place in a shared linguistic register and is embedded in the tempo, idiom, and conversational norms of village life. Informants were interviewed by someone whose own olive trees they know. This reduces the performative dimension of the research encounter and permits the open-ended, associative mode of talk characteristic of everyday rural exchange (Turrini et al., 2018). Second, with respect to topic coverage, citizen scientists are spontaneously attuned to the salient grievances and silences of their community: it is not incidental that olive mill wastewater ("black water") discharges and the tightening labor market for the harvest were raised unprompted across multiple interviews. A researcher unfamiliar with Bozdoğan would likely have reached these themes only through iterative revisiting, or not at all. Third, with respect to trust, peer-to-peer interviewing mobilizes pre-existing relational capital that cannot be reconstructed within a single fieldwork visit. This is particularly important for sensitive disclosures where speaking with a neighbor carries different, and often lower, perceived risks than speaking with an outside researcher (Coeugnet et al., 2023). Fourth, with respect to the elicitation of tacit knowledge, peer interviewing surfaces procedural and embodied knowledge about olive production that farmers frequently cannot articulate to unfamiliar interlocutors (Sumane et al., 2018). When an elderly farmer explains harvest timing, milling delays, or the visual cues of olive ripeness to another farmer, she can presuppose a shared sensorial-practical background; the resulting accounts are richer in technical specificity and more candid about the gap between normative and actual practice than equivalent accounts produced for an external researcher.

These four epistemic affordances—of dynamics, coverage, trust, and tacit knowledge—are not incidental to the democratic or participatory character of the design; they are the specific content of its epistemic value. The methodological innovation of this study, accordingly, should be understood not as the distribution of data-collection tasks to local residents per se, but as the deliberate use of peer-to-peer interviewing to generate a class of qualitative data that asymmetric researcher-informant encounters would systematically under-represent. This claim is made compatibly with, rather than in displacement of, the design's trade-offs: peer interviewing reduces the distance that can sometimes be protective for informants discussing highly sensitive matters, and its situatedness may reinforce community-level framings at the expense of critical distance. The fifteen researcher-conducted key-informant interviews reported below were designed, in part, as methodological triangulation against these risks, by introducing interlocutors from outside the peer network (municipal officers, agricultural engineers, cooperative representatives) whose accounts could be read alongside, and against, the peer-generated corpus.

In consultation with the Bozdoğan Chamber of Agriculture and local cooperatives, farmer citizen scientists assisted in collecting data. They provided in-depth, applied knowledge about traditional and modern methods of olive production, with most of the participants owning or managing orchards. The qualitative data were collected in August 2024 and involved multiple as well as interconnected phases.

Prior to data collection, all citizen scientists participated in structured training sessions for the in-depth interview process as well as courses on sustainability and sustainable olive oil production. In these meetings, 40 farmers received training on conducting semi-structured interviews, focusing on techniques to elicit detailed information on traditional practices, challenges, and sustainability awareness. Following their training, 36 citizen scientists (26 males and 10 females, aged between 25 and 79) engaged in fieldwork. The citizen scientists conducted peer-to-peer interviews, successfully completing 60 in-depth interviews with 45 males and 15 females, other local producers from various age groups (see Table 2). These interviews focused on documenting traditional olive oil production methods, challenges in olive production, and perceived impacts of climate change among farmers.

Between June and August 2024, the research team performed 15 more in-depth, semi-structured interviews with important information sources in Bozdoğan to triangulate and enhance the data gathered by citizens. The duration of each interview ranged from 40 to 90 min. Informants were composed of farmers, as well as municipal officers, agricultural engineers, members of agricultural credit cooperatives, and the most important local olive oil producers.

The qualitative data derived from the interviews were carefully investigated through "reflexive thematic analysis," following the six-stage framework established by Braun and Clarke (2006, 2019). After transcribing qualitative data, an iterative inductive coding procedure was employed to identify, analyze, and correlate emerging codes related to traditional practices, perceptions of sustainability, and socio-economic issues. After setting up the core norms and issues, like the "quality paradox" and the decline in social cohesion, two participation workshops were held with citizen scientists and other key local people (Figure 3).

Farmers were able to talk about and evaluate the themes that came up in these participatory workshops. They were also a good way to check that members were who they said they were. The collaborative analysis enhanced the qualitative validity, relevance, and reliability of the research findings by ensuring that the thematic structure was grounded in the actual experiences of Bozdoğan farmers. Prior to this comprehensive topic analysis, artificial intelligence transcription methods were utilized to accurately transcribe the audio recordings of the study interviews.

The data collection procedure, which uses a citizen science model that includes the local community, has certain problems as well. It was noted during fieldwork that senior citizen scientists encountered greater difficulties than their younger counterparts in systematic data gathering and record-keeping procedures. It was observed that individuals in this age predominantly concentrated on historical olive production methods and the agricultural heritage of the region, rather than contemporary ecological practices. While this shifts the nature of the dataset toward a "past-centered" perspective, as Braun and Clarke (2019) note, the construction of the data in this manner provided a rich historical context for understanding the region's ecological transformation.

Braun and Clarke's (2006, 2019) "reflexive thematic analysis" posits that the researcher's subjectivity is not a contaminating factor but a crucial analytical tool in the construction of meaning. In compliance with ethical norms, informed consent was obtained from all participants, and measures were implemented to reduce the influence of local biases and assumptions on the outcomes. During the data collection process, researchers employed reflexive diaries to keep an eye on their own biases. This approach ensured that the researchers not only reported the participants' statements but also examined the social and cultural meaning frameworks included in their statements concerning their own academic viewpoints. From the perspective of researcher positionality, the researcher's familial ties to Bozdoğan had a substantial impact on the field settings. Being an "insider" makes it easier to immediately create trust with local farmers and learn the cultural codes. But the researcher's personal connection to the place may have made them more positive, especially about Bozdoğan's potential for progress and ways to work together. We made sure that this probable bias did not affect the results by talking to other researchers and having "critical friend" chats during the analysis phase. The idea was to keep the data both local and analytical.

TABLE 2 Socio-demographic characteristics of citizen scientists and respondents.

Age	Citizen Scientists		Respondents	
	Male	Female	Male	Female
25–49	6	3	10	4
50–64	16	5	31	9
65–79	4	2	4	2
Total	26	10	45	15

5 Results and discussion

This section gives a full analysis of the results from the qualitative data that was collected about how olive oil is produced in Bozdoğan. The results are organized into four interconnected thematic areas that capture the primary challenges in olive oil production as well as socio-demographic dynamics: (i) the multifaceted challenges for sustainability; (ii) different types of olive oil production techniques and the quality issues; (iii) the erosion of social solidarity with aging population and its socio-economic consequences; and (iv) the emerging role of women and the youth entrepreneurs (see Figure 4).

5.1 Sustainability: conceptual ambiguity and structural problems

Sustainability has become a central organizing principle of contemporary agricultural policy, yet the ways in which lay actors construct its meaning under conditions of structural vulnerability remain inadequately theorized. Our findings show that for many farmers in Bozdoğan, sustainability is at once abstract and operationally uncertain. For farmers who economically rely on the land itself,



FIGURE 3
Data collection process.

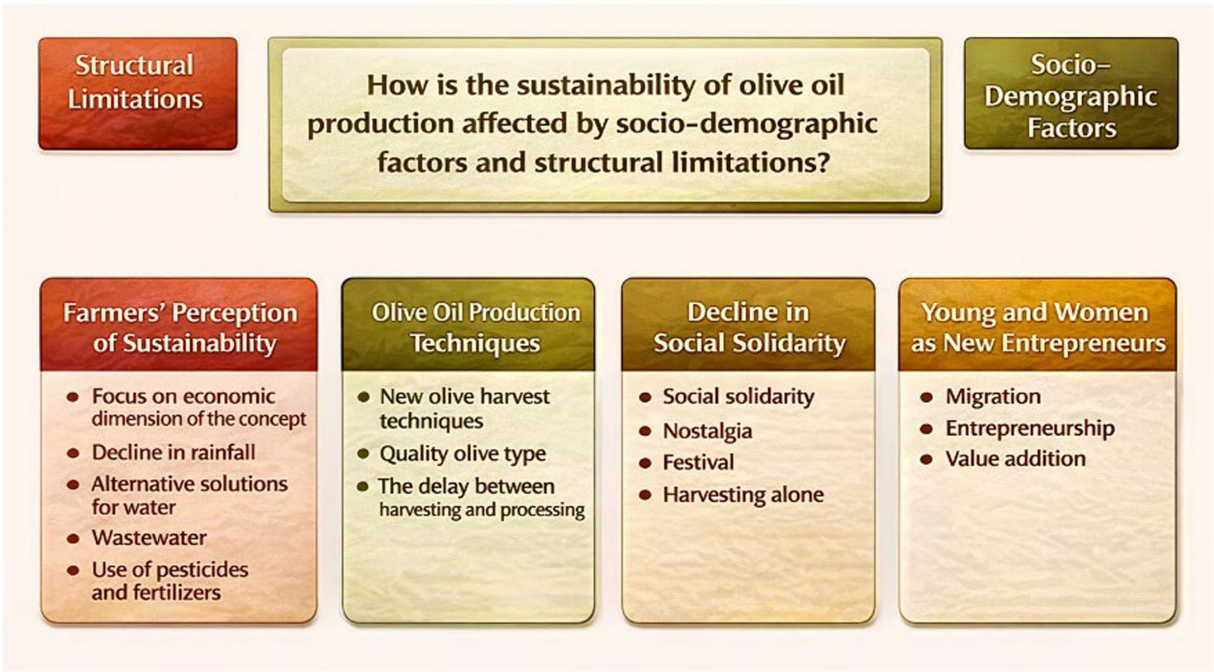

FIGURE 4
Themes of the interviews.

sustainability was largely seen as an abstract economic term. They defined the concept in terms of yield and income stability. As an elderly male farmer, with more than 50 years of farming experience expressed, "…Sustainability means that every year [you] can get a high yield". Economy was also articulated by another participant who said, "sustainability is getting something from your labor… You get up at 5 o'clock in the morning to work on your land; it must have a return". This sounds like a very basic and logical concern about life security, for which the environment and human elements of sustainability are often downplayed by farmers.

Awareness was even poorer among non-farmers consumers in Bozdoğan. Responses ranged from complete unfamiliarity—"Sustainability? What is that, I am hearing it the first time …"— to incomplete comprehensions. A minority of farmers, typically educated or exposed to educative tools, gave holistic definitions. For example, a farmer woman gave a kind of glossary definition: "…It means using natural resources efficiently and in a balanced manner to meet the needs of present and future generations". Yet these people were the exceptions which indicated a substantial gap in communication between world-wide scientific knowledge on sustainability and local context in Bozdoğan.

Despite this conceptual ambiguity, human-induced climate change is influencing production methods in many areas of the Mediterranean region, like Bozdoğan. Farmers consistently expressed that the level of dry periods and severity of droughts had sharply risen, accompanied by more erratic and heavier rainfalls. This evidence is consistent with the downscaled climate models for the Aegean region, which have forecast an increase in temperatures and drought (Tunalıoğlu and Durdu, 2012). The increasing water requirements for olive cultivation are a well-known problem in the Mediterranean region (Rodríguez-Cohard et al., 2025). This shift of climate has in turn changed irrigation from a supplementary to an indispensable factor in making production certain.

A middle-aged farmer, who recently invested in a new drip irrigation system, articulates it this way: "Irrigation simply wasn't necessary in the past; if it rained, then you had water for your olives and, generally speaking, weather was more predictable as well… But now we have very lengthy and extremely dry summers… It would not be possible; without a drip system, the yield would decrease." Although a drip system constitutes a so-called adaptive water-wise technology use, its increasing usage shows a significant growing water vulnerability. Such an approach produces a precarious situation where the solution to drought relies on the uncertain availability of water resources.

The most acute and visible environmental threat identified by the citizen scientists can be the mismanagement of olive mill wastewater, known locally as "black water." This wastewater has traditionally been considered highly polluting because of the high organic content (Niaounakis and Halvadakis, 2006). The practice of its disposal, as reported by multiple participants, is a testament to regulatory failure and institutional problems for sustainable food production. A middle aged man farmer reported with disappointment, "… factories discharge black water into the river on rainy days, causing fish deaths in the river. This is an important problem. The state tried to prevent it but was not successful". This uncontrolled discharge is a well-documented cause of severe degradation of aquatic ecosystems, which may lead to eutrophication, oxygen depletion, and toxicity (Kapellakis et al., 2025). The oxygen-poor conditions caused by the decomposition of organic material are the direct cause of the large-scale deaths of the fish. The fact that this problem was spontaneously brought up by many of the farmers and olive oil producers confirms how prevalent this problem is, as well as how severe the local environmental impacts of it are. This environmental issue is a major institutional failure, despite the fact that there are some regulations to address it.

The increasing use of pesticides and fertilizers is becoming a serious problem for growing food in a way that is good for the environment. A farmer said it best: "In the past, we did not use pesticides or

fertilizers very often; now we use them more and more." Farmers feel like they have to keep their yields up, especially since the weather is getting less predictable, and they think that modern farming needs chemicals. This creates a cycle: chemicals are introduced, the ecology is disrupted, and subsequently, the soil, water, and local fauna are jeopardized (Gomiero et al., 2011).

A precise formulation of the Bozdoğan finding's theoretical contribution is assured at this point. That farmers in market-exposed smallholder systems define sustainability predominantly in economistic terms—centered on yield stability, income continuity, and livelihood security—is by now a well-documented pattern across comparable contexts (Sannou et al., 2023; Saleh and Ehlers, 2025; Wang and Ke, 2024); it is not, in itself, the novel contribution of this study. Crucially, this pattern is not generic to smallholder agriculture but is documented with particular clarity in traditional Mediterranean olive-farming communities. Research from the Spanish olive basins of Jaen and Andalusia (Parra-López et al., 2008; Rodríguez-Cohard et al., 2020) and from Portuguese sloping-land olive groves (Duarte et al., 2008) has independently recorded that olive producers systematically prioritize economic continuity and yield stability over environmental and social dimensions of sustainability, even while operating under comparable climate and demographic pressures. The Bozdoğan findings should therefore be read not as an isolated Turkish case but as an instance of a broader Mediterranean pattern whose structural drivers—land fragmentation, rain-fed dependency, demographic aging, and weak market-integration—are substantially shared across the basin. The comparative literature consistently shows that what from a policy perspective appears as a reductive or deficient understanding of sustainability is, from a producer perspective, the rational foregrounding of the dimension most proximate to survival under conditions of livelihood precarity.

In the literature, there are numerous competing interpretations of this economistic reduction. The effect of inadequate environmental education, a culturally embedded hierarchy of concerns that persist independently of material conditions, a rational adaptation to livelihood precarity, or a situated epistemological response to the practical irrelevance of environmental-sustainability framings under conditions of immediate economic vulnerability are all potential interpretations. Each of these interpretations carries distinct policy and theoretical implications, and the Bozdoğan data permit a principled adjudication among them. Younger and educated farmers articulate notably broader sustainability definitions, whereas economistic definitions cluster systematically among older, less educationally exposed, and more economically pressured producers. The distribution of framings therefore tracks position within the precarity structure rather than constituting an invariant cultural disposition or a uniform knowledge deficit. A rational-adaptation reading, folded into a situated-epistemological one, accounts for this distribution better than the cultural-persistence or deficit alternatives; the argument developed in the following paragraph specifies why.

What the Bozdoğan case contributes theoretically is a finding that the standard deficit model of sustainability communication (Sturgis and Allum, 2004; Bauer et al., 2007)—attributes economistic or reductive framings to insufficient lay knowledge of environmental science—cannot adequately explain. Our participants do not frame sustainability in an economistic sense because they are unaware of environmental stressors; on the contrary, their accounts register a fine-grained and spatially precise awareness of drought, hydrological change, pollution from olive mill wastewater, and the ecological costs of agrochemical intensification. In the same interviews in which they equate sustainability with "a high yield every year," they recount fish kills from "black water" discharges, observe that pesticide and fertilizer use has escalated as weather becomes less predictable, and narrate the temporal change in seasonal rainfall with reference to specific decades. The coexistence, within individual narratives, of economistic framing and detailed environmental knowledge indicates that it is livelihood precarity rather than knowledge deficit that produces the economistic framing. Economism here operates as a situated coping discourse under structural vulnerability rather than as the marker of a cognitive gap between expert and lay understandings. This approach aligns with work in agrifood and environmental studies that theorizes lay sustainability knowledge as situated and practice-embedded rather than deficient (Carolan, 2006), and it carries a direct policy implication: interventions premised on closing a knowledge gap will fail to reshape farmer framings so long as the material conditions of precarity that make those framings rational remain in place.

5.2 "Quality paradox" in olive oil production

One of the old farmers stated "In the past they were retrieved by beating the branches with other branches; this process crushed the olives. Damaged or smashed fruits go into fermentation very rapidly, and acidity of the oil increases". Damaged branches and buds to trees have an influence to the tree or crops and influence to next year's crops. New modern techniques such as handheld rakes or trunk shakers are a new way of olive collection to have lesser labor with lower fruit damages.

In recent years, using tarpaulins or nets under the tree has improved many factors of hygienic when compared with picking the olive directly on the ground. An olive grower's comment shows the advantage of using tarpaulins: "…before nothing is laid down under the tree so olive was collected directly on the ground, and old fruits on the ground will mix with fresh fruits in the tree that can cause damages and affect quality, now olive growers are much more aware…". Separating olives in this way is a quality factor, where soil contaminated and already fermented olive oil will cause high content of free fatty acids, and unpleasant aromas (Clodoveo, 2012).

The delay between the harvesting and processing is another very important factor in the quality of olive oil, since fruits have very short life, especially in bags, and if no action is taken immediately, it will undergo anaerobic fermentation, accompanied by a steep increase of acidity and the reduction of beneficial phenolic compounds (Clodoveo, 2012). One farmer described a common frustration: "… You know, waiting in a long queue at the mill, the olives sit in sacks for several days under the sun or rain. It lowers the quality. I wish every village had a small cold-press machine". This statement highlights not only the structural problem they are facing but also a farmer's potential local solution. Small-scale processing that could preserve quality. Nevertheless, since these mills are only used for 2 or 3 months for olive processing, it is not economically effective to increase olive oil mills.

The region is endowed with high-quality olive cultivars, primarily Memecik and Gemlik types, which are known for their robust flavor profile and high polyphenol content, particularly when grown under low-input and or water-stressed conditions (Korkmaz, 2023). Polyphenols are powerful antioxidants responsible for the stability of oil, bitterness, pungency, and its associated health benefits. Paradoxically, this inherent biochemical quality is often not leveraged

in the market due to a pervasive lack of quality consciousness among a segment of producers. Many older farmers act according to tradition rather than measurable parameters. One farmer admitted, "Acidity, polyphenols… these were things we didn't know before; we are just beginning to learn about them. We often didn't even check the acidity of the oil. Still many people don't know the acidity of their olive oil". Low awareness of olive oil quality and mistakes made throughout the production process, from olive fruit to oil, result in a high-potential food product being sold at much lower prices.

The absence of an implemented quality strategy and a regional brand is generating frustration for those more innovative farmers, who are seeing the success of adjacent regions as lost opportunities. The owner of an olive oil factory and an olive trader conveyed this view: "Milas is near us; they registered the olives from Milas with the EU, however, my Memecik type olives here are far superior. I don't understand how they registered that small olive; how did they make it a brand… We absolutely need our own brand. Our olives are among the best in the world… if we had a brand, we could sell outside of Türkiye and our farmers could benefit economically from selling their products." This feeling reflects an important failure of collective action and regional marketing which clearly demonstrates a major gap between the region's high-quality agriculture products and the marketing recognition and economic benefits those products deserve.

The field findings converge on what we term the "quality paradox" in olive oil production in Bozdoğan: a systemic disjuncture whereby producers endowed with biochemically superior olive varieties and favorable agro-ecological conditions consistently fail to translate this potential into high-value, quality-differentiated olive oil in the marketplace. The paradox, we argue, is neither a matter of agronomic deficit nor of individual misjudgement; it emerges at the intersection of material production capacity and the normative, organizational, and evaluative infrastructures through which quality is recognized, certified, and remunerated. There are several interlocking reasons for this gap between the region's potential for high-quality olive oil and its low production outcomes.

First, although many farmers have traditionally moved away from harsh harvesting practices (such as beating the trees with sticks or mixing damaged or worm-eaten fruit with high-quality fruit) in recent years, some improper practices that compromise quality still persist during the harvesting process. Second, despite the limited number of large-scale central mills, their insufficient capacity during the olive harvest season forces farmers to store olives in bags for extended periods. In fact, olives stored for long periods in sunny and hot weather ferment, causing their acidity levels to rise and leading to the loss of valuable polyphenols. Third, the tendency to produce using traditional methods limits "quality-conscious production." Field findings indicate that many farmers, particularly older ones, do not have their olive oil analyzed for polyphenol and acidity levels. Without standardized and measurable quality data, it is impossible to prove to premium buyers that their oil is of higher quality. Fourth, weak collaboration among stakeholders—such as farmers, cooperatives, olive oil producers, and the Ministry of Agriculture—and the lack of a marketing strategy make it difficult to promote and sell the produced olive oil.

To theorize this paradox analytically we draw on two complementary registers. First, Ogburn's (1922) concept of "cultural lag" remains generative here not because of its period of formulation but because the causal mechanism it specifies is demonstrably operative in the Bozdoğan case. The rapid diffusion of cold-press mills, harvesting nets, and drip irrigation in recent years has outpaced the concomitant adaptation of quality norms, cooperative arrangements, and market-oriented practices on which the economic value of these technologies ultimately depends. The analytical purchase of cultural lag here is distinct from, and irreducible to, the market-coordination failures captured by value chain approaches (Rodríguez-Cohard et al., 2020): whereas value chain theory diagnoses breakdowns in the downstream articulation between production, processing, and marketing, cultural lag points upstream, to the normative substrate that conditions whether a quality-oriented chain can be constructed at all. Second, because cultural lag alone cannot fully explain why high biochemical quality fails to translate into market recognition, we complement it with convention theory (Boltanski and Thévenot, 1991; Goodman, 2003; Ponte, 2009), which analyses quality not as an objective property of a product but as a socially constructed outcome of shared frameworks of evaluation that coordinate the expectations of producers, intermediaries, and consumers.

In the European premium olive oil market, the dominant quality conventions are industrial (standardized measures such as acidity, polyphenol content, and organoleptic panels), civic (geographical indications and origin-based collective reputation), and, increasingly, ecological (organic and low-input certifications). The Bozdoğan trajectory illustrates a disarticulation between production practice and these conventions: producers cultivate oil of high intrinsic quality under essentially domestic conventions (inherited know-how, interpersonal trust, family-oriented local exchange), while the markets that reward quality operate through industrial and civic conventions that demand measurement, certification, and collective territorial branding. The grievance voiced by one olive trader regarding Milas—"I do not understand how they registered that small olive; how did they make it a brand"—illustrates this disarticulation precisely: what is registered and rewarded is not the biochemical product but its enrolment in a legitimate civic quality convention. Likewise, the admission that "Acidity, polyphenols… these were things we didn't know before" registers a cognitive distance from the industrial convention that governs premium-market valuation. Framing the paradox through this dual lens—cultural lag as the temporal mechanism, convention theory as the evaluative grammar—yields an analytical contribution that extends beyond Bozdoğan. It specifies that the failure of high-potential agricultural territories to capture value in quality-oriented markets is neither a deficiency of the product nor, primarily, a defect of the value chain. However, it is a mismatch between the conventions through which producers define quality locally and those through which markets authenticate it globally. This reframing carries clear policy implications: interventions targeting only technological modernization or value chain integration, without attending to the normative and cognitive work required to align production practice with prevailing quality conventions, are likely to reproduce rather than resolve the paradox.

Taken together, these findings demonstrate that the primary constraints in Bozdoğan are structural, sociological, and organizational rather than narrowly agricultural. High intrinsic quality and significant economic potential nevertheless, the combined effect of improper handling practices, weak organizational articulation, and the misalignment between local production conventions and externally authoritative quality conventions systematically prevents farmers from capturing the value their product could otherwise command.

5.3 Decline in social solidarity: from festival to harvesting alone

In agricultural societies, cooperation and social solidarity are not merely cultural inclinations; they are essential structures that ensure

the continuity of agricultural productivity and the sustainability of social existence. Putnam's (2000) concept of "social capital" explains how solidarity, characterized by elevated trust, norms of reciprocity, and informal networks in rural communities, significantly reduces the costs associated with agricultural production. Besides, Coleman (1988) asserts that these solidarity networks, vital to the social structure, facilitate the mobilization of collective effort during labor-intensive planting or harvesting seasons. In these societies, unpredictable weather and constrained technology compel individuals to unite for "collective benefit" as a pragmatic means of survival. This atmosphere facilitates collaboration among farmers by fostering community consciousness and social connections.

The direct impact of social solidarity on agricultural production and productivity is most clearly observed through collective action and the management of common-pool resources. In her theoretical framework "Governing the Commons," Ostrom (1990) emphasizes that traditional communities characterized by robust social cohesion and established cooperative norms can effectively manage essential agricultural resources—such as irrigation systems and agricultural land—without reliance on centralized state authority or market-driven privatization. Agarwal (2001) asserts that these mutual aid methods make the environment and economy more sustainable and speed up the spread of local ecological knowledge in both directions. Cooperative networks mitigate the risks of poor harvests or agricultural diseases by disseminating them among members. In traditional agricultural systems, social solidarity goes beyond a mere passive relationship that ensures social cohesion; it serves as an active socio-economic resource that enhances agricultural resilience.

In traditional societies, the impact of cooperation on agricultural production stands out as a significant survival mechanism. In this context, the sharing of common labor and resources has both secured production and strengthened social solidarity. Practices such as collaborative work ("imece" in Turkish), particularly in Turkish contexts, have institutionalized cooperation during critical periods like planting and harvesting, thus enabling the overcoming of individual difficulties (Küçük, 2025: p. 434). Such collective practices have not only facilitated the sharing of resources but also enabled the transfer of knowledge and experience, increasing both the originality and quantity of production. This culture of cooperation is seen to have played a vital role in the development of the historical system and its economic growth and has been passed down through generations as an unwritten legal form of solidarity (Yücel and Baki, 2020: p. 156). The erosion of traditional modes of social solidarity outlined in this study strongly demonstrates the social dimensions of sustainable agriculture.

The interviews with the citizen science group found one of the greatest impacts on the social fabric of the yearly olive harvest. For older generations, the yearly olive harvest is much more than a way to make money. It has been the central focus of their social and cultural events; the way in which they bonded as a community, worked for one another through mutual aid, and celebrated as one. The elder farmers spoke of this time with such nostalgia. "When we harvested olives, we did it all together. "There was a lot of friendship… we'd get together and harvest as one. We didn't have to pay people to help us, it was inexpensive. We helped one another, we had a sense of unity." said one elderly farmer.

An older female farmer described the harvest season as akin to a "festival": "Especially during the fig season, it was like a festival. Everyone would come together in their gardens, gatherings would be organized, and the gardens would come alive. On summer evenings, we would chat and socialize together. We would crush the olives with our feet and dip the fresh figs in that beautiful, fresh olive oil and eat them; it had an unparalleled taste." This testimony illustrates how labor and social life were intertwined, creating a rich cultural tradition. The traditional system of social solidarity functioned as an informal insurance mechanism and a vehicle for intergenerational knowledge transfer in the past.

Similar to many other rural areas, Bozdoğan has been undergoing changes brought by the rural-to-urban migration and changing attitudes toward work among the young generation. The gap between young people and agricultural production is gradually expanding because of increases in education levels and urban migration. A woman farmer complained: "My grandchildren don't come to help the olive harvest anymore; even when they come to village, they don't help to pick the olive. We are old and have the heavy burden of everything… olive harvesting is more and more difficult every year". Interview results show that this feeling is widely shared by many other elderly people.

The average age of people engaged in agricultural production in the region is quite close to the national average. According to the records of the Turkish Chamber of Agriculture, the average age of farmers in Türkiye was about 58 in 2023 (Turkish Chamber of Agriculture, 2023). The aging farming population is the result of a mass migration of young people to urban areas such as İzmir, Aydın, and Denizli or to occupations in the service industries at tourist towns like Kuşadası, Didim, and Bodrum. Young villagers migrate to cities often for economic reasons, such as social security problems in agriculture and the possibility of finding relatively higher-paying jobs in the city. This phenomenon is in line with what found by European studies whereby decrease in collective labor and increasing of opportunity costs led farmers to abandon their land especially on the marginal steep lands (Ustaoglu and Collier, 2018).

The current wave of migration is not just a financial one, but also social. As one participant observed: "Girls don't want to marry farmers. They have no desire to grapple with animals. What men also want is full-time jobs with social security". This clearly proves that farming does not seem to hold the image of an appealing or viable life and livelihood among the young, and that a problem which already is emerging in the villages where an elderly demographic exists is aggravated further with migration.

Due to the migration flows, social solidarity in jeopardy and the elderly farmers are largely reliant on paid seasonal labor, which has become the most expensive production cost and poses a substantial danger to economic viability, especially during years of low production. The statement, "now labor costs don't cover the return from olive production," is a striking economic indicator of the situation. The diminishing communal labor has not only elevated production costs, making small-scale farming economically precarious, but has also resulted in an irreversible loss of traditional knowledge, practical skills, and social capital that formerly conferred resilience (Duarte et al., 2008). While attempts have been made to mitigate production challenges through paid labor or mechanization, the erosion of social bonds and communal trust inherent in cooperative olive harvesting has led to greater social isolation and, in some cases, village abandonment. The olive harvest has ceased to be a communal festival, instead of becoming an individual financial and physical burden, fostering feelings of isolation and abandonment among the aging farming community.

These observations carry a specific theoretical weight that is worth drawing out explicitly. Read through the lens of social capital theory alone (Putnam, 2000; Coleman, 1988), the Bozdoğan data document a classic pattern of bonding-tie erosion under rural out-migration. Read through an Ostromian framework (Ostrom, 1990; Agarwal, 2001), they describe the decay of informal commons institutions that once coordinated labor across the olive cycle. Neither framework, however, fully captures what our participants most consistently foregrounded: that the collapse of collective harvest was simultaneously the collapse of an intergenerational mechanism through which tacit know-how, seasonal timing, and sensorial judgment of olive ripeness were transmitted from older to younger producers. What is lost in Bozdoğan, in other words, is not only social capital in the sense of ties-to-be-counted or a commons institution in the sense of rules-to-be-governed; it is a social reproduction infrastructure through which the production knowledge on which quality depends was historically renewed. The "festival" description offered by the older woman farmer—in which the harvest was simultaneously labor, sociality, pedagogy, and consumption—condenses this reading: when the festival ends, what ends with it is not merely cooperation but the sensory-practical curriculum of an entire production system.

This re-description bears directly on the paper's central argument. If intergenerational knowledge transmission has eroded in parallel with, and as a consequence of, demographic and economic restructuring, then the adaptive culture side of the cultural lag described in Section 5.2 is not simply out-of-date; it is under-reproduced, continually thinning at the very moments when the material culture of production (cold-press mills, quality-measurement devices, certification regimes) demands richer, not poorer, tacit competence to be deployed effectively. The decline of social solidarity is therefore not an auxiliary context for the quality paradox but one of its generative mechanisms: the loss of shared practice and its pedagogy contributes directly to the mismatch between technological availability and quality-convention enrolment. Hence, the social dimension of sustainability in Bozdoğan is neither ornamental to, nor merely co-occurring with, the economic and environmental dimensions; it is the infrastructural substrate whose erosion is actively producing the quality, convention, and sustainability deficits documented in the preceding sections.

5.4 Women and the youth entrepreneurs in olive production

Demographic challenges negatively impacting Turkish agricultural production are also clearly evident in Bozdoğan. Within these circumstances women and the youth farmer entrepreneurs seem to be a small but significant, and new, actor group. These groups, particularly young one, must be differentiated from existing traditional female work that always had been an integral part, but usually unseen part of family farming. These new entrepreneurs have not always been farmers. They are usually educated, have lived in cities, and possess an entrepreneurial spirit and business connections. They are taking a distinctly different approach to olive oil production, focusing on quality, branding, and sustainability. There are some examples supporting this argument. For example, some women farmers have organic olive oil certifications or a young veterinarian farmer was recognized for his exceptional product in the national olive oil competition. These examples demonstrate that some of the young people and women have a substantial understanding of long-term business models, market trends, and current production methods. This brings new and modern ways of producing olive oil to the region.

The profiles of these women and the youth correspond with a global trend of women-led agricultural firms focusing on diversification and value addition (De Schutter, 2013; Sachs et al., 2016; Shahbaz et al., 2023). For instance, one young farmer, who went back to her family's land after graduating from college, said: "I'm not just selling oil; I'm selling a story, health, and trust. My customers want to know what they are eating. I tell them about this clean journey from soil to table". These women are more likely to invest in modern and sustainable production to ensure product quality, brand their oil, and utilize online platforms for direct marketing.

The involvement of educated women and young people into quality production of olive oil may be a possibility for reviving the industry. For them, olive oil is a valuable agricultural product, and combining traditional methods with modern techniques can transform it into a profitable one. The numbers are still few and are struggling with same constraints as traditional farmers, such as market uncertainty, lack of water, high labor costs; so their success is not guaranteed without institutional support and policy making for structural changes. Such opportunities given by Southern Aegean Development Agency for the women's cooperatives may benefit producers lacking access to credit with financing and technical assistance. A specialist from the Agency stated, "All women entrepreneurs can easily take the advantage of these financial and technical opportunities".

Rodríguez-Cohard et al. (2020) classify European olive producers into five main categories: small family-run businesses focused on local markets; small-scale operations producing bulk oil for national and global markets; boutique enterprises focused on premium and branded products; large-scale traditional businesses selling both bulk and bottled products; and modern intensive farming models aimed at low-cost, high-yield production. While examples of these exist in Türkiye, the production structure in Bozdoğan is shaped by the size of the farmers' landholdings. In Bozdoğan, there are two primary production models: on the one hand, small family farms producing for local or national markets; on the other, a small number of boutique producers that have recently emerged and focus on high-quality and organic production.

Some young and middle-aged people in the first group are moving away from traditional ways and toward simpler modern production methods that increase olive quality. Their goal is to make more profit by making better-quality olive oil. This situation shows a strategic change between keeping the traditional legacy mentioned in the sources and adapting to the modern market's focus on quality.

Read interpretively, the emergence of this new entrepreneurial stratum invites several competing theoretical framings. The most prevalent in the literature—the feminization-of-agriculture narrative (De Schutter, 2013; Sachs et al., 2016)—captures part of what is happening in Bozdoğan, in that women indeed assume productive and managerial roles vacated by male urban migration. But this framing underspecifies the distinctive feature of our cases. The women and young entrepreneurs whose accounts we recorded do not simply substitute labor; they operate within a qualitatively different evaluative register than most of their older, more traditional counterparts. They speak the language of acidity measurement, polyphenol content, organic certification, geographical indication, and narrative branding ("I'm not just selling oil; I'm selling a story, health, and trust"). In the vocabulary developed in Section 5.2, they are *convention-competent*: they can enroll their oil in the industrial,

civic, and ecological quality conventions through which premium markets authenticate value, whereas traditional producers remain lodged in domestic conventions of quality that those markets do not recognize. The new entrepreneurs, on this reading, constitute the partial resolution pathway for the quality paradox identified in Section 5.2. Crucially, the resolution is not technological—many of these actors work with the same Memecik cultivar., on similar terrain, sometimes in the same mills as their more traditional neighbors; what they bring is not better hardware but a different evaluative grammar, a capacity to recognize, meet, and communicate the criteria by which premium markets adjudicate quality. This analytical reframing also has a policy implication that the feminization lens does not foreground: interventions aimed at resolving the Bozdoğan productivity-quality paradox should attend not only to infrastructural investment (cold-press mills, irrigation) and certification programs (organic, geographical indication) but also to the pedagogical and brokering work through which convention-enrolment can propagate from these pioneering actors to the broader producer community.

The comparative Mediterranean evidence on how such transitions are scaled is instructive for interpreting the Bozdoğan trajectory. In Spain and Italy, the structural shift from small traditional producers to boutique and premium producers has been mediated predominantly through cooperative institutional architectures (Rodríguez-Cohard et al., 2020; Bijman and Iliopoulos, 2014). These institutional forms have allowed smallholder olive territories in Jaen, Cordoba, and Tuscany to convert biophysical quality into market-recognized quality without requiring individual farmers to absorb the costs of certification, branding, and export on their own. Bozdoğan's emerging women-led and youth-led boutique producers currently pursue comparable goals, but through predominantly individual rather than collective strategies; the absence of functioning second-level cooperatives, the weakness of horizontal coordination among producers, and the under-development of geographical indication mechanisms for Memecik and Yamalak Sarısı cultivars together constitute a specific institutional lag relative to the Spanish and Italian cases. Read in this comparative frame, Bozdoğan's cooperative deficit is not a peripheral feature of the case but a structural condition that circumscribes the reach of individual entrepreneurial effort. The comparative literature accordingly suggests a forward-looking analytical claim: the durability of Bozdoğan's quality-oriented transition will depend less on the multiplication of individual entrepreneurs than on whether institutional scaffolds—cooperative marketing entities, geographical indication consortia, producer associations with quality-assurance mandates—can be constructed in the medium term.

6 Conclusion

Olive oil production in Bozdoğan exemplifies the significant challenges facing sustainable production, shaped by environmental and socio-demographic dynamics common in various Mediterranean regions, such as increasing climate risks, adverse environmental impacts of production methods, structural inefficiencies, insufficient marketing strategies, urban migration, and an aging agricultural workforce. This exploratory study uncovers hidden sources of resilience that could support sustainable production. This includes the ability to make better products, deep-rooted traditional knowledge, more contributions from women and young farmers, and a greater understanding of environmental issues.

This study used a state-of-the-art citizen science methodology to explain the underlying facts of the data, emphasizing the extent of the challenges and the opportunities for farmers to develop innovative production practices. The findings on sustainable food production in Bozdoğan have led to a more in-depth look at socio-ecological systems and changes in population around the production of olive oil. The results showed that technology and farming alone could not explain why Bozdoğan can produce olive oil sustainably. Instead, it is a part of a complicated process that includes the climate, society, economy, and culture. Increasing technological efficiency, improving food production quality, strengthening institutional collaboration, and addressing the evolving needs of farmers can make this possible. These conditions apply not only to olive oil producers in Bozdoğan but also to farmers and entrepreneurs on a broader scale in the world.

In conclusion, while olive oil production in Bozdoğan holds noteworthy potential, interconnected challenges are hindering the production of high-value, high-quality olive oil. Climate change, environmental issues, the breakdown of social structures, and an aging population are creating a cycle of vulnerability for sustainable agricultural production. The emergence of young people and women farmers, however, presents new opportunities for the region to develop high-quality olive oil.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://zenodo.org/records/14794656.

Ethics statement

The requirement of ethical approval was waived by the Center for Population and Social Policies, Marmara University for the studies involving humans. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their oral informed consent to participate in this study.

Author contributions

ÜA: Writing – original draft, Investigation, Software, Funding acquisition, Formal analysis, Writing – review & editing, Methodology. MA: Conceptualization, Project administration, Data curation, Writing – review & editing, Methodology, Funding acquisition, Writing – original draft, Software, Formal analysis. AA: Writing – review & editing, Conceptualization, Validation, Supervision.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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