GEOGRAPHICAL ANALYSIS

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Temporal Dynamics and Regional Trends of Fruit Productivity in the Guba-Khachmaz Economic Region of Azerbaijan (2014–2024)

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Abstract

This study examines the spatial and temporal dynamics of fruit production in the Guba-Khachmaz economic region of Azerbaijan between 2014 and 2024. Relying on official data from the State Statistics Committee and sectoral institutions, it analyzes trends in cultivation area and yield for five key fruit species: apple, pear, cherry, sour cherry, and peach. The findings reveal significant structural shifts driven by market demand, climate variability, and technological modernization. Notably, while peach and cherry orchards expanded considerably, productivity declined in some cases due to agroecological mismatches and insufficient technical support. In contrast, apples and pears exhibited yield increases despite reductions or stagnation in cultivated area, reflecting the positive impact of intensive and super-intensive orchard systems. The study concludes that sustainable agricultural development depends not only on land expansion but also on efficient resource use, climate-adaptive practices, and integrated state policies. These outcomes align with Sustainable Development Goals (SDGs) 2 (Zero Hunger), 12 (Responsible Consumption and Production), and 13 (Climate Action).

Keywords: Fruit production; Guba-Khachmaz; Agricultural productivity; Spatial analysis; Agricultural transformation; Climate-smart agriculture; Sustainable Development Goals (SDG 2, 12, 13); Azerbaijan

1 Introduction

Fluctuations in fruit production significantly influence market prices, farmers' income stability, and long-term investment decisions. Understanding the stability and variability of production systems is essential for ensuring food security and for assessing the resilience of agricultural systems at both national and regional levels. This study provides a conceptual basis for examining the drivers of variability in fruit production, with a particular focus on the Guba-Khachmaz economic region.

Production stability is inherently multidimensional, shaped by the interaction of economic, ecological, and social factors. Achieving consistent yields over the long term is one of the central goals of sustainable agriculture, requiring a balance between environmental conditions and management practices.

Among the most critical challenges to production stability is climate change. Increasingly erratic precipitation, rising average temperatures, and more frequent extreme weather events directly affect crop yields, water availability, plant diseases, pest outbreaks, and ecosystem balance[14]. Scientific evidence highlights how phenological shifts, desertification, pest migration, and biodiversity loss—often linked to warming trends—threaten agricultural ecosystems[7, 23]. In perennial crops like fruit trees, these disruptions are particularly impactful due to limited flexibility in cultivation schedules.

Fruit tree growth and productivity are heavily influenced by agroecological factors, especially soil type and climate suitability. Zoning studies that assess varietal compatibility with specific soil-climate regimes are increasingly critical for investment decisions. Research from Romania[10] illustrates how multi-criteria agro-climatic assessments guide optimized planting strategies under conditions of limited natural potential.

In Azerbaijan, the interaction of climate and soil dynamics has become a defining feature of regional agricultural productivity. The Guba-Khachmaz region, characterized by fertile soils and a moderate climate, has traditionally served as a major fruit-producing hub. However, over the past decade, production in the region has experienced pronounced variability. This variability is attributed to climate-induced stressors such as uneven rainfall, irrigation imbalances, and inconsistent application of agro-technologies across districts.

Understanding these trends requires a comprehensive temporal and spatial analysis. This research focuses on the period from 2014 to 2024, aiming to identify the productivity trajectories of key fruit crops in the region. Using time series data, variance indicators, and comparative analysis methods, the study evaluates both the impact of climate factors and the effectiveness of local management and policy interventions. The findings are expected to contribute to the scientific foundation for agro-ecological zoning, resource optimization, and the design of resilient fruit production strategies in Guba-Khachmaz. More broadly, the study aims to enhance sustainable agricultural development models across Azerbaijan through an integrated analysis of ecological and economic drivers in fruit farming.

2 Literature Review and Theoretical Background

Variability in fruit production influences market prices, income stability, and investment behavior[4, 14]. Assessing production stability and identifying the drivers of fluctuation are crucial for ensuring food security and evaluating agricultural resilience at both national and regional scales.

Stability in agricultural systems is multidimensional, emerging from the interplay of ecological, social, and economic factors[16, 28]. When environmental and management components are in equilibrium, sustained yields become achievable, which is a core goal of sustainable agriculture.

Climate change has become a major disruptor of agricultural stability. Key effects include altered rainfall regimes, rising average global temperatures, and more frequent extreme weather events. These changes influence yields, water availability, pest outbreaks, and livestock health[13, 14]. Specific impacts include shortened crop cycles[24], increased regional yield variability[23], desertification[12], invasive species spread[8], and biodiversity loss[7]. Biodiversity decline also undermines ecosystem services like nutrient cycling, local hydrology, and pest regulation[2].

Most fruit tree species require deep, well-drained loamy soils with a pH between 6 and 7. Nevertheless, climate remains the dominant factor in orchard success. Studies indicate that from the late 20th century, rising temperatures have caused significant shifts in plant phenology, species distribution, and ecosystem composition. Perennials are more vulnerable than annuals due to fixed planting schedules and limited adaptive capacity. For example, from the 1980s onward, many temperate regions reported earlier blooming and longer growing seasons[19, 22], though yield improvements have not always followed[9].

In orchard farming, climatic variability contributes to alternate bearing and yield instability. Therefore, site-specific investment decisions in fruit plantations must rely on agro-climatic zoning that integrates climate, soil, and economic data[3]. Zoning studies help design differentiated technological systems tailored to species and regional

conditions, enabling stable production and higher efficiency[18].

These scientific frameworks underline the importance of climate–soil interactions in determining yield patterns. In Azerbaijan's diverse agro-ecological landscape, such approaches are essential to guide long-term fruit production strategies and ensure sustainability under changing climate conditions.

3 Materials and Methods

This study analyzes the spatial and temporal dynamics of fruit productivity in the Guba-Khachmaz economic region from 2014 to 2024. The analysis is based on official statistical data sourced from the State Statistical Committee of Azerbaijan, the Ministry of Agriculture, the Ministry of Ecology and Natural Resources, and the Fruit-Growing and Tea-Growing Scientific Research Institute.

A combination of descriptive and comparative methods was applied to assess the changes in land use and yield across five major fruit crops: apples, pears, cherries, sour cherries, and peaches. The following analytical steps were employed:

- Time Series Analysis: Annual trends in cultivated area and yield for the selected crops were evaluated using statistical tables and line graphs, enabling the detection of inter-annual variability across the ten-year period.
- Spatial Distribution Assessment: Comparative analysis was conducted across the five administrative districts (Quba, Khachmaz, Qusar, Shabran, and Siyazan) to examine regional differences in orchard area and productivity. This helped identify correlations with climate conditions, soil types, and management practices.
- Structural Change Analysis: The percentage change in total orchard area and average yield was calculated to assess the economic and technical implications of agrarian transformation processes.
- Causal Interpretation: Observed statistical trends were interpreted in relation to agro-climatic conditions, state support policies, technological uptake, and market demand. Data from the Fruit-Growing Research Institute on varietal zoning and adaptation were utilized for this purpose.
- Crop-Level Comparative Analysis: Cross-sectional comparison across fruit types provided insights into regional specialization and structural shifts in fruit farming.

All data were processed and organized using Microsoft Excel. Statistical visualization was performed using SPSS and R software. The aim was not only to detect trends but also to evaluate the effectiveness of public and private sector interventions in the fruit-growing sector. This methodological framework supports both retrospective and prospective assessments and provides a reliable empirical basis for regional agricultural policy planning.

4 Results and Discussion

The Guba-Khachmaz economic region, located in northeastern Azerbaijan, is distinguished by its favorable geographical position and diverse agro-climatic conditions. Encompassing the districts of Quba, Khachmaz, Qusar, Shabran, and Siyazan, the region spans approximately 6,960 km² and plays a key role in the country's agricultural development[4].

Topographically, the region extends from the southern slopes of the Greater Caucasus Mountains to the Caspian coastline, encompassing mountainous, forested, and lowland zones. For instance, Quba and Qusar offer cooler, more humid conditions and high soil moisture retention, ideal for crops such as apples, pears, peaches, and sour cherries. In contrast, Khachmaz and Shabran feature subtropical microclimates suitable for persimmons, grapes, and pomegranates.

The region's climate is moderately warm and semi-humid, with average annual temperatures ranging from 12°C to 14°C in the lowlands. Precipitation varies between 500 mm and 1300 mm, with more rainfall in mountainous areas like Quba and Qusar, and less in lowland districts such as Shabran and Siyazan[13]. This variability necessitates the development of irrigation systems, especially in drier zones.

Natural water resources—such as the Gudyalchay, Qaraçay, Velveleçay, and Qusarçay rivers—serve as essential irrigation sources and support the adoption of modern drip irrigation systems. Additionally, the region's soils, including brown forest, mountain-meadow, and alluvial types, are rich in humus and provide favorable air and water permeability for root development[3].

Given these conditions, Guba-Khachmaz has evolved into a national fruit-growing center, supplying both domestic

and export markets. Apple cultivation is particularly dominant, with Quba district alone hosting 13,484 hectares of apple orchards—over 11,000 hectares of which are intensive or super-intensive systems. In 2023, 125,418 tons of apples were harvested in the region, accounting for approximately 70% of Azerbaijan's apple orchards and 96% of its intensive production[1, 6].

The region's agricultural labor market is deeply integrated into rural livelihoods. In 2023, the region's total population stood at 547,100, with 254,021 individuals employed and over 271,000 in the labor force[4]. Agriculture accounts for approximately 52.8% of the region's total gross product, underscoring its significance in employment and economic growth.

Historically, during the Soviet era, Guba-Khachmaz was part of a planned economic model, specialized in fruit and vegetable processing. The region benefited from the establishment of experimental stations and the institutional support of the Fruit-Growing and Tea-Growing Research Institute (founded in 1926), which provided scientific infrastructure for varietal testing and orchard development[11].

Traditional pome fruits like apples, pears, and quinces were widely cultivated in foothill zones and consumed fresh or processed into dried fruit, syrup, and preserves (anl.az). Regional diversification into high-value crops was also shaped by agro-ecological zoning and historical agricultural specialization.

Since 2014, both state and private sectors have played a growing role in modernizing fruit production. Government initiatives such as the "State Program for the Development of Fruit-Growing 2019–2023" introduced subsidies for intensive orchard development, with up to 800 AZN per hectare in support for apple growers[18, 25]. Scientific and technical assistance has been facilitated by the Fruit-Growing Research Institute through varietal nurseries and laboratory support (president.az).

The private sector has also invested significantly. For example, İsmikhanlı LLC established over 500 hectares of super-intensive orchards, while projects supported by the Entrepreneurship Development Fund (EDF) have created jobs and increased export volumes. Companies like Green Quba have expanded access to global markets through partnerships with buyers such as the UAE-based NRTC[17, 21, 26].

Overall, Guba-Khachmaz has transitioned from a traditional agricultural region into a modern, export-oriented fruit production hub. This transformation reflects both state-driven structural reforms and the growing role of technology, logistics, and private investment in the region's agro-industrial landscape.

Table 1: Apple orchards, including fruit-bearing areas (ha)

Year	Khachmaz (ha)	Guba (ha)	Gusar (ha)	Siazan (ha)	Shabran (ha)	Total (ha)
2014	4009.6	12579.6	3071.5	5.0	237.0	19902.7
2015	3944.8	13004.6	3316.6	5.0	372.8	20643.8
2016	4073.4	13037.0	3372.2	6.6	377.3	20866.5
2017	4197.4	13057.1	3214.7	21.5	414.7	20905.4
2018	4374.9	13031.1	3203.4	29.0	418.5	21056.9
2019	4303.1	13090.3	3473.7	29.0	424.7	21320.8
2020	4315.1	13192.7	3533.4	28.0	431.1	21500.3
2021	4364.9	13196.2	3915.1	27.5	465.2	21968.9
2022	3501.8	13308.9	3983.2	28.0	495.9	21317.8
2023	2574.6	11324.2	4123.1	28.0	501.1	18551.0
2024	2278.6	9472.7	4421.7	28.0	501.3	16702.3

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

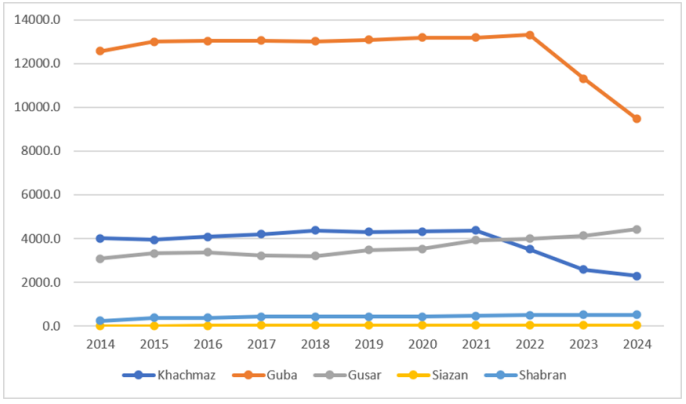


Fig. 1: Apple orchards area changes by districts, 2014–2024

Between 2014 and 2024, the Guba-Khachmaz economic region experienced a decrease in the total area of fruit-bearing apple orchards, alongside significant yield improvements. As illustrated in [Fig. 1] and [Table. 1], orchard area declined from 19,902.7 hectares in 2014 to 16,702.3 hectares in 2024—a loss of 3,200.4 ha or 16.08% [4]. The most notable declines were observed in Khachmaz (−43.2%) and Guba (−24.7%), due to factors such as the aging cycle of intensive orchards, price instability in key export markets (especially Russia), uneven distribution of

land and water resources, and a shift toward alternative fruits such as cherries and peaches[13, 18, 25].

By contrast, Gusar and Shabran districts showed notable expansion. Gusar's apple-growing area increased by 44%, from 3,071.5 ha to 4,421.7 ha, while Shabran more than doubled its area, from 237 ha to 501.3 ha. These gains are linked to new intensive orchard establishment, efficient use of land resources, and varying levels of agro-service support[18].

Table 2: Apple Productivity (c/ha)

Year	Khachmaz (c/ha)	Guba (c/ha)	Gusar (c/ha)	Siazan (c/ha)	Shabran (c/ha)	Guba-Khachmaz
2014	152.3	90.8	34.1	53.8	48.4	**93.9**
2015	133.7	86.8	59.8	56.8	40.0	**90.6**
2016	122.8	88.5	60.8	70.3	39.0	**89.8**
2017	117.1	88.4	78.6	66.0	51.5	**91.9**
2018	116.9	88.8	83.7	51.7	65.9	**93.4**
2019	123.2	90.2	87.2	75.2	69.3	**96.0**
2020	123.7	95.0	86.8	70.7	58.0	**98.6**
2021	119.9	97.9	88.8	73.8	43.0	**99.5**
2022	156.1	99.3	88.6	72.6	67.4	**105.8**
2023	178.6	110.3	96.9	71.1	59.0	**115.4**
2024	176.1	119.2	114.8	68.2	57.1	**123.9**

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

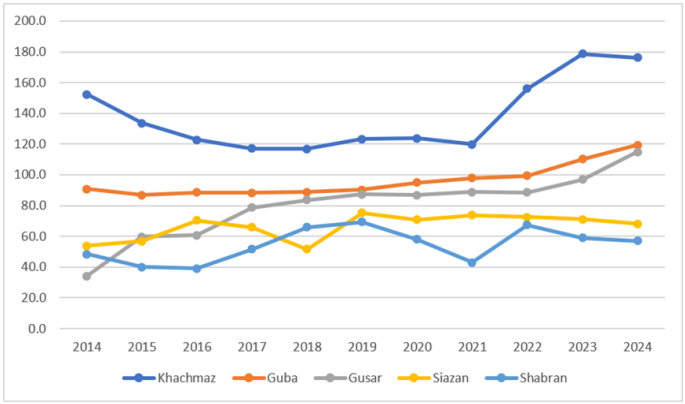


Fig. 2: Apple Productivity changes by districts, 2014–2024" (c/ha)

Regarding productivity, [Fig. 2] and [Table. 2] show a consistent upward trend in most districts. Guba's yield grew from 90.8 centners per hectare (c/ha) in 2014 to 119.2 c/ha in 2024—a 31.3% increase—attributed to the introduction of super-intensive orchards, drip irrigation, and improved technical services (Fruit-Growing and Tea-Growing Research Institute, 2023). Gusar district achieved an even more substantial increase, from 34.1 c/ha to 114.8 c/ha (+237%), reflecting the adoption of advanced technologies and appropriate agro-ecological zoning[10].

Although productivity in Khachmaz fluctuated—dropping sharply in 2021 (41.7 c/ha)—it rebounded to 176.1 c/ha by 2024. This instability is primarily attributed to weather variability, irrigation infrastructure constraints, and market risks. Siyazan and Shabran, while relatively stable, maintained lower productivity levels due to ecological limitations[3].

Overall, despite a 16% reduction in orchard area, regional average productivity rose from 93.9 c/ha in 2014 to 123.9 c/ha in 2024 (+32%). These structural dynamics indicate a transition to more efficient, market-driven farming models where higher productivity offsets spatial contraction.

Table 3: Pear orchards, including fruit-bearing areas (ha)

Year	Khachmaz (ha)	Guba (ha)	Gusar (ha)	Siazan (ha)	Shabran (ha)	Total (ha)
2014	136.8	411.1	179.4	5.0	55.9	788.2
2015	172.7	423.1	179.4	5.0	67.5	847.7
2016	188.0	428.1	161.1	7.2	70.8	855.2
2017	221.2	429.1	161.3	14.5	88.9	915.0
2018	236.5	432.4	170.5	17.0	95.9	952.3
2019	242.5	434.4	177.4	17.0	95.9	967.2
2020	244.0	422.7	191.0	17.0	96.0	970.7
2021	252.1	449.2	289.1	16.5	95.9	1102.8
2022	263.5	463.2	322.8	16.5	108.7	1174.7
2023	244.4	475.7	330.4	16.5	140.8	1207.8
2024	319.3	480.7	486.9	16.5	140.8	1444.2

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

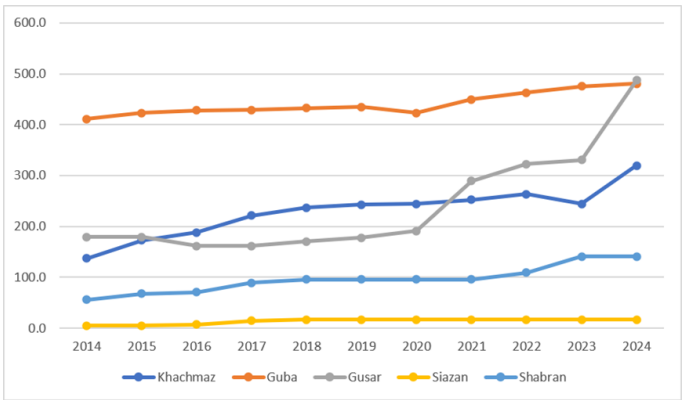


Fig. 3: Pear orchards area changes by districts, 2014–2024

Between 2014 and 2024, pear cultivation in the Guba-Khachmaz economic region exhibited substantial growth in both area and productivity. As shown in [Fig. 3] and [Table. 3], the total area of fruit-bearing pear orchards increased from 788.2 hectares in 2014 to 1,444.2 hectares in 2024—an 83.2% rise[4]. The most significant expansion occurred in Gusar, Khachmaz, and Guba. Gusar's orchard area rose from 179.4 ha to 486.9 ha (a 2.7-fold increase), while Khachmaz expanded from 136.8 ha to 319.3 ha, and Guba from 411.1 ha to 480.7 ha. These increases are mainly attributed to the establishment of new intensive orchards, favorable agro-ecological conditions, and growing market demand[18]. Shabran also saw growth—from 55.9 ha to 140.8 ha—whereas Siyazan remained relatively stable, with a modest increase of 11.5 ha, likely due to resource constraints and alternative crop preferences[3].

Table 4: Pear Productivity (c/ha)

Year	Khachmaz (c/ha)	Guba (c/ha)	Gusar (c/ha)	Siazan (c/ha)	Shabran (c/ha)	Guba-Khachmaz (c/ha)
2014	76.6	72.0	40.8	61.2	54.0	**64.4**
2015	77.1	69.8	55.0	63.6	32.7	**65.2**
2016	68.3	70.2	17.8	78.2	58.6	**59.0**
2017	83.0	70.3	20.0	78.6	64.2	**64.1**
2018	85.4	70.6	46.1	73.5	53.9	**68.3**
2019	80.2	85.8	53.2	79.4	57.1	**75.5**
2020	98.9	84.5	63.5	76.5	75.9	**83.0**
2021	115.9	82.1	288.2	77.6	53.8	**141.3**
2022	74.5	84.5	141.8	76.4	52.1	**94.9**
2023	73.1	90.2	119.2	75.2	60.0	**91.0**
2024	90.3	107.8	119.1	67.9	92.5	**105.8**

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

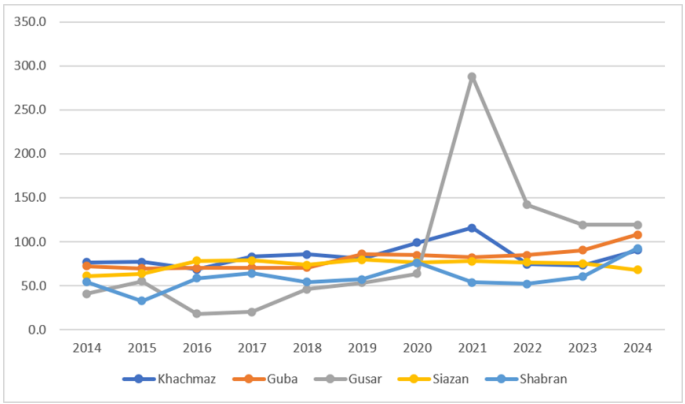


Fig. 4: Pear Productivity changes by districts, 2014–2024 (c/ha)

Regarding productivity, [Fig. 4] and [Table. 4] indicate a generally positive trend, though with regional variations. Gusar district showed the most dramatic change: yield increased from 40.8 c/ha in 2014 to 119.1 c/ha in 2024 (+192%). Notably, yield peaked at 288.2 c/ha in 2021, possibly due to exceptional climatic conditions or isolated high-performing orchards. Although yields normalized in subsequent years, the 2024 figure reflects growing long-term stability.

In Quba and Khachmaz, productivity grew more steadily. Quba's yield rose from 72.0 c/ha to 107.8 c/ha, while Khachmaz increased from 76.6 c/ha to 90.3 c/ha. These gains are linked to advanced techniques such as drip irrigation, targeted fertilization, pruning, and cultivar selection aligned with climatic conditions[15].

Yields in Siyazan and Shabran remained more modest. Siyazan increased slightly from 61.2 c/ha to 67.9 c/ha, while Shabran recorded a sharper rise—from 54.0 c/ha to 92.5 c/ha—due to more efficient use of soil and water resources.

Overall, the average regional yield for pears increased by 64.3%, from 64.4 c/ha in 2014 to 105.8 c/ha in 2024. This reflects a broader transition toward market-oriented, technology-driven farming strategies and confirms the growing strategic role of pear cultivation within the regional fruit sector.

Table 5: Cherry orchards, including fruit-bearing areas (ha)

Year	Khachmaz (ha)	Guba (ha)	Gusar (ha)	Siazan (ha)	Shabran (ha)	Total (ha)
2014	894.3	210.7	79.5	8.6	187.0	1380.1
2015	1 117.0	287.9	84.6	8.6	205.3	1703.4
2016	1333.3	298.3	156.1	8.1	212.2	2008.0
2017	1436.0	307.3	197.7	14.0	228.4	2183.4
2018	1714.2	308.5	211.4	17.0	230.4	2481.5
2019	1769.1	313.8	229.3	17.0	230.4	2559.6
2020	1856.4	447.4	281.1	17.0	258.5	2860.4
2021	1918.7	486.4	369.1	17.0	259.7	3050.9
2022	2056.9	502.4	437.7	17.0	276.1	3290.1
2023	2354.1	439.4	559.8	17.0	409.7	3780.0
2024	2681.9	2021.4	647.5	17.0	430.6	5798.4

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

Over the past decade, cherry cultivation in the Guba-Khachmaz economic region has undergone notable structural expansion. As shown in [Fig. 5] and [Table. 5], the total area of fruit-bearing cherry orchards increased

from 1,380.1 hectares in 2014 to 5,798.4 hectares in 2024, representing a 320.1% rise[4]. This reflects a significant shift in the regional fruit production structure. The expansion was largely concentrated in Khachmaz and Guba districts. Khachmaz grew from 894.3 ha to 2,681.9 ha (+200%), while Guba recorded a nearly tenfold increase—from 210.7 ha to 2,021.4 ha—driven by rising export demand, adoption of drip irrigation, and modern nursery systems[18].

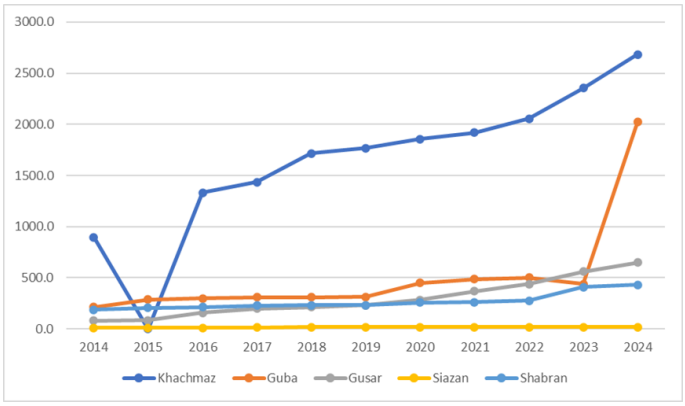


Fig. 5: Cherry orchards area changes by districts, 2014–2024

Table 6: Cherry Productivity (c/ha)

Year	Khachmaz (c/ha)	Guba (c/ha)	Gusar (c/ha)	Siazan (c/ha)	Shabran (c/ha)	Guba-Khachmaz
2014	107.4	74.1	99.0	42.9	15.3	**89.0**
2015	119.5	75.7	94.1	18.6	32.1	**99.8**
2016	119.6	77.8	27.1	24.3	30.5	**96.4**
2017	108.7	77.9	27.9	60.0	26.1	**88.1**
2018	94.4	81.1	92.5	55.3	28.1	**86.2**
2019	98.4	98.7	88.9	56.5	29.3	**91.1**
2020	101.5	86.7	103.6	57.6	29.8	**92.7**
2021	96.6	69.0	80.2	58.0	26.8	**84.1**
2022	98.1	70.4	78.1	56.5	27.4	**85.1**
2023	96.2	82.8	47.3	46.5	33.6	**80.4**
2024	93.9	63.8	45.0	42.4	30.3	**73.1**

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

Substantial growth was also observed in Gusar (from 79.5 ha to 647.5 ha) and Shabran (from 187.0 ha to 430.6 ha). Siyazan remained relatively stagnant, increasing only from 8.6 ha to 17.0 ha, due to local resource constraints and agroecological limitations[3].

However, yield trends diverged from the area expansion. As seen in [Fig. 6] and [Table. 6], average cherry yield declined from 89.0 c/ha in 2014 to 73.1 c/ha in 2024 (−17.9%). In Khachmaz, yield dropped from 107.4 c/ha to 93.9 c/ha, and in Guba from 74.1 to 63.8 c/ha. These declines are linked to soil fatigue, climate variability, suboptimal cultivar selection, and technical challenges in orchard maintenance[13, 15].

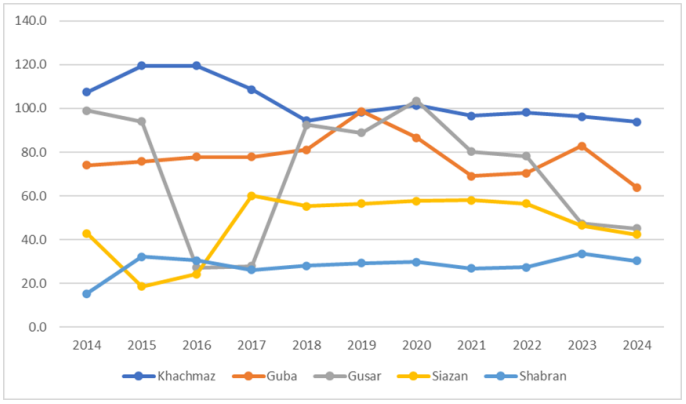


Fig. 6: Cherry Productivity changes by districts, 2014–2024 (c/ha)

In Gusar, yield showed steeper volatility: from 99.0 c/ha in 2014 to 80.2 c/ha in 2021 and down to 45.0 c/ha in 2024. Similarly, in Siyazan, productivity fell slightly (from 42.9 to 42.4 c/ha), while in Shabran, yield increased modestly from 15.3 to 30.3 c/ha but remained below regional averages.

Overall, although area expansion has been technically successful, yield improvements have lagged. Key issues include immature orchards not yet reaching peak productivity, uneven implementation of intensive technologies, and varied adaptation to climate conditions. Nevertheless, the rapid growth in cultivated area for an export-oriented crop like cherry marks a strategic development for regional agroeconomic diversification.

Between 2014 and 2024, sour cherry orchards in the Guba-Khachmaz region exhibited modest growth overall, with signs of decline in recent years. As shown in [Fig. 7] and [Table. 7], the total area of fruit-bearing sour cherry orchards increased from 253.8 ha in 2014 to 312.9 ha in 2024—an increase of 23.3%[4]. Orchard expansion peaked in 2022 at 349.6 ha but declined thereafter, likely due to orchard aging, farmer preference for alternative crops (especially cherries and peaches), and declining interest amid changing climate conditions[13, 18].

Table 7: Sour Cherry orchards, including fruit-bearing areas (ha)

Year	Khachmaz (ha)	Guba (ha)	Gusar (ha)	Siazan (ha)	Shabran (ha)	Total (ha)
2014	107.1	64.0	46.5	1.7	34.5	253.8
2015	110.6	69.8	46.5	1.7	33.3	261.9
2016	121.0	69.0	36.5	1.7	33.3	261.5
2017	154.6	69.0	36.5	10.0	33.3	303.4
2018	164.7	69.0	36.5	11.0	33.3	314.5
2019	161.9	69.0	40.5	11.0	33.3	315.7
2020	162.9	67.0	40.5	11.0	33.3	314.7
2021	167.9	67.0	40.5	11.0	33.3	319.7
2022	173.8	67.0	55.5	20.0	33.3	349.6
2023	134.8	67.0	55.5	20.0	33.6	310.9
2024	136.8	67.0	55.5	20.0	33.6	312.9

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

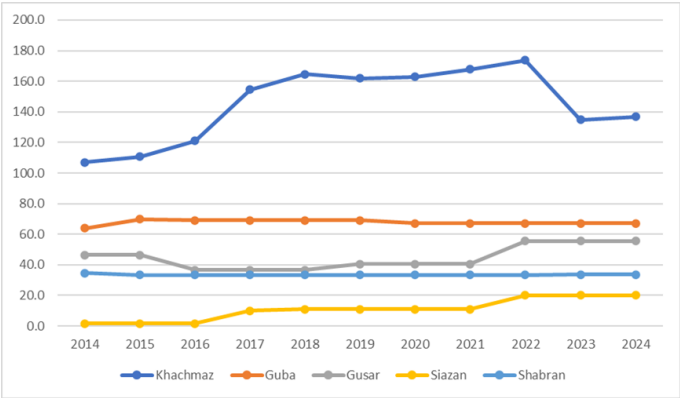


Fig. 7: Sour Cherry orchards area changes by districts, 2014–2024

Table 8: Sour Cherry Productivity (c/ha)

Year	Khachmaz (c/ha)	Guba (c/ha)	Gusar (c/ha)	Siazan (c/ha)	Shabran (c/ha)	Guba-Khachmaz
2014	51.4	38.6	38.7	62.9	11.4	**40.5**
2015	54.8	38.3	39.8	68.8	25.8	**44.2**
2016	55.6	38.7	14.0	72.4	33.3	**42.6**
2017	53.9	38.8	15.1	65.5	33.8	**44.0**
2018	50.4	39.0	69.3	63.6	34.3	**48.8**
2019	50.4	39.0	62.7	65.5	34.4	**48.3**
2020	50.6	39.4	63.2	69.1	33.9	**48.7**
2021	51.6	38.9	71.1	71.8	34.8	**50.4**
2022	49.8	37.6	53.2	63.0	34.1	**47.3**
2023	58.0	37.7	97.5	38.0	34.5	**56.8**
2024	44.3	38.2	95.5	37.0	34.7	**50.6**

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

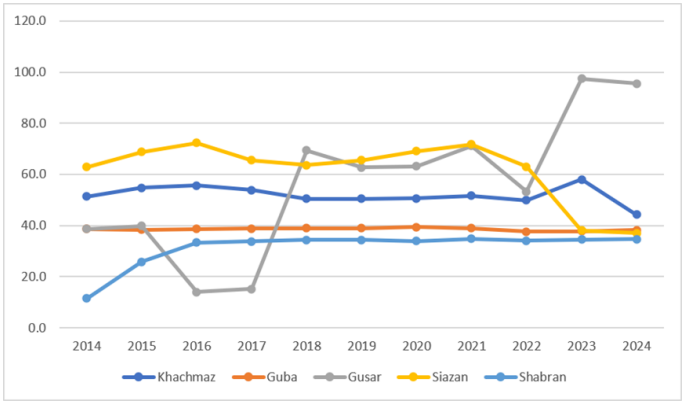


Fig. 8: Sour Cherry Productivity changes by districts, 2014–2024 (c/ha)

District-level data reveal that sour cherry cultivation is concentrated in Khachmaz. Here, the planted area increased from 107.1 ha in 2014 to 178.3 ha in 2022, but declined to 136.8 ha by 2024—attributed to price volatility, post-harvest challenges, and climatic sensitivity. In Quba, orchard area remained relatively stable (64–69 ha). Gusar saw a drop during 2014–2017 but stabilized at 55.5 ha post-2020. Siyazan showed the most notable growth, from 1.7 ha to 20 ha, while Shabran remained stable at 33–34 ha[3].

Productivity trends were more varied. As indicated in [Fig. 8] and [Table. 8], Khachmaz experienced a decline from 51.4 c/ha in 2014 to 44.3 c/ha in 2024, with a brief peak at 58.0 c/ha in 2023. These fluctuations are attributed to disease vulnerability, inconsistent technical support, and climatic variability[15].

In Quba, productivity remained almost unchanged (from 38.6 to 38.2 c/ha). Gusar, however, showed a remarkable improvement: after a low of 14.0 c/ha in 2016, yield peaked at 97.5 c/ha in 2023 and stabilized at 95.5 c/ha in 2024, driven by maturing orchards and climate-adapted cultivars. Siyazan's productivity decreased slightly (62.9 to 57.0 c/ha), while Shabran's increased from 11.4 to 35.7 c/ha—reflecting potential despite limited area.

Overall, the region's average sour cherry productivity rose from 40.5 c/ha in 2014 to 50.6 c/ha in 2024. However, this increase is primarily driven by gains in Gusar, indicating broader instability in the sector. These findings highlight the need for improved technical services, use of climate-resilient cultivars, and better logistical systems for sustaining sour cherry production.

Between 2014 and 2024, peach cultivation emerged as one of the fastest-growing fruit sectors in the Guba-Khachmaz economic region. As shown in [Fig. 9] and [Table. 9], the area of fruit-bearing peach orchards expanded from 1,322.2 ha in 2014 to 4,992.9 ha in 2024—a 277.5% increase[4]. The most significant expansion was observed in Khachmaz, where orchard area tripled (from 1,211.4 to 3,219.1 ha), driven by the adoption of intensive cultivation systems, drip irrigation, and export-oriented strategies[18].

Substantial growth also occurred in Quba and Gusar. In Quba, orchard area remained stable until 2022 but surged from 141.5 ha to 862.5 ha in 2023–2024. This spike likely reflects either formal registration of previously unrecorded orchards or the establishment of new commercial-scale farms. Gusar recorded a dramatic 33.9-fold increase—from 17.0 ha to 575.9 ha. In contrast, Siyazan's area remained virtually unchanged (23.4 → 23.5 ha), while Shabran grew moderately (45.9 → 311.9 ha).

Table 9: Peach orchards, including fruit-bearing areas (ha)

Year	Khachmaz (ha)	Guba (ha)	Gusar (ha)	Siazan (ha)	Shabran (ha)	Total (ha)
2014	1211.4	24.5	17.0	23.4	45.9	1322.2
2015	1803.9	24.5	17.0	23.4	52.1	1920.9
2016	2014.6	24.5	14.0	13.1	52.7	2118.9
2017	2137.9	24.5	18.0	19.0	62.6	2262.0
2018	2358.0	24.5	28.0	22.0	80.6	2513.1
2019	2372.3	24.5	47.2	22.0	80.6	2546.6
2020	2400.2	68.1	76.6	21.0	96.2	2662.1
2021	2460.5	110.3	202.3	21.0	122.6	2916.7
2022	2426.5	126.6	264.0	21.0	156.8	2994.9
2023	2934.0	141.5	327.2	23.5	311.9	3738.1
2024	3219.1	862.5	575.9	23.5	311.9	4992.9

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

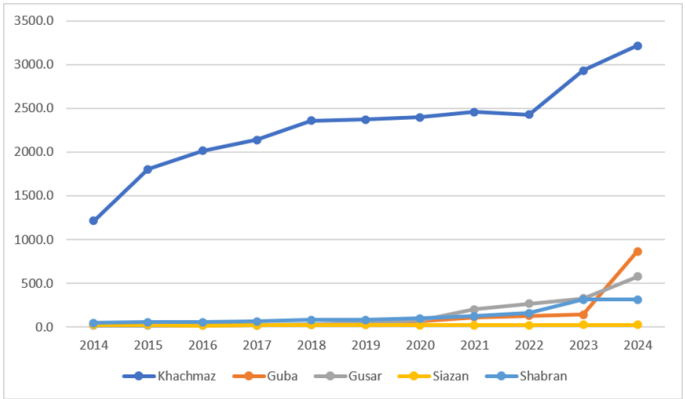


Fig. 9: Peach orchards area changes by districts, 2014–2024

Table 10: Peach Productivity (c/ha)

Year	Xachmaz (c/ha)	Guba (c/ha)	Gusar (c/ha)	Siazan (c/ha)	Shabran (c/ha)	Guba-Khachmaz
2014	109.8	57.8	23.5	45.7	24.8	**103.6**
2015	35.7	50.6	25.3	13.9	36.7	**35.6**
2016	38.7	51.0	5.0	35.6	26.6	**38.3**
2017	33.1	51.1	24.6	51.6	25.6	**33.2**
2018	30.6	51.4	40.9	41.8	22.3	**30.8**
2019	29.1	55.8	55.1	45.9	33.2	**30.1**
2020	29.3	39.3	37.5	45.2	48.9	**30.6**
2021	33.8	62.0	169.1	45.7	69.5	**45.9**
2022	41.8	86.2	178.9	50.0	58.3	**56.7**
2023	52.9	143.1	109.2	33.6	38.5	**59.9**
2024	60.0	104.8	78.7	32.3	38.8	**68.4**

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

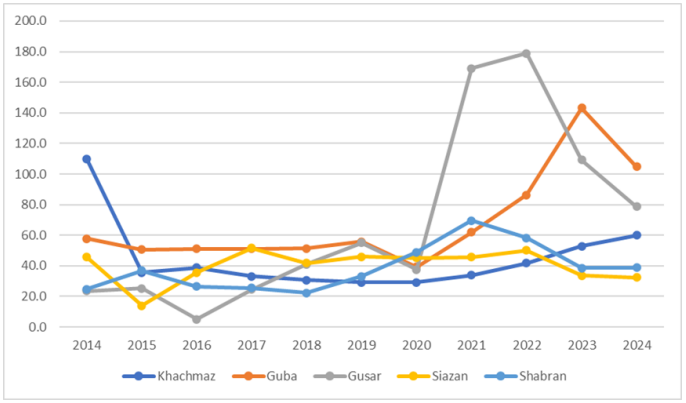


Fig. 10: Peach Productivity changes by districts, 2014–2024 (c/ha)

However, productivity trends did not mirror the rapid area expansion. As shown in [Fig. 10] and [Table. 10], Khachmaz's yield dropped from 109.8 c/ha in 2014 to 60.0 c/ha in 2024, fluctuating in the 30–60 c/ha range throughout the decade. These variations are attributed to orchard aging, cultivar suitability, and inconsistent technical services[13, 15].

In Quba, yield steadily increased from 57.8 c/ha to 104.8 c/ha, peaking at 143.1 c/ha in 2022–2023, owing to improved irrigation, new plant varieties, and agro-service expansion. Gusar showed more volatility—yield rose from 23.5 c/ha in 2014 to 178.9 c/ha in 2022, but dropped to 78.7 c/ha in 2024, suggesting early productivity followed by maintenance challenges.

Siyazan and Shabran remained low-performing. Siyazan declined from 45.7 to 32.3 c/ha, while Shabran increased modestly from 24.8 to 38.8 c/ha. Constraints such as poor soil fertility, inadequate irrigation, and underdeveloped technical infrastructure explain this underperformance[3].

In conclusion, while peach orchards experienced rapid spatial expansion, yield gains were uneven and limited to Quba and, to some extent, Gusar. Enhancing agronomic capacity, improving varietal selection, and adapting orchard systems to local agro-climatic zones remain strategic priorities for yield stabilization.

Table 11: Comparative Table of Fruit-Bearing Orchards (ha)

Fruit	2014	2024	Area variation (Ha)	Area variation (%)
Apple	19902.7	16702.3	- 3200.4	- 16.08
Pear	788.2	1444.2	656	83.2
Cherry	1380.1	5798.4	4418.3	320.1
Sour cherry	253.8	312.9	59.1	23.3
Peach	1322.2	4992.9	3670.6	277.6

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

Table 12: Comparative Table of Productivity (c/ha)

Fruit	2014 (c/ha)	2024 (c/ha)	Change (c/ha)	Change (%)
Apple	93.9	123.9	30	31.90%
Pear	64.4	105.8	41.4	64.30%
Cherry	89	73.1	−15.9	−17.9%
Sour cherry	40.5	50.6	10.1	24.90%
Peach	103.6	68.4	−35.2	−34.0%

Source: State Statistical Committee of the Republic of Azerbaijan (2024)

Between 2014 and 2024, the fruit-growing sector of the Guba–Khachmaz economic region underwent significant structural transformations, both in terms of cultivated area and productivity. The findings reveal that while the land allocated to key fruit crops expanded substantially, productivity patterns varied by fruit type and often exhibited contradictory trends. This indicates that agricultural modernization must go beyond mere land expansion and prioritize technological resilience, varietal adaptation, and agroecological alignment.

In terms of land use, cherry and peach orchards experienced the most dramatic growth — increasing by 4,418.3 ha (320.1%) and 3,670.6 ha (277.6%) respectively. This expansion signals a transition toward an export-oriented, market-driven fruit production model. Conversely, traditionally dominant apple orchards saw a contraction of 3,200.4 ha (–16.08%), reflecting a shift among farmers toward higher-value crops and adaptive responses to evolving market demands[20].

Yield trends, however, present a more complex picture. Pear and apple productivity increased by 64.3% and 31.9%, respectively, driven by technological adoption, improved cultivar selection, and enhanced agro-service delivery. In contrast, cherry and peach yields declined by 17.9% and 34.0%, respectively. This paradox suggests that area expansion alone does not guarantee productivity gains and may, in fact, backfire if not matched with suitable technologies, climate-fit varieties, and market access strategies[15].

Sour cherry exhibited moderate, stable growth in both area and yield, indicating its sustained relevance for household production and local markets. Overall, these patterns suggest that specialization and functional restructuring — not just expansion — have reshaped the region's fruit economy. Achieving economic efficiency from expansion requires a harmonious alignment of technology, ecology, and market dynamics.

Moreover, the evolution of the sector reflects a shift in agronomic and logistical paradigms. Short-cycle, high-demand fruits with favorable post-harvest characteristics (e.g., cherry, peach) gained ground, while labor-intensive crops with declining profitability (e.g., apple) lost competitiveness. This highlights the need to optimize not just what is grown, but how and for whom production is oriented.

Importantly, the adoption of advanced technologies such as drip irrigation and intensive orchard systems has played a key role in this transformation. In a context of land and water constraints, efficient irrigation became essential for stabilizing soil moisture, reducing disease pressure, and improving yields — particularly in apple and cherry orchards[20].

Intensive orchard models — characterized by high-density planting, mechanized pruning, and optimized nutrient delivery — have led to substantial gains in productivity per hectare and enabled faster harvest cycles[15]. These changes reduce labor costs and improve the speed and quality of market delivery.

Supporting these innovations are state-sponsored agro-service packages (soil testing, targeted fertilization, pest control), along with subsidized credit and investment support via the Agricultural Credit and Development Agency. Additionally, satellite-based monitoring tools (e.g., Azercosmos) have enhanced precision farming and risk mitigation strategies[5].

Taken together, these innovations have not only increased output volumes but also enhanced product quality and export competitiveness. The Guba–Khachmaz region is now positioned as a high-tech, resilient leader within Azerbaijan's agricultural sector, with fruit farming increasingly aligned with sustainable development objectives and international market integration.

Between 2014 and 2024, the fruit sector in the Guba–Khachmaz economic region experienced notable transformations in both spatial distribution and productivity structures. The observed changes in orchard areas and yield levels were not random; rather, they reflect the combined influence of socio-economic and biophysical factors.

For example, the reduction in apple orchard area accompanied by a significant 31.9% increase in yield suggests a successful shift towards intensive orchard systems. This outcome demonstrates the positive impact of technological efficiency on productivity[2, 4]. The widespread adoption of drip irrigation, improved cultivar selection, and the expansion of agro-service delivery have contributed directly to this improvement[20].

In contrast, cherry and peach orchards exhibited dramatic expansion — 320.1% and 277.6%, respectively — yet registered yield declines. This paradox highlights that scale expansion does not always translate into functional efficiency. Particularly under climate variability, disrupted vegetative cycles and altered phenophases have caused unstable productivity[19, 22].

Pear and sour cherry, however, demonstrated stable and rising trends in both area and yield, reflecting their agroecological compatibility with the region's soils and climate. Pear yield increased by 64.3%, largely due to technological modernization and market-driven production models[14].

Variations in land productivity across districts can be attributed to differences in land quality, irrigation infrastructure, and access to state subsidies. In Qusar and Khachmaz, favorable agro-resources led to higher productivity, while in Shabran and Siyazan, weaker infrastructure hindered stable output[9].

Notably, the expansion of cultivated area did not always correlate with increased productivity. This can be explained by the delayed productivity onset in newly established orchards and the destabilizing effects of climate change[8, 24]. Additionally, in some cases, rapid expansion occurred without sufficient technical capacity or specialization, leading to inefficiencies[23].

Conversely, the positive relationship between increased yield and reduced area — as seen in apple cultivation — indicates the benefits of more efficient resource use and targeted technological investment. This aligns with the principle of "quality-driven structural transformation" in agriculture[12].

Sustaining such structural shifts in fruit farming requires more than economic and technical interventions. Ecological and social dimensions must be integrated, including biodiversity preservation, soil conservation, and risk management under climate change[7].

In conclusion, the transformation of fruit agriculture in the Guba–Khachmaz region reflects not only quantitative shifts but also deeper structural realignments in production systems, technological diffusion, and governance strategies. These changes contribute meaningfully to regional food security and long-term agricultural resilience[4, 14, 20].

5 Conclusions

This study analyzed the spatio-temporal dynamics of fruit cultivation in the Guba–Khachmaz economic region of Azerbaijan over the period 2014–2024 and revealed several significant findings. The analysis demonstrated that over the last decade, the region's fruit sector has undergone substantial structural and geographical transformations, with increases in both the cultivated area and productivity for some fruit types, and declines for others.

The data show that cherry and peach orchards experienced a three- to fourfold increase in planted area, indicating strong alignment with high-export-potential fruit production trends. Conversely, apple orchards saw a 16.08% decrease in area, reflecting a shift in market

demand and farmers' transition toward more profitable crops.

In terms of yield, substantial increases were observed for pear (64.3%) and apple (31.9%), which can be attributed to the implementation of intensive orchard technologies, drip irrigation systems, and well-organized agro-service support. In contrast, cherry (-17.9%) and peach (-34.0%) yields declined, likely due to inadequate climate adaptation and technical maintenance in newly established orchards.

The study also highlights that expanding cultivated area alone is insufficient for sustainable development. Key priorities should include yield stability, optimal management of soil and water resources, cultivar adaptability, and technological integration. Differentiated approaches tailored to the region's diverse microclimatic and soil conditions will be crucial to ensuring continuity and resilience in fruit production.

Findings further indicate that the fruit sector in Guba–Khachmaz is transitioning toward a market-oriented, technology-driven, and climate-adaptive model. To ensure the success of this transition, priority must be given to state support (such as subsidies, concessional credit, and scientific guidance), improved agro-service quality, and expanded technical knowledge among farmers[20].

At the same time, the export-oriented initiatives of private agribusinesses operating in the region—such as "Green Quba" and "Ismikhanli" LLC—demonstrate that the fruit sector is moving from a local production model toward global market integration[21, 26]. This signals the beginning of a new phase in the region's agricultural development.

In conclusion, the study shows that sustainable growth in the Guba–Khachmaz fruit sector requires geographically differentiated, scientifically grounded, and technology-based strategies. This approach is essential not only for enhancing profitability in agriculture but also for ensuring food security, employment, and regional economic stability.

References

1. Agrokimya. *Fruit sector development in Guba-Khachmaz*. 2023;.https://agrokimya.az
2. Altieri MA. The ecological role of biodiversity in agroecosystems. *Agriculture, Ecosystems & Environment*. 1999;74(1-3):19-31.10.1016/s0167-8809(99)00028-6
3. AMEA Coğrafiya İnstitutu. (2022). *Azərbaycanın aqroekoloji zonalaşdırılması*. Bakı: AMEA.
4. ARDSK. (2024). *Azərbaycan Respublikası Dövlət Statistika Komitəsi: Aqrar sektor üzrə illik hesabatlar (2014–2024)*. Bakı: ARDSK.
5. Azercosmos & Ministry of Agriculture. (2022). *Space-based monitoring for precision agriculture*. Baku: KTN.
6. AZƏRTAC. *Quba-Khachmaz region: Apple production reaches new heights*. 2023;.https://azertag.az
7. Bellard C, Bertelsmeier C, Leadley P, Thuiller W, Courchamp F. Impacts of climate change on the future of biodiversity. *Ecology Letters*. 2012;15(4):365-377.10.1111/j.1461-0248.2011.01736.x
8. Burgiel SW. (2010). Invasive species and climate change: A global perspective. Global Invasive Species Programme (GISP).
9. Chmielewski FM, Müller A, Bruns E. Climate changes and trends in phenology of fruit trees and field crops in Germany, 1961–2000. *Agricultural and Forest Meteorology*. 2004;121(1-2):69-78.10.1016/s0168-1923(03)00161-8
10. Coman M, Chițu E. (2014). Multicriteria analysis of agro-climatic suitability for fruit tree species. *Scientific Papers Series B, Horticulture*, 58, 41–46.
11. Coğrafiya Cəmiyyəti. (2023). *Quba–Xaçmaz iqtisadi rayonunun təbii-coğrafi xüsusiyyətləri*. Bakı: Coğrafiya Cəmiyyəti.
12. El-Beltagy A. (2012). Food security and climate change in dry areas. *Food Security*, 4(4), 345–356.
13. ETSN. (2023). *Ekologiya və Təbii Sərvətlər Nazirliyi: İqlim dəyişikliyi və aqrar risklər*. Bakı: ETSN.
14. FAO. (2012). *Climate change and food security: A framework document*. Rome: Food and Agriculture Organization of the United Nations.
15. FAO. (2021). *Guidelines on orchard management and climate resilience*. Rome: FAO.
16. Fruit-Growing and Tea-Growing Scientific Research Institute. (2023). *Zonalaşdırma və sort uyğunluğu üzrə elmi məlumatlar*. Quba: MÇETİ.
17. ismikhanli.az. *Ismikhanlı LLC: Super-intensive orchard development. https://ismikhanli.az*. 2023;.https://ismikhanli.az
18. KTN. (2023). *Kənd Təsərrüfatı Nazirliyi: Meyvəçiliyin inkişaf proqramı 2019–2023*. Bakı: KTN.
19. Menzel A. (1999). Phenology in a changing climate. *Climatic Change*, 43(1), 173–181.
20. Ministry of Agriculture. (2023). *National agro-strategy reports*. Baku: KTN.
21. regioninfo.az. *Private sector initiatives in Guba-Khachmaz region*. 2023;.https://regioninfo.az
22. Romanovskaja D. (2009). Climate change and fruit tree phenology in Eastern Europe. *Baltic Forestry*, 15(1), 80–87.
23. Ray DK, Gerber JS, MacDonald GK, West PC. Climate variation explains a third of global crop yield variability. *Nature Communications*. 2015;6(1).10.1038/ncomms6989
24. Sarr B. Present and future climate change in the semi-arid region of West Africa: a crucial input for practical adaptation in agriculture. *Atmospheric Science Letters*. 2012;13(2):108-112.10.1002/asl.368
25. Yeniazerbaycan.com. *Subsidy mechanisms for intensive orchards*. 2023;.https://yeniazerbaycan.com
26. edf.gov.az. *Entrepreneurship Development Fund reports*. 2023;.https://edf.gov.az