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GIS-Based Analysis of Agricultural Land Use Changes in Socio-Economically Less Developed Rural Settlements: The Case of Saray, Şarköy, and Hayrabolu Districts (Tekirdağ/Türkiye)

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ABSTRACT

Agricultural land cover has changed over time, and monitoring these changes has become an effective tool in development processes by linking them to ecological and socio-economic issues. In this context, the main hypothesis of the study is that "determining land use changes spatially and temporally using CORINE Land Cover data is crucial in development-oriented planning processes." The study analyzes changes in agricultural land use based on CORINE land cover classes between 1990 and 2018 in the districts of Saray, Şarköy, and Hayrabolu in Tekirdağ Province, which have low levels of socio-economic development. The research aims to answer the following questions: during which periods did significant changes occur in agricultural areas in Saray, Şarköy, and Hayrabolu? What are the total rates of increase or decrease in these areas? Into what types of land have agricultural are+as significantly transformed? The methodology was developed using Geographic Information Systems (GIS)-based maps, graphs, and tables. The findings reveal the spatial and temporal dimensions of changes in agricultural land use and land cover between 1990 and 2018. The data obtained are anticipated to provide a concrete foundation for developing rural development policies and ensuring the sustainable use of natural resources.

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Introduction

Land use morphology represents a general pattern of land use types shaped by natural and socio-economic factors, which can change over time (Grainger, 1995). Land use and land cover emerge as a result of the interaction between natural and socio-economic elements across spatial and temporal dimensions (Rawat & Kumar, 2015). In regions significantly influenced by climate change and population growth, changes in land use have become increasingly critical for environmental management (Zoungrana et al., 2015; Niculae et al., 2023). On both local and global scales, these changes are fundamental to understanding ecological, biophysical, social, and climatic impacts (Turner, 2002; Foley et al., 2005; Mamun et al., 2022).

Many studies have highlighted land use changes as a core component of sustainability research (Turner et al., 2007; Bakker & van Doorn, 2009), often associating them with global climate change and socio-economic challenges (Long & Li, 2002; Kalnay & Cai, 2003; Long et al., 2007; Lambin & Meyfroidt, 2011). Kaya et al. (2020) emphasized that land use changes serve as a basis for studies in economic and socio-cultural domains. Similarly, Yohannes et al. (2018) pointed out that these studies should be considered in environmental protection strategies and sustainable resource management.

Grainger (1995) stressed the direct relationship between land use changes and socio-economic conditions. Similarly, Olğaç and Doğan (2020), along with Milentijević et al. (2024), underlined that identifying temporal changes in land use is a crucial tool for the effective and accurate management of natural resources. Pukowiec-Kurda and Vavrouchová (2020) noted the scientific importance of land use changes in rural settlements and identified a research gap in the literature due to their dynamic and ongoing nature.

In this context, the CORINE (Coordination of Information on the Environment) system, initiated by the European Commission in 1985, has been a fundamental data source enabling the monitoring of spatial and temporal changes in land use through satellite imagery and Geographic Information Systems (GIS) (EEA, 2007). CORINE has been widely used in research to examine rural development, urbanization, and agricultural transformation processes (Feranec et al., 2007; Türker, 2021).

In Türkiye, studies utilizing CORINE Land Cover (CLU/CLC) data have revealed that agricultural lands are increasingly being converted into urban areas, providing critical insights for sustainable planning (Sarı & Özşahin, 2016; Kurtar, 2021). Both nationally and internationally, numerous studies have focused on identifying land cover and land use changes and examining temporal shifts using CLU/CLC data (Keleş & Durduran, 2019; Kaya et al., 2020; Üyük et al., 2020; Pazúr et al., 2024). Feranec et al. (2007) analyzed changes in grassland areas in Slovakia between 1990 and 2000 using CLU/CLC data and emphasized that these changes are significant indicators for understanding trends in agricultural landscape development. Bayar (2018) highlighted that identifying changes in agricultural areas is effective for developing planning decisions and taking preventive measures. Sarı and Özşahin (2016) examined land use and land cover (LULC) changes in Tekirdağ Province based on the CLU/CLC system over a 15-year period from 2000 to 2015. Kurtar (2021) investigated land cover changes in Tekirdağ between 1990 and 2018 using CLU/CLC data, finding that artificial areas had expanded while agricultural lands had decreased. Üyük et al. (2020) analyzed temporal changes in land use in Denizli Province between 1990 and 2018 using CLU/CLC data, revealing an increase in agricultural areas, a decrease in grasslands, and an expansion of urban areas. Türker (2021) studied land use changes in Uşak Province over 28 years (1990-2018) and found that unirrigated arable lands were the most common type of use, while the proportional increase in urban structures was linked to urbanization and economic factors.

These studies demonstrate that CLU/CLC data is an effective tool for examining spatial and temporal land use and land cover changes, serving as a vital component in regional development policies and planning processes (Irwin & Geoghegan, 2001; Bürgi et al., 2004; Grassi et al., 2017; IPCC, 2019).

The primary hypothesis of this study is that "determining spatial and temporal land use changes with CLU/CLC data is essential in development-oriented planning processes." Based on this premise, the study analyzed agricultural land use changes between 1990 and 2018 in the districts of Saray, Şarköy, and Hayrabolu in Tekirdağ Province, which are characterized by low levels of socio-economic development, using CLU/CLC classes. The study aims to answer the following questions:

During which periods did significant changes occur in agricultural lands in Saray, Şarköy, and Hayrabolu?

What are the total rates of increase or decrease in agricultural areas in these districts?

Into which land use types have agricultural lands been transformed?

Within this framework, agricultural land use and land cover changes in the high-agricultural-potential yet socio-economically underdeveloped districts of Şarköy, Saray, and Hayrabolu in Tekirdağ Province were analyzed using CLU/CLC data for the 1990-2018 period, employing GIS techniques. The findings of the study are expected to provide a solid foundation for rural development policies and the sustainable use of natural resources.

Materials and Methodology

The methodology of this study comprises five main stages:

Stage 1: Selection of the Study Area

The study focuses on the districts of Hayrabolu, Şarköy, and Saray, located in the north, south, and east of Tekirdağ Province, as shown in Figure 1. These districts have high agricultural potential but rank in the 3rd and 4th levels in socio-economic development within Tekirdağ. The selection of the study areas was based on data from the Socio-Economic Development Index (SEGE) (2022) and the Tekirdağ Agricultural Report (2022). Criteria such as location, socio-economic development level, and agricultural potential were prioritized.

According to SEGE 2022, Saray ranks 295th, Şarköy 303rd, and Hayrabolu 420th among districts nationwide. Analysis of the distribution of cultivated agricultural lands in Tekirdağ indicates that 19.40% of cultivated areas are in Hayrabolu, 8.15% in Saray, and 3.94% in Şarköy (Tekirdağ Agricultural Report, 2022). Vision plans for the districts identify agriculture as a core opportunity. In Saray's Vision Plan, the broad and fertile agricultural lands are recognized as a key advantage, with a focus on enhancing agricultural potential (Saray District Vision Plan, 2012). In Şarköy's Vision Plan, the strong agricultural sector and its diversification are highlighted, envisioning the integration of tourism and agriculture (Şarköy District Vision Plan, 2011). Hayrabolu's Vision Plan identifies its strength in agricultural production as a core opportunity but also notes the lack of economic transformation of agricultural outputs as a challenge. The plan aims to develop Hayrabolu as a rural center distinguished by its agricultural production (Hayrabolu District Vision Plan, 2012).

The population figures for the districts are presented in Table 1. When analyzed based on the years corresponding to the CORINE land cover classifications, an increase in population is observed in Şarköy and Saray between 1990 and 2018, whereas a decrease is noted in Hayrabolu.

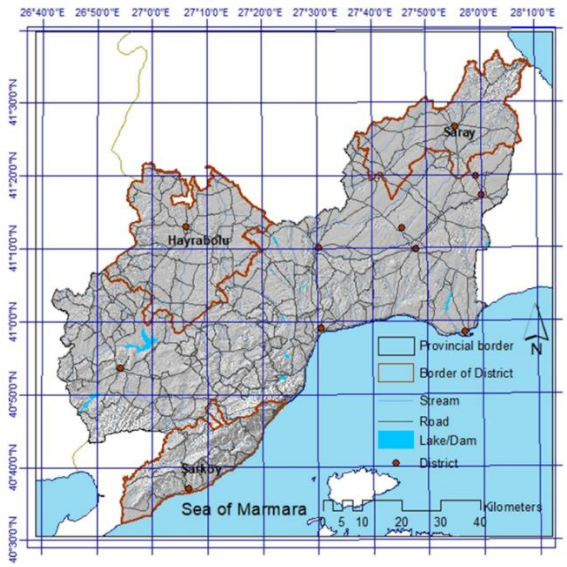


Figure 1. Study area: Hayrabolu, Şarköy, and Saray districts

Table 1. Population of Şarköy, Saray, and Hayrabolu districts (1990-2018) (TÜİK, 2022).

Districts	1990	2000	2007	2012	2018
Şarköy	28.480	32.660	29.395	29.991	32.267
Saray	33.716	41.217	44.540	47.522	49.605
Hayrabolu	45.640	40.130	36.942	33.488	32.268

Table 2. CLU/CLC classification used in the study (Ministry of Agriculture and Forestry, 2024).

Level 1	Level 2	Level 3
1. Artificial Surfaces	1.1 Urban fabric	111 Continuous urban fabric 112 Discontinuous urban fabric
2. Agricultural Areas	2.1 Arable Land	211 Non-irrigated arable land 212 Permanently irrigated land 213 Rice fields
	2.2 Parmenant Crops	221 Vineyards 222 Fruit trees and berry plantations 223 Olive groves
	2.3 Pastures	231 Pastures
	2.4 Heterogeneous Agricultural Areas	242 Complex cultivation patterns 243 Land principally occupied by agriculture, with significant areas of natural vegetation
3. Forest and seminatural areas	3.1 Forest	311 Broad-leaved forest 312 Coniferous forest 313 Mixed forest
4.Wetlands	4.1 Inland Wetlands	4.1.1 Inland marshes
5. Water	5.1 Inland waters 5.2 Marine waters	5.1.1 Water courses 5.1.2 Water bodies 5.2.3 Sea and ocean

Stage 2: Defining the objective

The purpose of this study is to examine the spatial and temporal changes in agricultural lands using CORINE land cover classes and data in rural settlements with high agricultural potential but low socio-economic development levels. Accordingly, the changes in agricultural lands within Hayrabolu, Şarköy, and Saray districts between 1990 and 2018 were analyzed.

Stage 3: Land use classification

In this study, the classification of agricultural land use for the years 1990–2018 was performed using GIS based on CORINE land cover classes for each district. Agricultural lands include areas harvested annually, fallow lands, and crops requiring intensive water usage, such as rice (Ministry of Agriculture and Forestry, 2024). The study utilized third-level agricultural land classes from CORINE land cover data shown in Table 2.

Stage 4: Temporal and spatial change analysis

Using the CORINE Land Cover classes from 1990 to 2018, agricultural land use maps for the years 1990, 2000, 2006, 2012, and 2018 were generated with ArcGIS 10.8 software. In this process, agricultural land use classes were calculated at the district level within the total agricultural land use area, and percentage change rates were determined using Microsoft Excel 2024. The sizes and percentage ratios of agricultural land use classes for each district were visualized through tables and graphs. Additionally, the percentage ratios of forests, settlements, wetlands, and water features were evaluated based on total area size, and land use changes were analyzed in the results section. The representations of maps and graphs illustrating agricultural land use conditions between 1990 and 2018 were prepared using the codes from the CORINE Land Cover classification. In the numerical expressions within the graphs, decimal values were rounded by considering only the first decimal place.

Stage 5: Results and recommendations

The spatial change rates of agricultural lands were compared across different years, general evaluations were made, and recommendations were developed.

Results

In this study, the spatial and temporal changes in agricultural areas in the districts of Hayrabolu, Saray, and Şarköy between 1990 and 2018 were analyzed based on CORINE land cover data. The maps presented in Figures 1, 2, and 3 show the thematic maps of CORINE land cover classes for Hayrabolu, Saray, and Şarköy for the years 1990, 2000, 2006, 2012, and 2018, respectively. In each map, spatial changes in land use types across these three districts are visualized using different colors.

Hayrabolu, Saray, and Şarköy Districts: Temporal and Spatial Changes (1990-2018)

Hayrabolu district: A significant transformation in agricultural lands was observed in Hayrabolu district between 1990 and 2018 (see Figure 2). The "Non-irrigated arable land (211)" category showed an increase of 28.1%, while the "Permanently irrigated land (212)" category experienced a decrease of 22.6%. This indicates that a significant portion of irrigated agricultural land has been converted to dryland farming. Unlike the other districts, the "Rice fields (213)" category stands out in Hayrabolu. In 1990, this category accounted for 6.36% of the total area, but by 2018, it had decreased to 5%, marking a 1.36% reduction (see Figure 3).

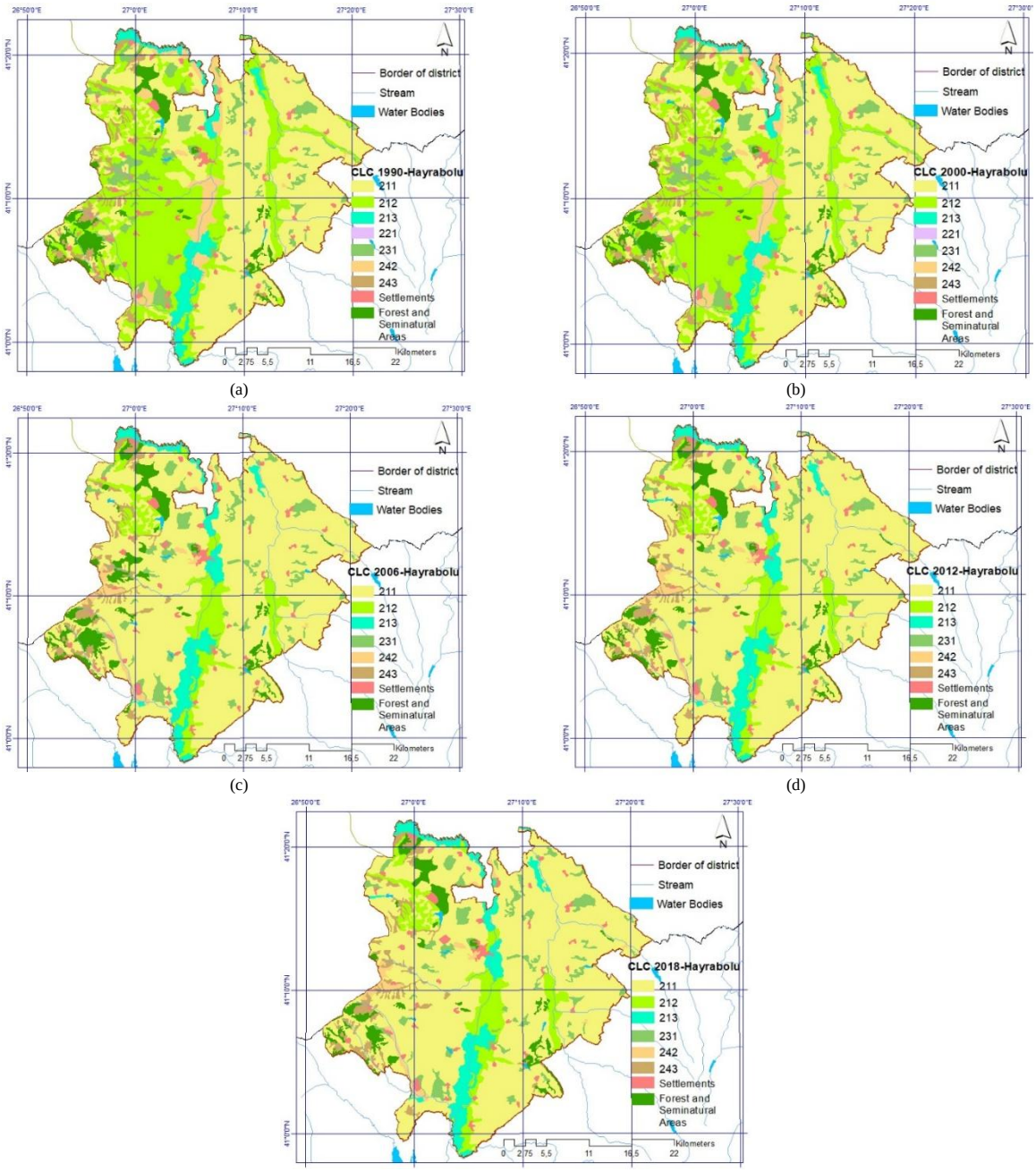
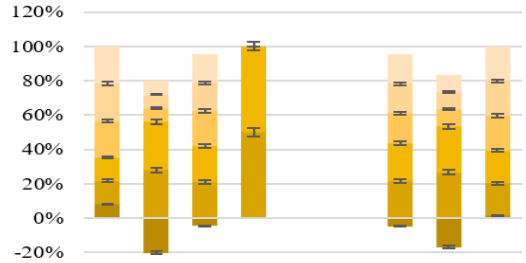


Figure 2. CLU/CLC maps of Hayrabolu district: (a) 1990, (b) 2000, (c) 2006, (d) 2012, and (e) 2018



	211	212	213	221	222	223	231	242	243
2018	74.9	8.8	5	0	0	0	5.4	1.7	4.2
2012	74.9	8.8	5	0	0	0	5.5	1.7	4.2
2006	73.5	9	6.1	0	0	0	5.5	1.7	4.2
2000	46.8	31.5	6.3	0.03	0	0	7	4.6	4
1990	46.8	31.4	6.4	0.03	0	0	6.9	4.6	3.9
Difference (1990-2018)	28.1	-22.6	-1.4	0	0	0	-1.5	-2.9	0.3

Figure 3. Changes in the spatial size of agricultural areas in Hayrabolu district according to CLU/CLC Level 3 classification over the years (1990-2018)

It was found that the decreased areas were largely converted into "Non-irrigated arable land (211)". It was noted that there were no "Vineyards (221)" or "Olive groves (223)" categories in the district. The "Fruit trees and berry plantations (222)" category was present only in 1990 and 2000, with a minimal 0.03% presence, and disappeared in subsequent years. The "Pastures (231)" category saw a 1.5% reduction, with most of this decrease being converted into "Non-irrigated arable land (211)". Similarly, the "Complex cultivation patterns (242)" category experienced a 2.9% decline, with some of these areas being converted into "Non-irrigated arable land (211)" or "Permanently irrigated land (212)".

Additionally, no significant changes were observed in the category "Land principally occupied by agriculture, with significant areas of natural vegetation (243)".

Saray district: In Saray district, significant changes in land use were observed between 1990 and 2018 (Figure 4).

During this period, while there was a decrease in other agricultural areas, the "Non-irrigated arable land (211)" category saw an increase of 6.8%. This increase indicates that agricultural activities have become concentrated in certain areas, which have retained their importance. The "Permanently irrigated land (212)" category experienced a decrease of 0.8%. This reduction is understood to be linked to the conversion of these areas to "Non-irrigated arable land (211)" (Figure 5).

It was found that the district did not include "Vineyards (221)" or "Olive groves (223)" categories. However, the "Fruit trees and berry plantations (222)" category began to form at 0.1% in 2012 and maintained this percentage through 2018. A 1.6% reduction in the "Pastures (231)" category was observed, indicating that pasture areas have been converted to agricultural or settlement areas. Similarly, the "Complex cultivation patterns (242)" category experienced a 1.7% decrease, with these areas largely being transformed into "Non-irrigated arable land (211)". A 2.9% reduction occurred in the "Land principally occupied by agriculture, with significant areas of natural vegetation (243)" category, and this loss was largely converted into "Non-irrigated arable land (211)" or settlement areas.

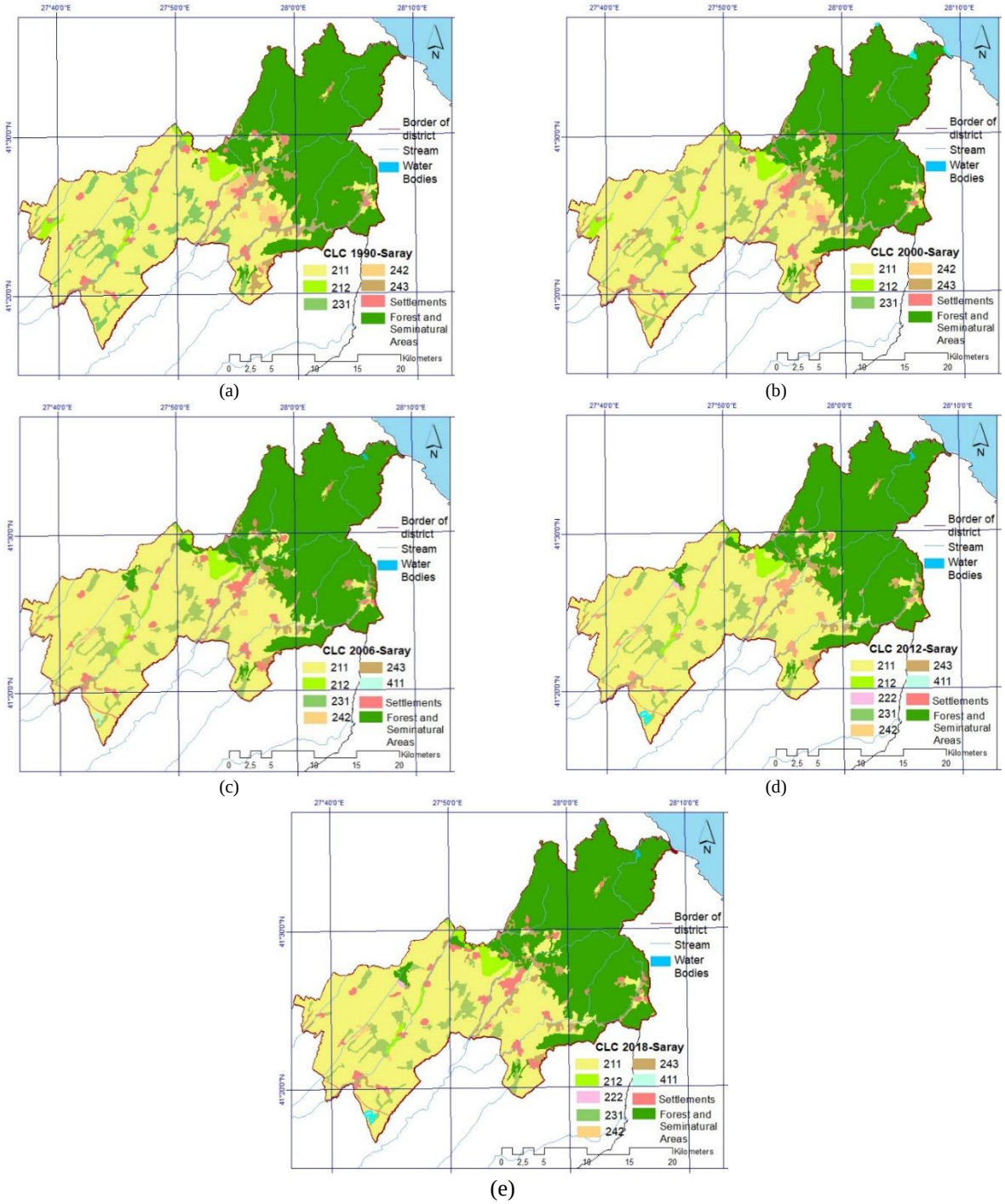
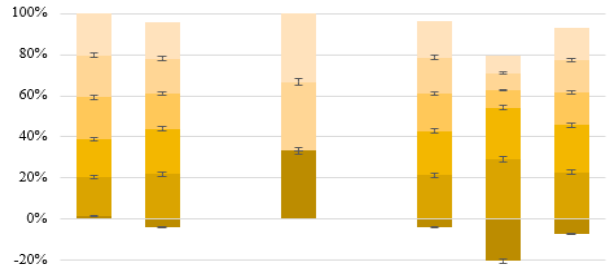


Figure 4. CLU/CLC maps of Saray district: (a) 1990, (b) 2000, (c) 2006, (d) 2012, and (e) 2018.



	211	212	221	222	223	231	242	243
2018	81.8	3.4	0	0.1	0	7.6	0.7	6.3
2012	81.9	3.3	0	0.1	0	7.6	0.7	6.4
2006	81.7	3.3	0	0	0	7.9	0.7	6.4
2000	75	4.2	0	0	0	9.3	2.1	9.3
1990	75	4.2	0	0	0	9.2	2.4	9.2
Difference (1990-2018)	6.8	-0.8	0	0.1	0	-1.6	-1.7	-2.9

Figure 5. Changes in the spatial size of agricultural areas in Saray district according to CLU/CLC level 3 classification over the years (1990-2018).

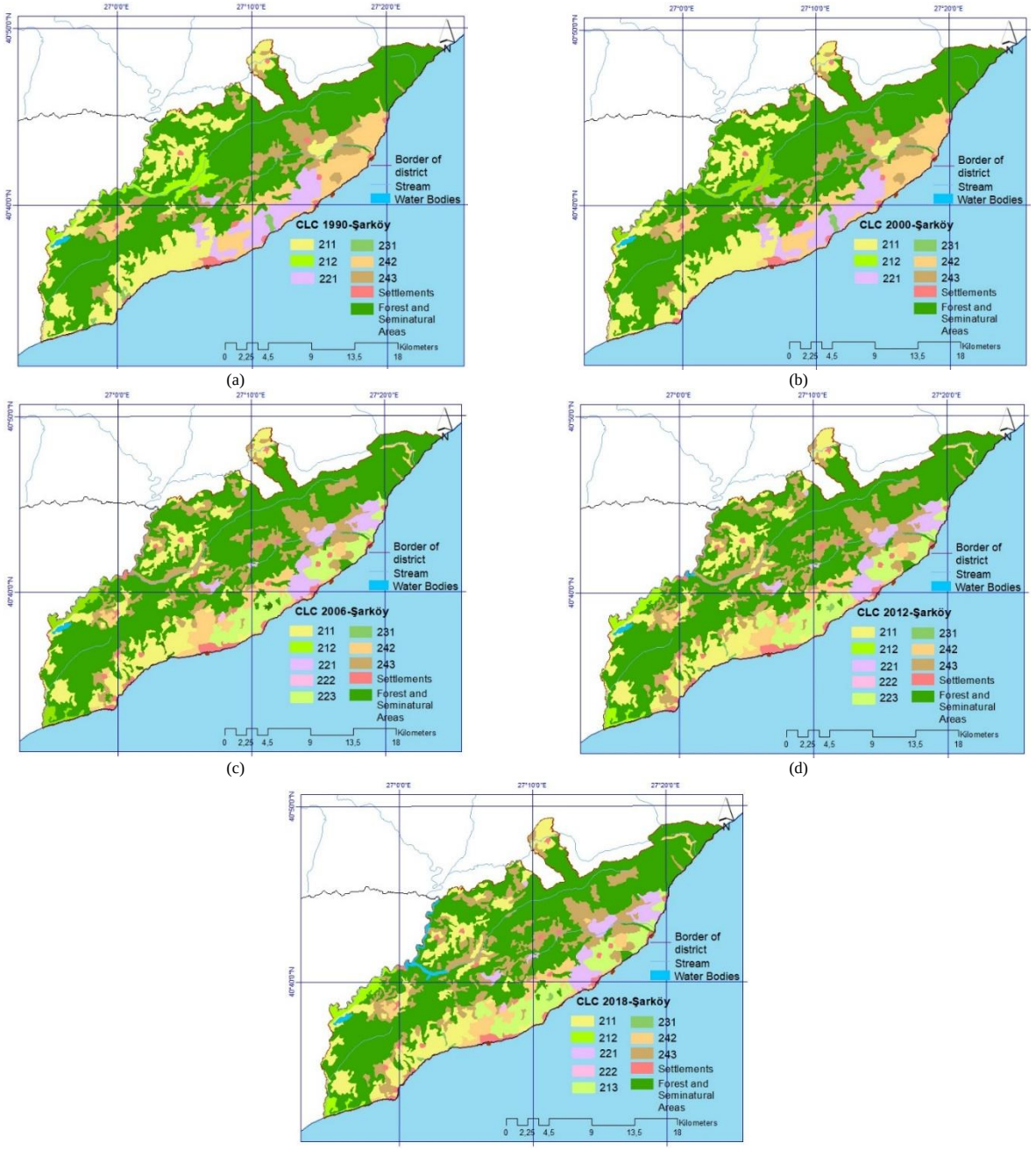
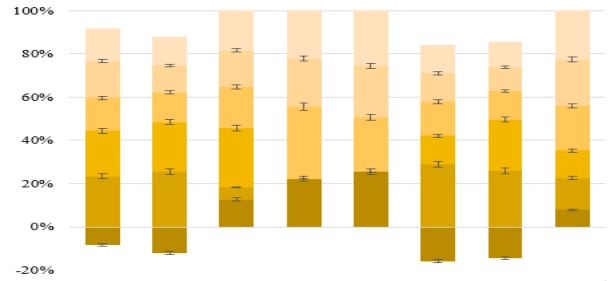


Figure 6. CLU/CLC maps of Şarköy district: (a) 1990, (b) 2000, (c) 2006, (d) 2012, and (e) 2018

Şarköy district: Significant temporal and spatial changes in land use and land cover were observed in Şarköy district between 1990 and 2018 (Figure 6).

During this period, the "Non-irrigated arable land (211)" category experienced a notable decrease of 15.7%, while the "Complex cultivation patterns (242)" category decreased by 13.1%. Additionally, declines were observed in the "Permanently irrigated land (212)" and "Pastures (231)" categories. These reductions indicate that these areas were largely transformed into forested areas, other agricultural categories such as "Land principally occupied by agriculture, with significant areas of natural vegetation (243), or settlement areas (Figure 7).



	211	212	221	222	223	231	242	243
2018	28	3.8	8.8	0.2	14.5	0.5	10.5	33.5
2012	31.9	3.5	8.1	0.2	13.6	0.5	10.1	31.9
2006	28.8	3.9	9.1	0.3	14.4	0.6	12	30.9
2000	39.6	6.5	13.2	0	0	0.5	21.3	18.9
1990	43.7	7.2	2.7	0	0	1.1	23.6	21.7
Difference (1990–2018)	-15.7	-3.4	6.1	0.2	14.5	-0.6	-13.1	11.8

Figure 7. Changes in the spatial size of agricultural areas in Şarköy district according to CLU/CLC Level 3 classification over the years (1990-2018)

Table 3. Spatial changes in CLU/CLC (1990-2018) in selected districts: agricultural areas, forests, and settlements

CLU/CLC Level 3	CLU/CLC data years	Hayrabolu	Saray	Şarköy
	1990	46.8	75	43.7
	2000	46.8	75	39.6
211	2006	73.5	81.7	28.8
	2012	74.9	81.9	31.9
	2018	74.9	81.8	28
Percentage Difference	1990–2018	+28.1	+6.8	+15.7
	1990	31.4	4.2	7.2
	2000	31.5	4.2	6.5
212	2006	9	3.3	3.9
	2012	8.8	3.3	3.5
	2018	8.8	3.4	3.8
Percentage Difference	1990–2018	-22.6	-0.8	-3.4
	1990	6.36	0	0
	2000	6.25	0	0
213	2006	6.1	0	0
	2012	5	0	0
	2018	5	0	0
Percentage Difference	1990–2018	-1.36	0	0
	1990	0.03	0	2.7
	2000	0.03	0	13.2
221	2006	0	0	9.1
	2012	0	0	8.1
	2018	0	0	8.8
Percentage Difference	1990–2018	-0.03	0	+6.1
	1990	0	0	0
	2000	0	0	0
222	2006	0	0	0.3
	2012	0	0.1	0.2
	2018	0	0.1	0.2
Percentage Difference	1990–2018	0	+0.1	+0.2
	1990	0	0	0
	2000	0	0	0
223	2006	0	0	14.4
	2012	0	0	13.6
	2018	0	0	14.5
Percentage Difference	1990–2018	0	0	+14.5
	1990	6.9	9.2	1.1
	2000	7	9.3	0.5
231	2006	5.5	7.9	0.6
	2012	5.5	7.6	0.5
	2018	5.4	7.6	0.5
Percentage Difference	1990–2018	-1.5	-1.6	-0.6
	1990	4.6	2.4	23.6
	2000	4.6	2.1	21.3
242	2006	1.7	0.7	12
	2012	1.7	0.7	10.1
	2018	1.7	0.7	10.5
Percentage Difference	1990–2018	-2.9	-1.7	-13.1
	1990	3.9	9.2	21.7
	2000	4	9.3	18.9
243	2006	4.2	6.4	30.9
	2012	4.2	6.4	31.9
	2018	4.2	6.3	33.5
Percentage Difference	1990–2018	+0.3	-2.9	+11.8

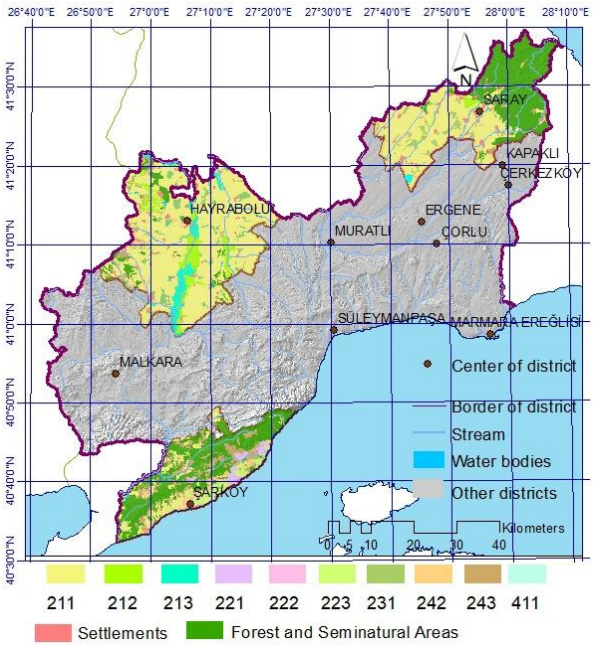


Figure 8. Agricultural land use map of Saray, Şarköy, and Hayrabolu districts in 2018

However, significant increases were also observed in certain land use categories. For instance, the "Vineyards (221)" category saw an increase in area share from 2.7% in 1990 to 8.8% in 2018. This increase demonstrates the continued importance and growth of viticulture in the region. The "Fruit trees and berry plantations (222)" category, which was not present in 1990, was recorded at 0.3% in 2006, and this proportion remained relatively stable in subsequent years. Furthermore, the "Olive groves (223)" category, which did not exist in 1990, began to emerge in 2006 and reached 14.5% by 2018. This indicates that olive cultivation has become a new and significant agricultural activity in the region. The 0.6% decrease in the "Pastures (231)" category suggests that pasture areas have been converted to agricultural or settlement areas. Similarly, the 13.1% reduction in the "Complex cultivation patterns (242)" category points to the transformation of these areas, particularly into "Olive groves (223)" and other agricultural categories. Another notable increase occurred in the "Land principally occupied by agriculture, with significant areas of natural vegetation (243)" category, which saw an 11.8% increase between 1990 and 2018. This increase appears to be linked to the conversion of "Non-irrigated arable land (211)" into this category.

Discussion

This study examines the temporal and spatial changes in agricultural land use in Hayrabolu, Saray, and Şarköy districts in Tekirdağ province, which have high agricultural potential but low socio-economic development levels, based on CORINE land cover data. The map illustrating the agricultural land use of the districts covered in the study for the year 2018 is presented in Figure 8.

In the three selected districts, significant changes in agricultural areas were most notably observed in 2006. The change rates between 1990 and 2018 are presented in Table 3, and the changes within agricultural areas were evaluated internally. Transitions between sub-classes are detailed in the findings section. Accordingly, a shift to dry farming was observed in the districts of Hayrabolu, Saray, and Şarköy. In addition, increasing trends in "Olive groves (223)" and "Vineyards (221)" were identified in Şarköy as of 2006.

Furthermore, considering the overall spatial distribution rates, it was determined that agricultural areas were converted into settlement areas in Hayrabolu and Saray (Figure 9).

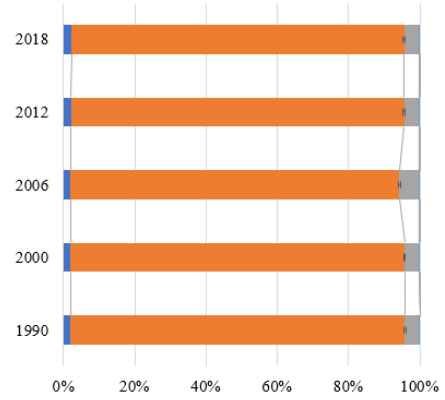
According to the Tekirdağ Agricultural Report (2018), the total agricultural areas in Hayrabolu, Saray, and Şarköy are reported as 805.66 km², 338.45 km², and 163.66 km² (Tekirdağ Agricultural Report, 2018), respectively. However, according to CORINE land cover data, these values are 933.69 km² for Hayrabolu, 391.98 km² for Saray, and 237.40 km² for Şarköy. This discrepancy arises from differences in the calculation methods between the CORINE system and official agricultural reports. This highlights the differences between the data provided by the CORINE land cover dataset and the "Agricultural Report" data.

In the study, agricultural land use changes from 1990, 2000, 2006, 2012, and 2018 were assessed in 9 different classes at Level-3 scale, based on CORINE land cover data, and land use classes for each district were analyzed. Table 3 shows the spatial changes in agricultural areas, forests, and settlements across the selected districts.

Kurtar (2021) examined land cover changes in Tekirdağ province using the CORINE land cover database, finding a 1.96% decrease in agricultural land between 1990 and 2018. In the three districts studied, the total agricultural land area decreased by approximately 0.34% over the same period. This change can be associated with socioeconomic factors. The study conducted by the Trakya Development Agency, which surveyed 910 producers to identify agricultural issues in Tekirdağ, supports this finding. The study highlighted key issues such as economic problems (81%), agricultural debt (43%), and migration (34%) (Trakya Development Agency, 2013). These findings suggest that land use changes are closely linked to socioeconomic issues, supporting numerous studies (Long & Li, 2002; Kalnay & Cai, 2003; Long et al., 2007; Lambin & Meyfroidt, 2011).

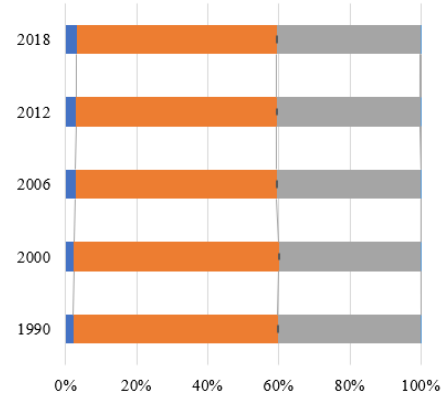
The presence of "Rice fields (213)" in Hayrabolu and "Vineyards (221)" and "Olive groves (223)" in Şarköy reveal the agricultural differences in these districts. The most common land use across the selected districts from 1990 to 2018 was in the "Non-irrigated arable land (211)" category. Similarly, in a study by Türker (2021) on Uşak province, it was found that the most common land use was "Non-irrigated arable land (211)".

According to 2018 CLC data, the highest proportional distribution in the "Non-irrigated arable land (211)" category was found in Saray district at 81.8%, while the highest increase in this category was observed in Hayrabolu at 28.1%. In contrast, the "Permanently irrigated land (212)" category showed a decrease of 22.6%, with Hayrabolu being notably affected. The "Pastures (231)" category showed decreases ranging from 0.6% to 1.6% across the districts, indicating that the category was generally maintained. Furthermore, the "Fruit trees and berry plantations (222)" category was not significantly present in any of the three districts.



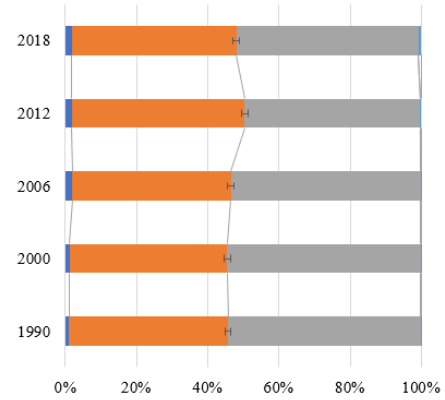
	1990	2000	2006	2012	2018
Settlements	1.97	2.03	2.03	2.06	2.11
Agricultural areas	93.86	93.66	92.16	93.46	93.51
Forest and seminatural areas	4.11	4.1	5.52	4.19	4.09
Wetlands	0	0	0	0	0
Water bodies	0.18	0.21	0.28	0.28	0.29

(a)



	1990	2000	2006	2012	2018
Settlements	2.17	2.38	2.81	2.87	3.05
Agricultural areas	57.58	57.59	56.46	56.57	56.3
Forest and seminatural areas	40.25	40	40.57	40.38	40.46
Wetlands	0	0	0	0.09	0.09
Water bodies	0.0046	0.04	0.07	0.08	0.09

(b)



	1990	2000	2006	2012	2018
Settlements	1.08	1.2	2.02	1.95	1.75
Agricultural areas	44.63	44.23	44.57	49.89	46.28
Forest and seminatural areas	54.08	54.36	53.2	50.84	51.13
Wetlands	0	0	0	0	0
Water bodies	0.21	0.21	0.21	0.27	0.84

Figure 9. Percentage distribution of land use types in the selected districts: (a) Hayrabolu, (b) Saray, (c) Şarköy.

The percentage distribution of settlement areas, agricultural areas, forests and seminatural areas, wetlands, and water bodies based on the total area size in the selected districts is presented in Figure 9. Settlement areas in Saray and Şarköy increased by approximately 0.9% and 0.7%, respectively, a trend that supports the findings of Sarı and Özşahin (2016). This growth appears to be associated with population growth rates in both districts and indicates that the increase in settlement areas has had a limited yet noticeable impact of urban expansion on rural landscapes.

When examining the general distribution rates of land use, agricultural areas have the highest percentage value among the three selected districts, with Hayrabolu accounting for 94% according to CLC 2018. In the other two districts, the distribution rates of agricultural and forest areas range between 40% and 56%, showing relatively similar values. District vision plans also support this finding, emphasizing that the agricultural sector is the primary socio-economic strength in all three districts (Saray District Vision Plan, 2012; Şarköy District Vision Plan, 2011; Hayrabolu District Vision Plan, 2012). Grainger (1995) similarly highlighted the relationship between land use rates and socio-economic conditions in his study.

A detailed analysis of agricultural land distribution reveals a decrease of approximately 0.4% and 1.3% in Hayrabolu and Saray, respectively. The decline in Hayrabolu is likely associated with the reduction in “Rice fields (213)”, whereas in Saray, the changes can be linked to transitions between “Pastures (231)”, “Complex cultivation patterns (242)” and “Land principally occupied by agriculture, with significant areas of natural vegetation (243)” land cover classes. On the other hand, Şarköy experienced an increase of 1.7% in agricultural land, which can be attributed to the expansion trends in “Vineyards (221)” and “Olive groves (223)”.

Regarding forests and seminatural areas, no significant changes were observed in Hayrabolu and Saray districts, while Şarköy district experienced a notable decrease of approximately 3%. As for the distribution of water bodies, a slight increasing trend was observed across all three districts.

When evaluated by district:

- *Hayrabolu:* Among seven different agricultural land use classes, the “Non-irrigated arable land (211)” category showed a remarkable increase of 28.1%. In contrast, a decrease of 22.6% was recorded in the “Permanently irrigated land (212)” category, indicating a shift from irrigated to dryland farming. No significant changes were observed in other categories.
- *Saray:* Among six different agricultural land use classes, a 6.8% increase was found in the “Non-irrigated arable land (211)” category. No significant changes were recorded in other land use categories.
- *Şarköy:* Among eight different agricultural land use classes, increases were observed in the “Vineyards (221)”, “Olive groves (223)”, and “Land principally occupied by agriculture, with significant areas of natural vegetation (243)” categories. In particular, the “Vineyards (221)” category showed an increase compared to 1990, with this growth primarily concentrated in the eastern coastal regions where the

greatest reduction was seen in "Complex cultivation patterns (242)". This finding is similar to the increase observed in "Vineyards (221)" in a study by Üyük et al. (2020) in Denizli province. The "Olive groves (223)" category, which was absent in 1990, began to emerge in 2006 and reached a 14.5% share by 2018. This suggests that olive cultivation has become an increasingly important agricultural activity in the region.

Conclusion

With globalization, factors such as technological advancements, population growth, climate change, and pandemics have driven significant changes and transformations in both urban and rural areas. This study highlights that these factors have had a notable impact on agricultural land use, particularly in rural areas, as observed in the study region. National-scale rural development plans, such as the Eleventh and Twelfth Development Plans, emphasize the preparation of agricultural land use plans to ensure the conservation, sustainable use, and effective management of agricultural lands (Presidency of the Republic of Türkiye, Strategy and Budget Department, 2019; Presidency of the Republic of Türkiye, Strategy and Budget Department, 2023).

The findings from this study underline the importance of developing strategies to conserve agricultural land cover. For example, the observed decrease in irrigated agricultural areas in Hayrabolu and the expansion of residential areas in Şarköy and Saray (Figure 9) suggest that population growth and land use changes are intricately linked. This aligns with existing literature, which associates land use changes with socio-economic conditions and underscores the critical role of detecting these changes for sustainable resource management (Long & Li, 2002; Kalnay & Cai, 2003; Long et al., 2007; Lambin & Meyfroidt, 2011; Zoungrana et al., 2015; Olğaç & Doğan, 2020; Kaya et al., 2020; Milentijević et al., 2024). Similarly, Gilbert and Shi (2023) emphasized that detecting and predicting land use/land cover (LULC) changes is a crucial tool for achieving sustainable development.

This study further suggests that integrating the dynamics of land use changes with future scenario development will be essential for effective rural development planning. For instance, the results point to the need for targeted conservation strategies in regions where agricultural land is under pressure from urban expansion. Future research should prioritize the use of high-resolution spatial data, combined with fieldwork validations, to refine monitoring systems and scenario-based planning. This approach will contribute to the sustainable use and management of agricultural lands, enhancing their role in national development goals.

Evaluation of Study Limitations and the use of CORINE CLC Data

This study was conducted based on the detailed classification advantages provided by CORINE Level 3 data. Land cover classification systems such as CORINE offer a standardized approach to monitor and analyze land use changes over time, allowing for detailed classification of land cover types (Duymaz, 2024). CORINE Level 3 includes 44 distinct land use categories (semantic coverage), spans 39 European countries (spatial coverage), and provides temporal coverage from 1990 to 2018 (Falťan et al., 2020; García-Álvarez & Nanu, 2022). CORINE maps, based on 1:100,000 scale satellite imagery, feature a minimum mapping unit of 25 hectares and a resolution of 100 meters, making them a robust dataset for large-scale analyses (Özür & Ataol, 2018a; Aytop, 2024). However, the literature widely discusses certain limitations of these features concerning data accuracy.

Büttner (2014) and Altürk (2023) highlighted thematic accuracy issues when using CORINE data, particularly at local scales. Büttner et al. (2014) noted that the accuracy rate of CORINE data for 1990 fell below 86% for many countries. Furthermore, specific categories, such as mining sites, construction areas, and mixed agricultural lands, were reported to have significantly lower accuracy rates (Baudoux et al., 2021). However, the 2012 evaluation addressed some shortcomings by introducing 12 new subcategories at Level 4 for Türkiye (CORINE, 2018). As a result of technological advancements, the accuracy rates of CORINE data for 2012 and 2018 improved significantly, ranging between 86% and 98% (Moiret-Guigand et al., 2021). These advancements align with the observations of Özür and Ataol (2018b), who emphasized that future iterations of CORINE data are expected to overcome current limitations and provide more accurate and detailed information on land cover.

Our study utilized CORINE data as a "preliminary study and baseline," relying on existing literature findings that validate its applicability for independent analyses. However, we have explicitly acknowledged the limitations of CORINE data in this study and emphasize the need for future research to enhance accuracy through methods such as field validation and the integration of additional data sources.

Declarations

Author Contribution Statement

M.G.T.: Conceptualization, Investigation, Methodology, Data collection, Data curation, Software, Visualization, Writing – Original draft preparation.

T.K.: Conceptualization, Investigation, Methodology, Writing-Reviewing and Editing.

Conflict of Interest

The authors declare no conflict of interest.

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