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Determining Population Movement-Land Use Interactions for Sustainable Land Management: Case of Türkiye

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Abstract

Throughout history, people have had different impacts on the natural resources of the regions to which they have migrated. The industrialization of the last century has caused increased migration from rural to urban areas, leading to urbanization and a consequent decrease in rural population density. The study examined the effects of population movements on land cover and land use changes (LULCC) between 1990 and 2018 in Türkiye. The CORINE Land Cover products were used to identify changes in land cover and objectively evaluate land use status. The study conducted a Spearman correlation analysis to examine the association between population and LULCC. The results indicated that between 1990 and 2018, there was a significant rise in artificial surfaces, showing a 62.7% increase. In contrast, agricultural areas experienced a moderate growth of 0.7%, with a 1% increase in shrub and/or herbaceous plant area and a substantial increase of 24.8% in wetlands (W). There was a 1.4% reduction in forested areas (FA) and a 9.7% decline in open spaces with minimal or no vegetation (OS). During this period, 1.8% of agricultural area (AA) was transformed into artificial surfaces (AS), 4.8% changed to shrub and/or herbaceous plant associations (SH), whereas 0.4% of FA was transformed into AS, 4.1% into AA, and 0.5% into OS. A negative correlation was noted between population variables in rural regions and alterations in AS and FA. To safeguard FA, AA, and Wetlands, it is vital to pay enough consideration to the migration phenomenon. Therefore, periodic monitoring operations for land use at national and local levels should be conducted.

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INTRODUCTION

The efficient and effective use of resources is fundamental to sustainable development. It is crucial to optimize the utilization of human and natural resources. In particular, land-use change contributes significantly to negative impacts on forest ecosystems, especially in developing countries (Hari et al. 1986). The rise in the demand for raw materials, particularly after the urbanization and production surge initiated after the Industrial Revolution, has resulted in human activities' decimation of natural resources. The overconsumption and unstructured exploitation of natural resources have resulted in detrimental effects on ecosystem services (Twisa et al. 2020) and climate change (Pielke 2005; Sherbinin et al. 2007; Emmott 2013). Therefore, the interplay between humans and the environment is among the most studied subjects.

It is seen that migration movements, which are realised due to many reasons, cause various effects especially in urban and rural areas. Whilst the overpopulation accumulated in and around cities has adwerse effects on natural resources, it can have positive effects in rural areas (Toksoy et al. 20011; Sen et al. 2015). It is estimated that three quarters of the Earth's land surface have been altered in the last millennium as a result of human impacts (Luyssaert et al. 2014). Assessing changes in land use extent and management intensity is critical to understan land system dynamics and their environmental and societal impacts (Kuemmerle et al. 2016). Determining the extent to which anthropogenic impacts affect land use is paramount for sustainable development and resource management. Therefore, to overcome problems such as climate change, establishing management politics and sustainable development, it is crucial to determine land use changes and the causes of these changes.

Furthermore, land use change affects ecosystems, directly or indirectly and the services they provide (Lambin and Meyfroidt 2011; Arneth et al. 2014). However, it is crucial to use reliable data when making these determinations. Studies typically involve processing statistical data or high-resolution satellite images. Nonetheless, a recent study conducted in 2021 using satellite imagery has found that changes in land use between 1960 and 2019 impacted roughly one-third of the world's land, which is around four times higher than previous statistical estimates (Winkler et al. 2021).

Throughout history, Turkey has witnessed internal and external migrations caused by ecological or socio-economic factors. These migrations have resulted in several positive and negative outcomes. For instance, the migration of people has led to adverse effects on forests and farmlands, particularly in urban fringes where settlement and industrialisation are predominant. In contrast, reforestation has risen in rural regions with abandoned agricultural fields and dwindling animal husbandry (Toksoy et al. 2011). Numerous studies have been conducted and are ongoing to investigate these alterations in land cover and land use (Turner et al. 1993; Lambin et al. 2003; Bayar and Karabacak 2017; Gibas and Majorek 2017; Şen et al. 2018; Şen and Güngör 2018; Bayramoğlu and Kadiogullari 2018; Akturk and Güney 2021; Roy et al. 2022; Dogan et al. 2023). However, previous research has focused on residential areas or local levels to investigate climate change (GDM, 2006), alterations in wetland land use (Turan et al. 2021; Baysal 2022), as well as changes in land use across different provinces and districts (Koday and Kızılkan 2019; Eraydın 2022; Diktaş Bulut 2023). Some large-scale studies have only analysed changes in forest areas and the extent of these changes were also examined. However, there has been no systematic investigation into where different land use change processes occur on a country level and how spatial patterns are interconnected.

Furthermore, studies utilising forest management statistics as a source exhibit some limitations. For instance, areas that have undergone deforestation due to mining, forest fires, landslides, construction, and other causes continue to be categorised as forest regions in official statistics (TOD 2022). Therefore, with developing technology, remote sensing and satellite imagery studies have become critical (Wulder et al. 2018). Although studies carried out at the national level are essential to allow comparisons between countries, not all countries have the same socio-economic, cultural, and geographical characteristics. For this reason, examining the factors that cause changes in land use at a national level but at a smaller scale will give much more accurate results in determining the causes of these changes than those obtained with previous methods. The research shows that such studies are minimal and generally based on statistical data (Şen and Toksoy 2006; Ünal et al. 2019; Şen 2022; TOD 2022).

This study analysed the land use status in Turkey between 1990 and 2018, examining changes and class transitions and investigating the influence of population movements on said changes (Other factors were held constant). Findings shall empower policymakers and land managers with the information necessary to make informed decisions about land use planning and management, particularly regarding the land-use classes affected by internal and external migration and changes in population structure within city boundaries. This study's results can be a foundation for similar research in other countries. In summary, this study fills a noteworthy gap in the literature. Additionally, It aims to enhance comprehension of the connections between changes in land cover and population shifts, aiming to facilitate better sustainable land management practices.

MATERIALS & METHODS

Study area

Turkey is situated between 36° - 42° North parallels and 26° - 45° East meridians, north of the equator, east of the prime meridian and in the middle belt (Figure 1). Turkey has a predominantly mountainous terrain, with limited plains and coastal areas (Sensoy et al. 2008). Turkey is located in the Alpine Mountain belt. In addition to the general characteristics of this belt, Turkey has many unique geological and geomorphological features (Kuzucuoğlu et al. 2019). Due to its geographical location, it is also a transit route for migration from north to south. For this reason, it is very rich in fauna and flora. It has an average elevation of 1141 m (Elibüyük and Yılmaz 2010) and has more than 10 thousand plant species, 3,649 of which are endemic (Christenhusz and Byng 2016). It is stated that approximately 40 thousand animal species live in Turkey (Kurnaz and Babür 2018).

Turkey has 45 national parks (905,520 ha), 250 nature parks (107,632 ha), 31 nature reserves (46,461 ha), 14 Ramsar sites (184,487 ha), 115 nature monuments (9,393 ha), 84 wildlife development areas (1,158,820 ha), 59 wetlands of national importance (869,000 ha). 697 ha.), 13 wetlands of local importance (14,513 ha.), 54 protected forests (247,708 ha.), 134 urban forests (10,089 ha.), 336 seed gardens (1,506 ha.) and 318 nurseries (41,880 ha.), totalling a total area of 3,642,826 ha. under protection (TOB 2023). Furthermore, according to the World Wildlife Fund (WWF), Turkey is home to nine of the world's most ecologically diverse and essential hotspots (Bastemur and Güneş 2013).

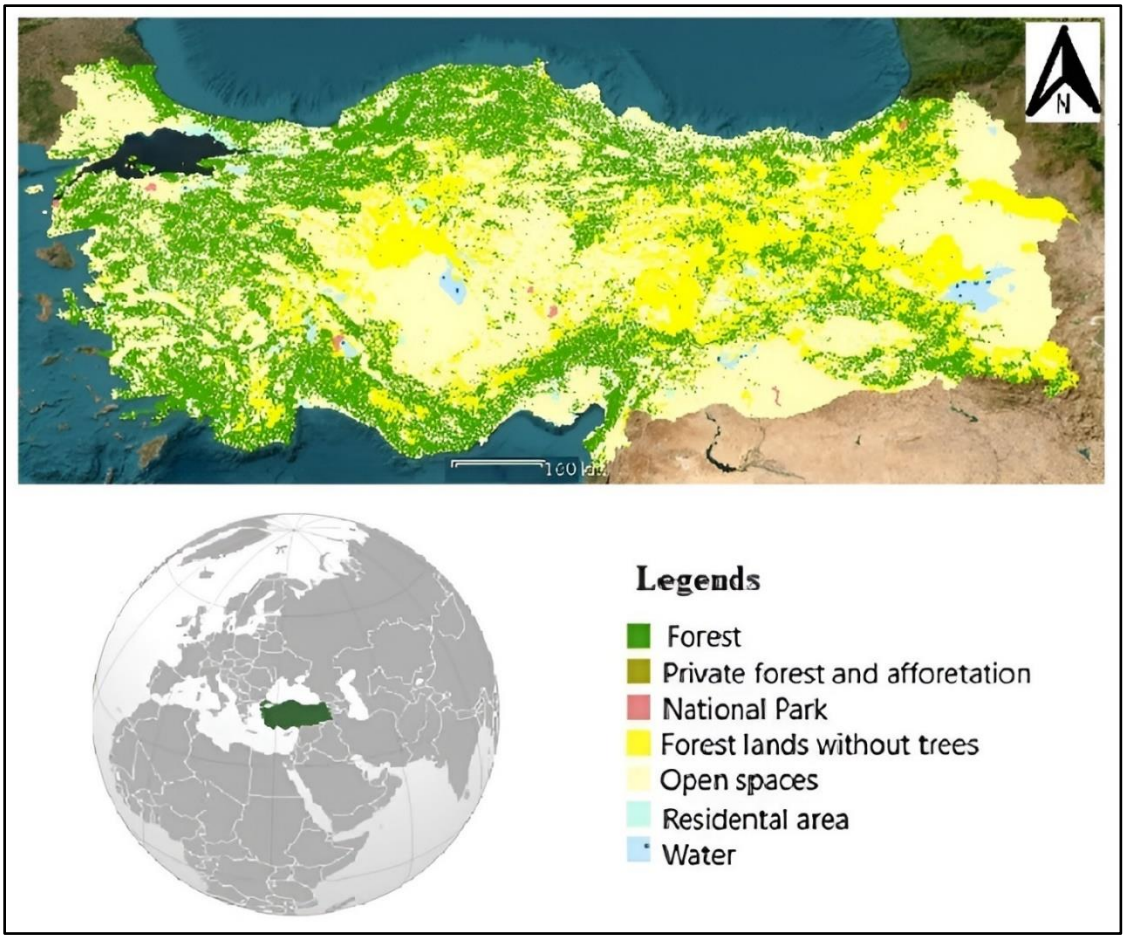


Figure 1. National country and province boundaries of the study area (GDF, 2023)

Dataset & Analysing Methods

The primary data of the study are in two groups. The first group consists of data on the 1990, 2006 and 2018 land use status. The second group consists of data on population variables based on provinces. Spatial data were obtained from the Coordination of Information on the Environment (CORINE) Land Cover (CLC) products created by the Copernicus Land Monitoring Service (CLMS 2023). CORINE provides land cover analyses in forty-four sub-categories across five main groups (Bossard et al. 2000). The datasets obtained from this system have been used both in Turkey (İkiel et al. 2013; Ateşoğlu 2016; Sari and Özşahin 2016; Bayar and Karabacak 2017; Konukçu et al. 2017; Aktürk et al. 2020; Aktürk and Güney 2021; Karaosmanoğlu 2023) and in various researches worldwide (Petrişor 2008; Rusu et al. 2020; Akbari et al. 2022; Bachantourian et al. 2022; Işınkaralar et al., 2022; Czyża et al. 2023; de Bode et al. 2023; Hoffmann et al. 2023; Işınkaralar, 2023; Lumia et al. 2023; Rahman et al. 2023) and continues to be widely used. Although the CORINE system has problems, such as not capturing abandonment in agricultural areas, it will not disrupt the study since those areas are still in the same land use class. Land use data for the years 1990, 2006 and 2018 with a spatial resolution of 100 metres was used in the study (CLMS 2023). The range of land cover classes offered by the CLC products, their coverage, and the inclusion of data for the necessary dates made them the preferred choice for this study. The examination of spatial data utilised ArcMap 10.8.1, with all raster and vector datasets initially altered to the ETRS89 LAEA geographic coordinate system through spatial alignment. The CLC maps maintained a cell resolution of 100 metres, and their Level 3 land cover classes (CLCL 2023) were re-categorised to reflect the study's objective. As a result, six Level 1 classes were assigned: Artificial Surfaces (AS), agricultural areas (AA), forest areas (FA), shrub and/or herbaceous plant associations (SH), open areas with little or no vegetation (OS), and wetlands (W). In this context, the Pastures subclass in the Agricultural areas class (CORINE Level 3) and Natural grasslands, Moors and heathland, Sclerophyllous vegetation and Transitional woodland-shrub subclasses in the Forest and Semi Natural Areas class (CORINE Level 3) are evaluated in the SH (CORINE Level 3) group. In addition, Beaches, Dunes, Sands, Bare rocks, Sparsely vegetated areas, Burnt areas and Glaciers and perpetual snow subclasses in the Forest and Semi Natural Areas class (CORINE Level 3) were analysed in the OS class (CORINE Level 3).

To assess the impact of population on changes in land use, diverse population metrics were initially established. These variables were identified as follows: total provincial population (TPP), total female population in the province (TFPP), total male population in the province (TMPP), total population in the city centre (TUP), total population in rural areas (TRP), total female population in the city centre (TFUP), total female population in rural areas (TFRP), total male population in the city centre (TMUP), total male population in rural areas (TMRP), net migration rate (NMR), and population density (PD). When identifying population variables that could impact land cover change, we considered the data availability for the relevant years provided by the Turkish Statistical Institute or other institutions for each province.

A correlation analysis was conducted to unveil the association between modifications in land cover from 1990 to 2018 and the population variables that influence these alterations. The strength of the correlation coefficient is interpreted as very weak when it ranges from (+-)0.00-0.25, weak when it ranges from (+-) 0.26-0.49, medium when it ranges from (+-) 0.50-0.69, high when it ranges from (+-) 0.70-0.89, and very high when it ranges from (+-) 0.90-1.00 (Özdamar 2002; Büyüköztürk 2010). The analysis used 11 dependent and independent variables (population variables). Dependent variables for the correlation analysis were determined as artificial surfaces (AS), agricultural areas (AA), forest areas (FA), shrub and/or herbaceous plant associations (SH), open areas with no or very little vegetation cover (OS), wetlands (W), and the changes in land cover classes between 1990-2018.

RESULTS

The research identified land use and land cover (LULC) in Turkey during 1990, 2006 and 2018 using CLC maps. These maps are presented in Table 1 and Figure 2. Subsequently, Table 2 shows the change in LULCs observed between 1990-2006, 2006-2018, and 1990-2018. Furthermore, the transition matrix between classes is also presented in the same table. Table 3 presents the changes recorded at the provincial level during the same periods. Lastly, Table 4 shows the LULC inter-class transition matrices within the provinces.

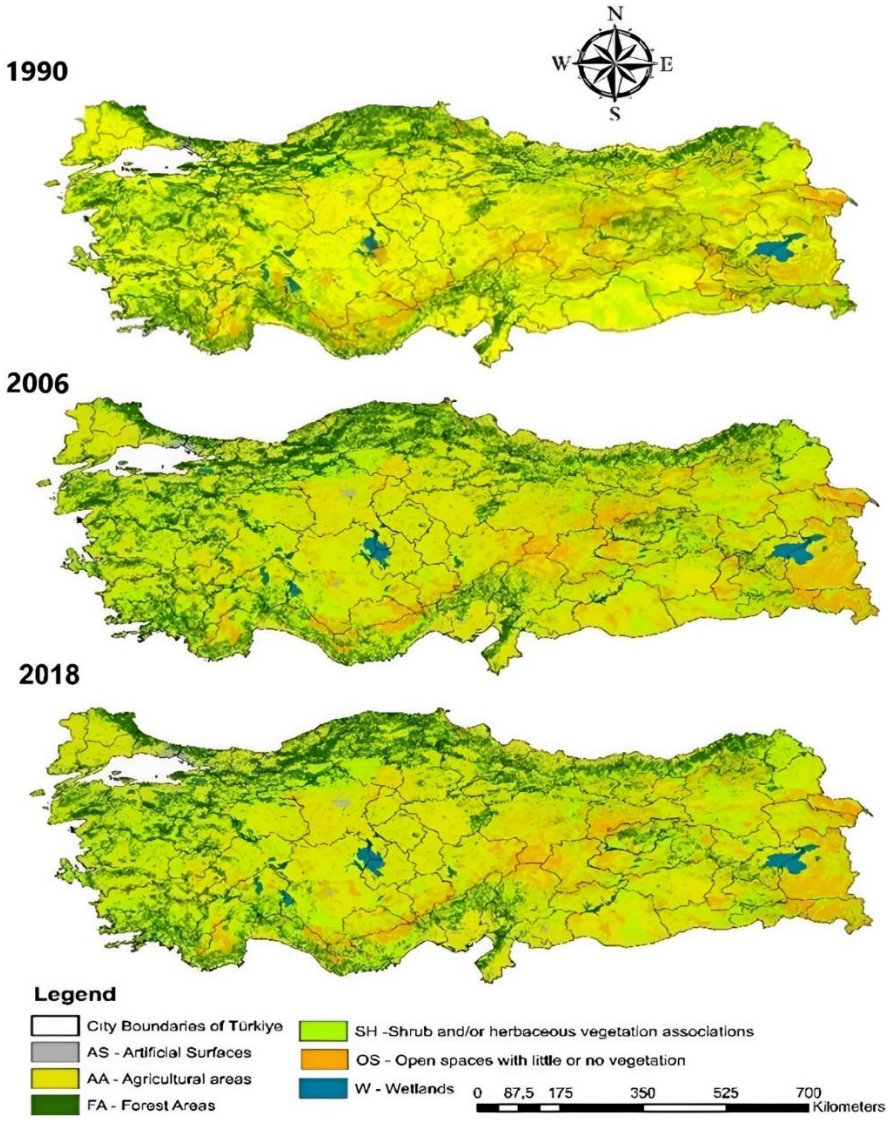


Figure 2. 1990, 2006 and 2018 land cover maps of Türkiye

Table 1. Area coverage of land cover classes for 1990-2018

		1990		2006		2018		Change during 1990-2006		Change during 2006-2018		Change during 1990-2018	
		ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
LULC Classes	AS	955250	1,23	1290342	1,65	1553805	1,99	335092	35,08	263463	20,42	1458280	62.66
	AA	31841636	40,82	32017143	41,05	32064930	41,11	175507	0,55	47787	0,15	223294	0.70
	FA	11682852	14,98	11634050	14,92	11522103	14,77	-48802	-0,42	-111947	-0,96	-160749	-1.38
	SH	19506542	25,01	19531874	25,04	19701165	25,26	25332	0,13	169291	0,87	194623	1.00
	OS	12548867	16,09	11775822	15,10	11330566	14,53	-773045	-6,16	-445256	-3,78	-1218301	-9.71
	W	1464725	1,88	1750661	2,24	1827620	2,34	285936	19,52	76959	4,40	362895	24.78
		77999872	100,00	77999892	100,00	78000189	100,00						

LULC: Land use land change, ha: Hectar

Table 2. The change matrix of land cover classes for Türkiye from 1990 to 2000

Changed from	Changed to	1990-2006		2006-2018		1990-2018	
		ha	%	ha	%	ha	%
AS	AS	729817	76,4	1214171	94,1	715978	75,0
	AA	168334	17,6	44678	3,5	176240	18,4
	FA	4642	0,5	2779	0,2	5406	0,6
	SH	39067	4,1	19013	1,5	42205	4,4
	OS	10461	1,1	5112	0,4	11121	1,2
	W	2929	0,3	4589	0,4	4300	0,5
AA	AS	401010	1,3	205151	0,6	569313	1,8
	AA	29459210	92,5	31089413	97,1	28853782	90,6
	FA	196553	0,6	118151	0,4	280335	0,9
	SH	1305955	4,1	400597	1,3	1533262	4,8
	OS	354617	1,1	137402	0,4	423164	1,3
	W	124291	0,4	66429	0,2	181780	0,6
FA	AS	20586	0,2	23724	0,2	41606	0,4
	AA	369716	3,2	148781	1,3	479157	4,1
	FA	10259751	87,8	11015802	94,7	9878386	84,6
	SH	969123	8,3	422723	3,6	1211238	10,4
	OS	60496	0,5	15834	0,1	61686	0,5
	W	3180	0,0	7186	0,1	10779	0,1
SH	AS	109922	0,6	78759	0,4	172141	0,9
	AA	1305945	6,7	552007	2,8	1685164	8,6
	FA	1119570	5,7	365842	1,9	1281653	6,6
	SH	14827679	76,0	18128065	92,8	14113221	72,4
	OS	2083880	10,7	377078	1,9	2177053	11,2
	W	59546	0,3	30123	0,2	77310	0,4
OS	AS	23928	0,2	29138	0,2	47320	0,4
	AA	676083	5,4	211538	1,8	825456	6,6
	FA	51659	0,4	18396	0,2	73935	0,6
	SH	2362109	18,8	718173	6,1	2770425	22,1
	OS	9249523	73,7	10782881	91,6	8637858	68,8
	W	185565	1,5	15696	0,1	193873	1,5
W	AS	5078	0,3	2860	0,2	7445	0,5
	AA	37854	2,6	18442	1,1	45060	3,1
	FA	1875	0,1	1148	0,1	2404	0,2
	SH	27930	1,9	12479	0,7	30699	2,1
	OS	16842	1,1	12162	0,7	19568	1,3
	W	1375146	93,9	1703570	97,3	1359549	92,8

Table 3. The change matrix of land cover classes for Türkiye from 1990 to 2000

	1990-2006 (ha)						2006-2018 (ha)						1990-2018 (ha)					
Province	**AS**	**AA**	**FA**	**SH**	**OS**	**W**	**AS**	**AA**	**FA**	**SH**	**OS**	**W**	**AS**	**AA**	**FA**	**SH**	**OS**	**W**
Adana	10.284	-15.864	-9.133	14.675	-8.905	8.943	7.888	-22.720	183	13.274	-2.554	3.929	18.172	-38.584	-8.950	27.949	-11.459	12.872
Adıyaman	950	-4.236	-4.324	-22.824	-5.559	35.993	2.359	317	629	-2.334	-860	-111	3.309	-3.919	-3.695	-25.158	-6.419	35.882
A.Karahisar	4.432	2.639	-3.517	24.311	-25.813	-2.052	3.009	1.885	2.009	-8.296	948	445	7.441	4.524	-1.508	16.015	-24.865	-1.607
Ağrı	2.678	23.645	-113	8.492	-39.089	4.388	3.971	6.420	0	-6.214	-4.666	517	6.649	30.065	-113	2.278	-43.755	4.905
Aksaray	7.913	-6.463	-590	-8.631	-64.688	72.459	1.143	5.354	135	-1.909	-6.462	1.739	9.056	-1.109	-455	-10.540	-71.150	74.198
Amasya	-1.913	5.994	6.430	22.817	-33.738	410	929	451	964	5.724	-8.385	317	-984	6.445	7.394	28.541	-42.123	727
Ankara	28.033	-34.443	2.601	27.782	-39.431	15.458	17.618	-11.524	303	8.743	-17.846	2.706	45.651	-45.967	2.904	36.525	-57.277	18.164
Antalya	15.274	-7.148	-14.684	83.421	-78.661	1.798	6.896	-1.734	-4.585	-573	-2.001	1.997	22.170	-8.882	-19.269	82.848	-80.662	3.795
Ardahan	-956	9.733	200	-280	-19.357	10.660	1.232	10.454	253	-5.327	-2.175	-4.413	276	20.187	453	-5.607	-21.532	6.247
Artvin	358	997	-11.606	8.071	2.744	-564	589	-2.485	-315	3.144	-3.642	2.730	947	-1.488	-11.921	11.215	-898	2.166
Aydın	5.813	9.815	-6.458	-2.356	-6.911	97	2.794	2.378	-5.753	2.591	-2.661	651	8.607	12.193	-12.211	235	-9.572	748
Balıkesir	10.414	30.123	32.883	-60.865	-13.029	474	7.504	-3.068	-5.109	-1.155	231	1.597	17.918	27.055	27.774	-62.020	-12.798	2.071
Bartın	-779	-2.541	1.870	1.449	17	-16	355	-883	399	115	-1	15	-424	-3.424	2.269	1.564	16	-1
Batman	1.238	38.813	-915	-315	-38.490	-331	1.201	803	1.145	22.517	-25.676	10	2.439	39.616	230	22.202	-64.166	-321
Bayburt	-161	-363	-1.346	850	811	209	200	-719	83	33.673	-33.630	393	39	-1.082	-1.263	34.523	-32.819	602
Bilecik	3.231	17.783	-20.361	213	-1.070	204	-313	6.280	-899	-1.003	-4.325	260	2.918	24.063	-21.260	-790	-5.395	464
Bingöl	-909	-76.801	-33.965	106.542	1.574	3.559	1.304	-1.427	4.095	-4.977	63	942	395	-78.228	-29.870	101.565	1.637	4.501
Bitlis	297	7.252	-1.799	12.718	-18.705	237	1.336	1.099	-12.520	17.987	-7.715	-187	1.633	8.351	-14.319	30.705	-26.420	50
Bolu	2.617	7.469	-14.561	11.160	-6.871	186	2.006	-1.411	-109	-1.777	61	1.230	4.623	6.058	-14.670	9.383	-6.810	1.416
Burdur	1.243	3.991	-625	64.241	-73.050	4.200	2.120	1.235	-3.938	2.475	-2.599	707	3.363	5.226	-4.563	66.716	-75.649	4.907
Bursa	16.245	-6.546	25.899	-34.968	-628	-2	7.664	2.027	-8.539	-2.606	-188	1.642	23.909	-4.519	17.360	-37.574	-816	1.640
Çanakkale	4.367	30.428	47.836	-78.152	-6.768	2.289	1.067	1.699	-7.187	2.997	-9	1.433	5.434	32.127	40.649	-75.155	-6.777	3.722
Çankırı	634	-15.313	5.179	13.010	-3.479	-31	1.788	-976	809	6.551	-8.462	290	2.422	-16.289	5.988	19.561	-11.941	259
Çorum	-4.996	29.187	16.914	10.869	-52.220	246	951	451	579	-2.703	-6.780	7.502	-4.045	29.638	17.493	8.166	-59.000	7.748
Denizli	4.596	32.322	5.640	13.676	-57.937	1.703	3.142	1.134	-1.396	2.011	-4.576	-315	7.738	33.456	4.244	15.687	-62.513	1.388
Diyarbakır	4.729	-9.167	-2.376	-3.372	4.011	6.175	6.881	5.053	209	-12.161	-514	532	11.610	-4.114	-2.167	-15.533	3.497	6.707
Düzce	3.745	30.739	-28.762	-5.874	-484	636	1.518	-1.727	-788	865	1	131	5.263	29.012	-29.550	-5.009	-483	767
Edirne	219	3.710	6.379	-7.474	-2.155	-679	1.911	1.075	607	-4.629	-137	1.173	2.130	4.785	6.986	-12.103	-2.292	494
Elazığ	-321	-18.698	-9.259	57.083	-30.674	1.869	2.555	6.430	992	955	-10.365	-567	2.234	-12.268	-8.267	58.038	-41.039	1.302
Erzincan	-679	-7.690	-8.292	14.411	-117	2.367	2.255	-1.966	-973	13.240	-12.391	-165	1.576	-9.656	-9.265	27.651	-12.508	2.202
Erzurum	-3.037	-448	-11.076	89.668	-79.191	4.084	3.558	-3.877	-2.998	3.420	-954	851	521	-4.325	-14.074	93.088	-80.145	4.935
Eskişehir	4.425	2.428	-246	25.652	-33.028	769	3.518	167	-1.454	7.666	-10.609	712	7.943	2.595	-1.700	33.318	-43.637	1.481
Gaziantep	6.534	-38.282	1.918	12.597	14.836	2.397	10.449	-25.537	1.183	10.733	2.925	268	16.983	-63.819	3.101	23.330	17.761	2.665
Giresun	1.348	29.361	-29.045	-7.271	3.372	2.235	2.779	-2.252	-117	4.643	-5.408	355	4.127	27.109	-29.162	-2.628	-2.036	2.590
Gümüşhane	407	-16.075	-1.625	23.208	-6.300	385	944	-3.457	10.027	-6.438	-2.009	933	1.351	-19.532	8.402	16.770	-8.309	1.318
Hakkari	373	3.660	-58.960	-157.456	212.641	-256	1.294	4.577	3.764	18.930	-27.906	-650	1.667	8.237	-55.196	-138.526	184.735	-906
Hatay	7.964	-4.549	3.879	-6.493	-1.703	906	1.712	1.653	-6.266	3.729	-1.220	420	9.676	-2.896	-2.387	-2.764	-2.923	1.326
Iğdır	2.590	3.554	35	12.256	-17.850	-585	1.118	3.370	350	-2.408	-1.637	-779	3.708	6.924	385	9.848	-19.487	-1.364
Isparta	2.568	575	-3.474	71.300	-71.967	998	2.242	799	1.543	-2.685	-2.351	452	4.810	1.374	-1.931	68.615	-74.318	1.450
İstanbul	37.648	-15.100	-3.519	-20.349	-210	1.530	14.164	-4.247	-1.075	-8.850	37	-29	51.812	-19.347	-4.594	-29.199	-173	1.501
İzmir	27.203	-22.560	-4.965	16.919	-18.888	2.291	5.851	-2.245	-12.741	10.382	-2.275	1.028	33.054	-24.805	-17.706	27.301	-21.163	3.319
K.Maraş	7.435	-102.323	7.269	26.810	53.081	7.728	5.396	-5.111	7.716	-1.008	-9.533	2.540	12.831	-107.434	14.985	25.802	43.548	10.268
Karabük	-783	-4.604	9.997	-1.032	-4.251	673	889	-2.965	653	1.389	-50	84	106	-7.569	10.650	357	-4.301	757

Karaman	1.333	21.642	15.743	-1.823	-35.205	-1.690	865	1.641	4.719	7.792	-22.449	7.432	2.198	23.283	20.462	5.969	-57.654	5.742
Kars	2.435	-9.085	-2.147	14.764	-6.624	659	3.850	859	-555	-5.300	935	255	6.285	-8.226	-2.702	9.464	-5.689	914
Kastamonu	1.415	7.146	12.773	-16.670	-5.398	734	1.499	8.095	2.568	-8.907	-3.618	363	2.914	15.241	15.341	-25.577	-9.016	1.097
Kayseri	5.621	-3.022	-658	-20.543	-2.712	21.314	5.996	10.415	-825	-17.756	840	1.330	11.617	7.393	-1.483	-38.299	-1.872	22.644
Kırıkkale	-1.246	1.588	7.949	5.335	-14.276	650	1.465	-1.825	132	3.578	-3.479	129	219	-237	8.081	8.913	-17.755	779
Kırklareli	1.929	141	15.660	-15.009	-4.155	1.434	714	146	7.399	-9.746	-107	1.594	2.643	287	23.059	-24.755	-4.262	3.028
Kırşehir	2.266	-4.240	-109	-3.767	8.763	-2.913	718	-395	111	-700	-1.821	2.087	2.984	-4.635	2	-4.467	6.942	-826
Kilis	490	-15.397	743	12.783	1.209	172	409	-218	238	156	-568	-18	899	-15.615	981	12.939	641	154
Kocaeli	12.658	6.951	-15.291	-4.949	31	600	3.579	3.761	-8.974	1.410	-65	289	16.237	10.712	-24.265	-3.539	-34	889
Konya	10.483	-14.256	2.645	56.842	-89.465	33.751	9.592	9.845	8.239	-44.194	19.100	-2.582	20.075	-4.411	10.884	12.648	-70.365	31.169
Kütahya	3.198	23.741	13.210	-13.135	-27.276	262	3.436	18.480	-1.812	-5.748	-14.941	585	6.634	42.221	11.398	-18.883	-42.217	847
Malatya	2.989	-20.685	-1.759	40.804	-22.229	880	2.088	2.521	-219	-5.704	719	595	5.077	-18.164	-1.978	35.100	-21.510	1.475
Manisa	8.793	1.513	-5.350	22.193	-27.481	332	3.773	536	-14.054	8.410	497	838	12.566	2.049	-19.404	30.603	-26.984	1.170
Mardin	2.776	33.042	869	-9.848	-27.037	200	3.498	-8.611	-74	-19.215	24.573	-166	6.274	24.431	795	-29.063	-2.464	34
Mersin	7.492	100.390	50.801	-5.298	-152.200	-1.185	8.571	2.177	-44.160	50.486	-18.314	1.240	16.063	102.567	6.641	45.188	-170.514	55
Muğla	10.280	-8.397	9.388	25.854	-37.894	769	2.980	-6.255	-8.841	16.257	-5.217	1.076	13.260	-14.652	547	42.111	-43.111	1.845
Muş	-795	22.554	-3.221	22.065	-38.521	-2.082	2.711	-3.557	-2.936	4.949	-9.764	8.597	1.916	18.997	-6.157	27.014	-48.285	6.515
Nevşehir	742	-393	0	-1.871	1.311	211	2.636	-4.669	0	-1.458	2.374	1.117	3.378	-5.062	0	-3.329	3.685	1.328
Niğde	1.184	2.103	1.535	12.363	-17.339	154	2.937	6.962	-161	-19.858	10.021	99	4.121	9.065	1.374	-7.495	-7.318	253
Ordu	3.119	36.140	-24.480	-14.842	64	-1	602	14.166	-12.709	-2.053	-283	277	3.721	50.306	-37.189	-16.895	-219	276
Osmaniye	2.660	-11.001	8.182	317	-655	497	2.610	-2.157	-2.776	2.586	-315	52	5.270	-13.158	5.406	2.903	-970	549
Rize	1.022	1.760	-23.366	18.080	3.315	-811	159	1.476	-1.690	2.887	-2.728	-104	1.181	3.236	-25.056	20.967	587	-915
Sakarya	5.108	50.393	-40.580	-15.156	-169	404	5.699	-6.979	1.061	-235	-425	879	10.807	43.414	-39.519	-15.391	-594	1.283
Samsun	2.508	17.710	14.041	-11.459	-26.252	3.452	1.551	12.620	-8.315	-3.443	-3.389	976	4.059	30.330	5.726	-14.902	-29.641	4.428
Siirt	1.052	21.943	-5.089	55.080	-73.135	149	1.506	6.491	-833	-6.045	-2.063	944	2.558	28.434	-5.922	49.035	-75.198	1.093
Sinop	804	3.052	24.247	-4.063	-25.604	1.564	1.483	-4.057	2.211	1.795	-3.974	2.542	2.287	-1.005	26.458	-2.268	-29.578	4.106
Sivas	4.545	-60.051	28	-54.562	103.328	6.712	5.941	4.591	2.664	26.774	-40.746	776	10.486	-55.460	2.692	-27.788	62.582	7.488
Şanlıurfa	6.954	14.586	-132	-256.145	211.217	23.528	10.793	12.404	863	6.878	-34.457	3.520	17.747	26.990	731	-249.267	176.760	27.048
Şırnak	-390	4.743	-29.011	16.393	8.206	59	2.947	2.631	2.121	-6.294	-1.478	91	2.557	7.374	-26.890	10.099	6.728	150
Tekirdağ	12.646	-9.637	13.112	-16.012	-671	562	3.183	1.904	3.801	-11.269	-107	2.488	15.829	-7.733	16.913	-27.281	-778	3.050
Tokat	-109	3.423	3.871	-2.618	-5.126	559	4.916	8.895	-2.100	-6.634	-5.155	78	4.807	12.318	1.771	-9.252	-10.281	637
Trabzon	2.128	-51.553	23.925	29.312	-2.133	-1.679	1.419	-426	-731	1.425	-1.516	-171	3.547	-51.979	23.194	30.737	-3.649	-1.850
Tunceli	247	-2.683	-6.562	17.647	-9.519	870	-21	-5.726	3.755	34.382	-34.526	2.136	226	-8.409	-2.807	52.029	-44.045	3.006
Uşak	-868	34.381	-4.337	9.602	-39.874	1.096	2.415	-5.066	1.731	1.259	-487	148	1.547	29.315	-2.606	10.861	-40.361	1.244
Van	7.095	42.800	898	-225.908	177.558	-2.442	4.101	-10.733	-87	59.669	-53.508	643	11.196	32.067	811	-166.239	124.050	-1.799
Yalova	1.555	-1.113	2.072	-2.134	-400	20	956	338	-2.634	1.137	0	203	2.511	-775	-562	-997	-400	223
Yozgat	1.194	32.422	-4.313	-4.622	-27.859	3.178	3.245	13.065	-354	-8.675	-10.516	3.235	4.439	45.487	-4.667	-13.297	-38.375	6.413
Zonguldak	-3.492	-12.148	6.578	9.843	-708	-73	854	-338	-588	-6	7	71	-2.638	-12.486	5.990	9.837	-701	-2

Table 4. Province-level status of the land cover change matrix for terms of 1990-2006, 2006-2018 and 1990-2018

	From AS (ha)					From AA (ha)					From FA (ha)					From SH (ha)					From OS (ha)					From W (ha)					No Change (ha)
	to AA	to FA	to SH	to OS	to W	to AS	to FA	to SH	to OS	to W	to AS	to AA	to SH	to OS	to W	to AS	to AA	to FA	to OS	to W	to AS	to AA	to FA	to SH	to W	to AS	to AA	to FA	to SH	to OS	
Adana	3126	228	220	44	181	17913	13342	25144	3465	9572	1115	10205	51173	708	1449	2117	11381	40245	14920	844	743	5177	1723	20564	2602	83	83	83	83	213	1144729
Adıyaman	1497	2	102	70	46	4041	587	14242	8282	23825	13	986	5565	326	1	746	33682	2501	32229	2784	225	10749	106	26863	9392	1	144	0	12	9	556073
Afyon.	2879	19	512	116	0	7166	765	10982	2020	1232	169	763	15075	132	2	3105	14302	13401	16047	460	507	4366	448	35390	3206	20	4379	0	1371	737	1262035
Ağrı	1036	0	215	110	80	5861	0	21939	4892	1618	0	0	113	0	0	874	38813	0	37655	3983	1286	23953	0	60508	892	69	571	0	819	213	903800
Aksaray	2106	0	551	156	42	7930	21	11813	3379	503	0	27	816	28	0	3330	15543	245	12996	1312	500	3958	150	9103	75416	151	903	0	603	1418	613089
Amasya	3108	38	435	114	9	1778	2099	10019	1953	497	134	3868	12807	515	32	531	9856	19842	2615	216	277	5921	2765	38337	44	0	38	6	3	24	445589
Ankara	6815	37	2246	926	128	44576	986	46118	25061	3785	109	1830	14388	123	6	8685	34673	16916	37167	905	2394	30198	1413	71474	15172	39	1043	8	645	97	2198418
Antalya	5144	257	583	137	26	17406	11164	28257	8111	2579	2379	11515	89369	2793	547	6672	25665	71024	30417	586	1742	15958	4836	98348	1272	118	353	53	655	36	1580739
Ardahan	2000	0	646	48	20	2038	280	16898	1439	407	79	280	1757	105	66	629	34074	2364	8725	5879	242	4870	93	26632	13	2	17	0	124	0	382635
Artvin	455	90	113	175	95	790	5569	12411	1512	823	371	5844	20518	914	178	315	11580	9411	23774	846	71	1357	644	24082	1148	328	378	181	8	29	614999
Aydın	5137	45	931	0	11	11039	2410	16500	342	626	199	14284	24265	180	194	3212	20841	23554	977	594	221	2096	892	7689	204	60	752	10	28	31	674300
Balıkesir	3519	136	699	53	142	15453	5425	24119	316	2237	1496	11251	31612	40	390	5307	56277	64585	580	792	181	2185	2403	8993	29	30	1373	14	98	4	1218154
Bartın	2065	22	1	0	3	1268	3487	2625	51	72	320	1773	959	2	31	33	175	1817	0	5	22	2	8	6	4	24	64	20	3	5	218061
Batman	852	0	19	19	1	2303	72	4016	2676	1249	0	314	2401	373	0	193	16918	2818	18288	47	790	31177	428	53944	216	44	671	0	86	1033	308000
Bayburt	566	1	144	30	9	534	88	7680	5619	556	0	190	1458	292	0	142	6114	483	15398	46	113	6511	105	47422	7	0	14	0	2	0	281080
Bilecik	967	40	244	4	0	2019	3758	6545	299	313	670	12642	19936	33	47	1424	21997	8191	455	116	60	1384	79	4663	0	0	7	0	5	0	332003
Bingöl	1227	75	1036	201	3	1347	3192	73069	13179	2144	43	1848	38455	1844	374	957	7164	8349	43084	650	527	4389	1067	48622	2254	63	75	11	587	188	545624
Bitlis	708	3	85	22	4	1859	749	7014	3680	94	45	1524	16956	2080	24	312	12651	4415	11186	1192	222	6170	1136	36329	17	17	694	7	77	486	719666
Bolu	2205	20	150	64	0	4339	3157	9374	1204	196	727	8902	28426	218	90	1986	11838	20262	1123	1370	9	1234	192	7984	0	1	149	62	28	0	726139
Burdur	1158	9	150	101	50	2418	732	9447	1829	4629	219	1258	20576	92	55	1085	5975	16430	1049	379	1109	15294	464	60539	1562	0	596	2	922	248	569022
Bursa	2359	119	222	0	17	20008	5511	16368	184	1363	2084	12661	17294	31	374	4388	22916	43972	246	606	79	466	190	560	6	67	513	12	110	24	928944
Çanakkale	3350	62	490	15	57	7296	3603	10729	331	2788	374	6841	28162	333	370	1569	45886	72261	1410	717	38	615	784	7198	286	131	182	19	109	55	785818
Çankırı	672	5	247	193	4	2529	503	16750	6404	566	2	264	4603	105	49	736	6844	10094	4323	102	273	2501	409	19641	142	3	182	0	419	0	676430
Çorum	7094	83	777	273	94	2287	6077	29342	7252	5317	200	7343	16253	244	150	1230	39600	32377	18378	1507	552	25814	3145	54839	799	7	62	1	47	2	981323
Denizli	2763	23	254	26	1	7083	3106	8861	729	1237	94	5592	35917	294	41	2723	25448	40284	1909	946	669	19958	2729	41366	1181	236	711	40	599	432	1008860
Diyarbakır	4777	41	1039	487	79	12758	411	40094	11328	5478	6	592	7648	239	35	4257	39553	5632	89317	2638	928	19515	269	76625	1221	84	1518	0	458	684	1187661
Düzce	1128	24	3	0	2	5351	855	354	0	363	386	31386	2001	1	5	475	3279	3340	111	202	208	134	8	40	205	0	8	2	0	0	199283
Edirne	3289	20	479	2	56	5060	1277	8950	31	2191	143	2576	8399	1	92	748	14161	16140	165	540	16	176	738	1534	30	9	2092	22	289	3	545659
Elazığ	2833	11	851	253	9	3462	598	37616	8847	1808	70	310	9788	158	255	747	16260	1641	25076	443	1878	20046	63	53777	516	34	614	1	173	907	744788
Erzincan	1486	2	670	121	25	1331	388	22877	8663	551	3	471	10528	789	4	1092	16877	1975	42460	1583	1453	5211	163	57419	368	1	109	2	144	73	1004366
Erzurum	4894	1	1245	390	49	3546	947	91067	19264	5848	132	2009	17051	1894	6	2595	60966	5378	101219	1213	824	46451	692	154566	588	3	2027	0	530	209	1975502
Eskişehir	1672	14	966	155	5	6039	1357	21332	4881	1135	27	1758	19580	95	9	2952	24135	18202	23862	980	1642	9311	184	61243	273	95	463	12	328	23	1192322
Gaziantep	3068	383	508	228	12	17351	2401	52907	10120	2638	70	345	4204	172	0	3590	15421	5094	15969	177	144	2616	14	5906	91	27	147	0	37	43	536645
Giresun	158	0	13	0	27	3433	6368	14155	1664	1565	300	36240	6924	491	40	189	16270	8188	6455	485	183	1446	253	7860	904	220	180	24	7	0	588322
Gümüşhane	287	2	79	36	0	746	3859	23283	5007	730	209	1962	8157	641	183	360	7199	14785	23127	281	440	4623	905	30999	153	0	22	3	4	0	538858
Hakkari	365	0	43	83	0	1238	1023	7176	5593	446	5	3334	31528	25269	0	713	16315	3679	190901	576	201	3224	239	34854	45	1	469	0	67	1436	378881
Hatay	2158	112	154	78	162	10792	3295	8025	539	897	356	2798	19618	159	39	925	13548	16445	3798	36	230	2101	756	4167	256	36	19	0	5	4	459582
Iğdır	497	0	0	43	0	2949	336	3311	2372	143	0	0	0	0	0	149	5711	0	2258	267	1012	9560	40	13547	182	138	267	9	1375	176	320928
Isparta	1604	132	266	18	2	4104	1200	8108	613	1830	306	1046	21005	272	66	1763	8318	18391	15463	433	629	5891	1026	82931	240	30	370	15	673	33	717943
İstanbul	3064	1241	3142	174	411	30807	2865	4644	10	724	12328	8390	13245	35	504	15860	7942	25476	125	1159	126	177	53	194	31	723	130	273	138	64	412306
İzmir	1590	118	962	44	76	23977	5361	22925	903	2695	1560	8589	42618	387	90	8994	19551	29507	3237	873	997	1054	539	22739	550	316	272	13	219	145	988592
K.maraş	1326	15	298	100	72	12616	14561	83302	18879	6667	102	3255	23460	717	648	1065	16962	28045	72989	854	856	5961	539	38648	3135	3	1087	7	9	2	1115997
Karabük	713	24	273	34	3	573	4462	8236	257	46	206	1448	6598	35	120	93	3195	14409	415	25	234	536	121	3382	769	47	113	41	5	0	368152
Karaman	974	8	362	266	64	1335	1087	8169	4749	3574	132	533	3212	373	987	2118	14313	22816	39503	1360	265	26362	1788	73452	889	22	15	0	884	211	657881
Kars	1976	3	706	89	46	6993	96	29646	11320	508	0	102	3293	114	0	1817	31908	671	14813	603	285	6110	37	25537	145	10	230	0	87	64	882296
Kastamonu	557	26	112	1	0	1794	9921	10929	775	401	705	20339	11587	420	78	767	16595	38003	1835	117	320	1564	492	9108	563	24	6	28	4	0	1179042
Kayseri	1988	0	576	363	85	10972	436	20514	10656	6950	111	170	3170	217	68	2471	39104	1623	43679	6621	1032	15340	194	29704	11637	43	319	0	1235	1120	1486312
Kırıkkale	2338	0	349	160	13	2133	458	9537	5167	788	0	35	352	91	0	484	8063	6982	1627	91	456	7329	1119	15886	38	6	81	0	36	28	415636
Kırklareli	1532	19	187	14	52	3172	1104	4044	11	2159	75	1905	6253	10	165	888	7293	25212	1217	720	294	31	5117	73	5	18	16	15	18	6	584693
Kırşehir	1621	3	560	168	4	4019	419	15560	6112	1360	0	326	3049	171	0	995	13874	2843	12007	400	305	6102	21	5875	49	21	912	262	608	836	579274
Kilis	291	0	16	0	0	1205	410	15310	940	154	0	20	430	0	0	1	2015	1019	755	0	0	77	2	975	0	0	0	0	0	0	117168

Kocaeli	2134	130	403	0	143	12390	2641	1692	1	566	1530	14797	13290	0	289	5034	11020	2841	0	54	0	2	5	17	11	93	49	24	8	0	270478
Konya	8373	21	8107	960	115	21087	2067	58598	13739	1845	122	1162	12710	195	15	12839	59917	21373	131773	7586	2538	18465	1620	157180	41526	1065	5008	7	9541	4297	3477671
Kütahya	3549	148	1393	887	19	4850	3548	14846	752	818	1616	5770	15828	146	105	5007	40218	30439	881	351	1134	17123	728	25886	16	23	375	0	60	4	987332
Malatya	357	0	402	122	33	3166	598	34933	25863	951	4	823	5105	310	0	1601	21326	3507	70062	230	1220	24775	159	91321	499	0	66	0	65	107	940509
Manisa	2550	221	682	120	184	11173	6466	22409	778	874	2496	6098	42235	195	122	2133	26624	24494	1335	276	521	8099	557	20096	164	0	378	4	43	25	1152428
Mardin	1627	0	148	83	0	6014	15	19566	10017	147	0	6	91	1	0	1196	44736	860	68310	0	920	13750	18	66192	0	2	71	0	35	5	643972
Mersin	2779	101	358	171	192	15605	8270	28229	4692	1388	905	13819	84654	1008	176	2342	59784	90449	30729	164	733	83434	8351	114838	266	79	935	32	577	508	1045355
Muğla	3974	436	1068	18	58	10414	9440	21546	794	1414	1780	5514	75284	1057	246	5839	13947	68037	4203	1235	550	5030	6402	36959	325	231	491	113	515	83	988183
Muş	2597	0	514	177	266	4106	224	22829	6548	6780	17	714	8971	317	6	901	29614	3020	30153	1419	332	25090	624	59468	666	114	1469	0	339	700	657110
Nevşehir	2346	0	293	140	26	5097	0	6141	4932	1179	0	0	0	0	0	579	6711	0	4334	84	502	3179	0	1901	140	5	51	0	44	1	510932
Niğde	1179	0	417	258	2	2684	99	7959	5465	247	30	53	776	151	0	1755	14900	2220	25448	23	1503	9323	65	27693	59	5	64	0	6	3	621131
Ordu	1312	54	83	34	170	4853	6712	6512	73	279	374	43705	5377	39	48	36	23361	5541	93	91	12	176	40	255	0	99	181	7	0	25	486420
Osmaniye	686	3	93	3	1	4797	7623	5853	249	573	297	2957	9721	30	130	756	2121	10723	791	23	153	74	140	1632	44	53	99	52	18	0	282049
Rize	299	1	14	0	6	888	4387	5580	0	121	140	13182	16712	196	60	25	191	717	4873	0	0	2	13	4467	0	448	538	116	0	0	330123
Sakarya	2319	244	46	0	31	11357	6433	3258	291	1367	1081	47980	6161	8	179	679	14888	9192	0	183	237	156	9	67	452	93	777	12	19	28	374564
Samsun	4968	66	66	8	52	7160	10900	9687	353	3480	372	28631	5350	332	413	1372	15786	27633	277	1642	124	11711	2108	16642	596	191	814	117	63	570	820856
Siirt	144	0	52	49	0	1867	179	4171	1788	320	9	1373	8203	585	0	356	16536	3272	14112	842	571	18565	795	71444	553	0	141	2	283	196	425559
Sinop	203	19	14	30	4	1543	9182	12573	734	2386	367	4951	6341	50	426	255	11324	28195	234	925	346	8872	1100	19730	578	46	63	97	7	0	461504
Sivas	1246	31	192	313	38	7049	2849	83003	44395	5977	137	1036	15229	1224	5	2967	53960	16450	128259	1831	2135	30686	992	76627	1248	18	885	1	628	79	2337524
Şanlıurfa	5669	24	652	454	270	14730	45	28472	11700	15261	1	290	516	3	85	9683	86201	1524	184136	5750	379	4820	33	8347	5973	22	216	0	35	19	1536626
Şırnak	1538	0	409	237	3	3072	270	12047	5819	154	69	980	27652	8376	4	949	13555	8400	91018	137	617	12487	1523	83839	287	37	167	0	203	34	433127
Tekirdağ	1026	10	509	1	19	15181	1061	2934	16	3075	197	1424	2479	2	53	1998	11491	19984	77	175	0	353	9	515	0	18	240	4	7	3	556053
Tokat	1510	70	131	83	7	4619	5100	11857	2340	709	395	11037	15952	493	111	917	18384	23003	3450	148	533	5733	1543	8657	185	144	279	43	53	4	885940
Trabzon	105	2	0	0	20	2840	37080	21741	0	93	194	7330	8748	4	36	66	1069	2054	433	0	207	105	11	3763	0	367	1166	359	107	0	375391
Tunceli	619	0	43	11	66	249	1619	18188	4710	1431	124	1766	15347	1994	213	402	9321	11485	19063	944	177	5995	3526	59611	561	13	87	7	55	47	601929
Uşak	3299	33	137	35	0	3118	1401	5770	1204	383	380	2811	10391	65	17	1183	18214	9243	287	823	370	16862	381	24313	26	0	5	0	0	0	454804
Van	2027	9	255	321	98	10856	75	24306	26488	4022	0	116	594	11	0	1132	46950	1369	288241	2178	1427	45016	31	145816	227	491	3705	48	2623	1457	1481570
Yalova	178	4	105	0	143	2043	372	543	0	54	540	1189	1694	0	135	184	862	2226	0	86	0	0	393	7	0	174	8	1	12	0	68875
Yozgat	3775	15	583	401	42	5498	1470	14638	6320	5547	47	4194	11324	333	1	1540	42760	8597	7147	522	2170	28169	1150	20505	584	0	62	0	219	2	1200865
Zonguldak	4858	251	105	1	15	1970	8031	11048	193	462	308	3505	1951	5	40	6	352	3468	0	27	99	153	28	500	140	209	350	21	86	20	296032

When analysing Tables 3 and 4, which examine changes in land use on a province basis, it was found that Istanbul (51812 ha), Ankara (45651 ha) and İzmir (33054 ha) experienced the highest increases in AS between 1990-2018. Conversely, Çorum (4045 ha), Zonguldak (2638 ha) and Amasya (984 ha) had the highest decreases. The regions that experienced the most significant increase in AA are Mersin (102567 ha), Ordu (50306 ha), and Yozgat (45487 ha). Conversely, the regions that saw the most significant decrease in AA are K.Maraş (107434 ha), Bingöl (78224 ha), and Gaziantep (63819 ha). Regarding FA, the regions with the highest increases are Çanakkale (40649 ha), Sinop (26548 ha), and Balıkesir (27774 ha). In comparison, the areas with the most substantial decreases are Hakkari (55196 ha), Sakarya (39519 ha), and Ordu (37189 ha). The three provinces that saw the most significant increase in SH are Bingöl (101565 hectares), Erzurum (93088 hectares), and Antalya (82848 hectares), respectively. On the other hand, Şanlıurfa (249267 hectares), Van (166239 hectares), and Hakkari (138526 hectares) experienced the highest decline in SH. Hakkari (184735 hectares), Şanlıurfa (176760 hectares), and Van (124050 hectares) showed the most significant increase in OS. The provinces with the most significant decrease in OS are Mersin (170514 hectares), Antalya (80662 hectares), and Erzurum (80145 hectares).

When examining changes in land use, it is evident that the provinces with the highest rate of transition from AA to AS between 1990-2018 are Ankara (44576 ha), Istanbul (30807 ha) and Izmir (23977 ha). Trabzon (37080 ha), K.Maraş (14561 ha) and Adana (13342 ha) ranked highest in transitioning from AA to FA. The top three cities with the most significant number of changes from AA to SH are Erzurum (91067 ha), K.Maraş (83302 ha) and Sivas (83003 ha).

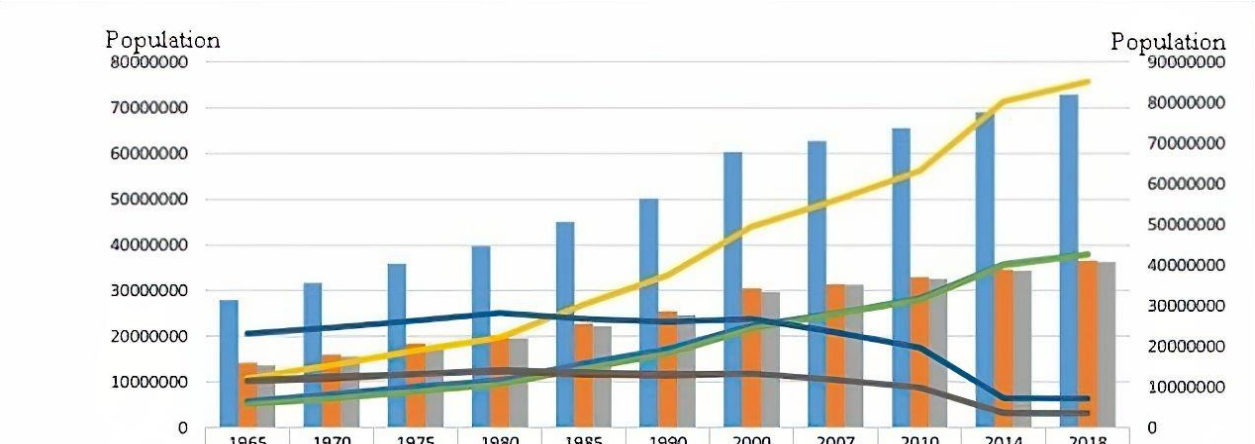
During this period, Istanbul (12328 ha), Manisa (2496 ha) and Antalya (2379 ha) experienced the highest number of shifts from FA to AS. The provinces with the top three highest numbers of transitions from FA to AA were Sakarya (47980 ha), Ordu (43705 ha), and Giresun (36240 ha). Additionally, the provinces with the top three highest numbers of areas converted from FA to SH were Antalya (89369 ha), Mersin (84654 ha), and Muğla (75284 ha).

When examining the shift from SH to alternative uses during this timeframe, Istanbul (15860 ha), Konya (12839 ha), and Sivas (9683 ha) were the top three provinces in terms of AS conversion. The top three provinces with the most significant number of areas transformed to Aa are Şanlıurfa (86201 ha), Erzurum (60966 ha), and Konya (59917 ha). When examining the areas that have been converted to FA, it is apparent that the top three provinces with the highest rate of conversion are Mersin (90,449 ha), Çanakkale (72,261 ha), and Antalya (71,024 ha).

An analysis of the conversion of OSs reveals that the cities with the highest conversion to AS are, in descending order, Konya (2538 ha), Ankara (2394 ha), and Yozgat (2170 ha). Likewise, the three cities with the highest conversion to AA are Mersin (83434 ha), Erzurum (46451 ha), and Van (45016 ha). In terms of areas converted to FA, Mersin (8351 ha), Muğla (6402 ha), and Kırklareli (5117 ha) experienced the highest number of conversions. The provinces with the most transition to SH are Konya (157180 ha), Erzurum (154566 ha), and Van (145816 ha).

Impacts of Demographic Factors on Land Cover Change

Since the proclamation of the Republic in Turkey in 1923, the resultant development has significantly impacted the country's demographic structure. According to Sağlam (2016), in the first census conducted in 1927, 75.78% of the population resided in villages, decreasing to 32.1% by the end of 2022 (MEUCC 2023). Several factors contributed to this change, including alterations to zoning law, the declaration of new provinces, and industrialization. Additionally, tourism incentives have played a significant role, especially since 1990 (Çekirge 2013; Dokuyucu 2023). Furthermore, the closure of primary schools and health centres in rural areas over the past 20 years has inreaced migration to district and provincial centres. Moreover, the arrival of more than six million asylum seekers in Turkey has placed significant strain on both the environment and the economy. Figure 3 displays the urban, rural and overall population in 1965 and later years (Turkish Statistical Institute, 2023).



	1965	1970	1975	1980	1985	1990	2000	2007	2010	2014	2018
Total	31391421	35605176	40347719	44736957	50664458	56473035	67803927	70586256	73722988	77695904	82003882
Total Male	15996964	18006986	20744730	22695362	25671975	28607047	34346735	35376533	37043182	38984302	41139980
Total Female	15394457	17598190	19602989	22041595	24992483	27865988	33457192	35209723	36679806	38711602	40863902
Urban	10805817	13691101	16869068	19645007	26865757	33326351	44006184	49747859	56222356	71286182	75666497
Urban Male	5783813	7312714	9004842	10272130	14010662	17247553	22427541	24928985	28308856	35755990	37912323
Urban Female	5022004	6378387	7864226	9372877	12855095	16078798	21578643	24818874	27913500	35530192	37754174
Rural	20585604	21914075	23478651	25091950	23798701	23146684	23797743	20838397	17500632	6409722	6337385
Rural Male	10213151	10694272	11739888	12423232	11661313	11359494	11919194	10447548	8734326	3228312	3227657
Rural Female	10372453	11219803	11738763	12668718	12137388	11787190	11878549	10390849	8766306	3181410	3109728

Figure 3. Urban and rural population of Türkiye

Figure 3 illustrates a consistent rise in the overall population from 1965 to 2018. Although the rural population decreased during this period, there was a notable increase in the population of provincial and district centres. Both male and female people have increased and reduced at very similar rates in urban and rural areas. The rise in urban population and decline in rural population notably accelerated between 1980 and 1985 and has decreased since 2014. As a result of these migrations, there have been substantial changes in land use patterns, both in rural zones and urban and suburban areas.

Correlation analyses were carried out to determine whether changes in population variables are effective in land use changes. Table 5 shows the results of the correlation analyses at the provincial level for the period 1990-2018.

Table 5. Results of Sperman Correlation analysis between land cover changes (1990-2018) and population variables

Term of 1990-2018		TPP	TFPP	TMPP	TUP	TRP	TMUP	TFUP	TMRP	TFRP	PD	NMR
Change in AS	Corre. Coef.	,652	,657	,646	,728	-,155	,245	,764	-,593	,342	-,553	,519
	Sig. (2-tailed)	**,000**	**,000**	**,000**	**,000**	,167	**,028**	**,000**	**,000**	**,002**	**,000**	**,000**
Change in AA	Corre. Coef.	-,082	-,082	-,090	-,004	,090	,167	-,003	,093	,051	-,045	-,067
	Sig. (2-tailed)	,467	,466	,425	,970	,423	,136	,982	,409	,650	,691	,551
Change in FA	Corre. Coef.	-,005	,004	-,010	,019	-,023	-,016	,042	-,019	,023	-,033	-,028
	Sig. (2-tailed)	,965	,975	,931	,863	,840	,886	,708	,864	,835	,773	,801
Change in SH	Corre. Coef.	-,105	-,100	-,105	-,128	-,054	-,111	-,144	,027	-,018	,116	-,132
	Sig. (2-tailed)	,349	,374	,352	,255	,635	,323	,199	,809	,871	,301	,240
Change in OS	Corre. Coef.	,090	,073	,103	,041	,098	-,071	,031	,067	,116	,008	,164
	Sig. (2-tailed)	,426	,516	,360	,715	,383	,531	,785	,551	,302	,943	,143
Change in W	Corre. Coef.	,191	,204	,186	,231	-,175	,045	,248	-,267	-,075	-,038	,068
	Sig. (2-tailed)	,088	,068	,097	**,038**	,117	,691	**,025**	**,016**	,505	,739	,546
from AS to AA	Corre. Coef.	,236	,258	,218	,343	-,276	,183	,395	-,577	-,014	-,391	,105
	Sig. (2-tailed)	,034	,020	,051	**,002**	,013	,103	**,000**	**,000**	,900	,000	,352
from AS to SH	Corre. Coef.	,244	,263	,239	,306	-,198	,062	,341	-,393	-,030	-,240	,084
	Sig. (2-tailed)	,028	,017	,032	**,005**	,077	,583	**,002**	**,000**	,787	,031	,457
from AS to OS	Corre. Coef.	,017	,017	,025	,058	-,167	,071	,065	-,220	-,174	,165	-,148
	Sig. (2-tailed)	,883	,878	,822	**,607**	,137	,526	**,561**	**,048**	,120	,142	,188

from AA to AS	Corre. Coef.	,601	,613	,591	,701	-,237	,225	,748	-,678	,276	-,565	,462
	Sig. (2-tailed)	,000	,000	,000	**,000**	,033	,044	**,000**	**,000**	,013	,000	,000
from SH to AS	Corre. Coef.	,463	,480	,454	,548	-,237	,205	,590	-,571	,120	-,464	,297
	Sig. (2-tailed)	,000	,000	,000	**,000**	,033	,066	**,000**	**,000**	,287	,000	,007
from OS to AS	Corre. Coef.	,142	,145	,148	,177	-,077	,132	,179	-,223	-,006	,080	-,008
	Sig. (2-tailed)	,207	,198	,189	**,115**	,495	,240	**,110**	**,045**	,960	,477	,943
from FA to AS	Corre. Coef.	,169	,180	,160	,294	-,268	,128	,319	-,353	,022	-,436	,215
	Sig. (2-tailed)	,132	,108	,155	**,008**	**,015**	,256	**,004**	**,001**	,844	**,000**	,054
from FA to AA	Corre. Coef.	,063	,067	,058	,263	-,349	,078	,274	-,401	,027	-,250	,086
	Sig. (2-tailed)	,578	,550	,604	**,018**	**,001**	,491	**,013**	**,000**	,810	**,024**	,444
from Fa to SH	Corre. Coef.	,125	,137	,116	,234	-,242	,038	,244	-,366	,021	-,203	,042
	Sig. (2-tailed)	,265	,222	,301	**,035**	**,030**	,735	**,028**	**,001**	,850	,069	,706
from FA to OS	Corre. Coef.	-,137	-,135	-,132	-,097	-,154	-,083	-,108	-,154	-,110	,287	-,243
	Sig. (2-tailed)	,221	,231	,240	,388	,171	,461	,335	,169	,328	**,009**	**,028**
from AS to FA	Corre. Coef.	,277	,293	,259	,415	-,312	,193	,451	-,551	,076	-,465	,246
	Sig. (2-tailed)	**,012**	**,008**	**,019**	**,000**	**,005**	,084	**,000**	**,000**	,501	**,000**	**,027**
from AA to FA	Corre. Coef.	,041	,045	,042	,225	-,370	-,019	,240	-,431	,045	-,195	,039
	Sig. (2-tailed)	,716	,690	,709	**,044**	**,001**	,868	**,031**	**,000**	,692	,081	,727
from SH to FA	Corre. Coef.	,177	,199	,157	,316	-,273	,103	,344	-,419	,058	-,336	,109
	Sig. (2-tailed)	,114	,075	,162	**,004**	**,014**	,360	**,002**	**,000**	,609	**,002**	,331
from OS to FA	Corre. Coef.	-,051	-,029	-,067	,018	-,157	-,001	,026	-,227	-,061	,006	-,142
	Sig. (2-tailed)	,648	,800	,553	,874	,161	,991	,820	**,041**	,587	,958	,206

According to the findings of the correlation analyses conducted, the subsequent relationships were identified between population variables and alterations in land usage across the provinces from 1990 to 2018:

A significant positive correlation was observed between AS and population variables TMUP (0.245-low), TFRP (0.342-low), TPP (0.652-modest), TFPP (0.657-modest), TMPP (0.646-modest), PD (0.519-modest), TUP (0.728-high) and TFUP (0.764-high). Conversely, TMRP (-0.593-modest) and NMR (-0.553-modest) found statistically significant negative correlations. A statistically significant positive correlation between W and population variables TUP (0.231) and TFUP (0.025) was determined at a low level. Additionally, a statistically significant negative correlation was observed between W and TMRP (-0.267-low).

Significant positive correlations were observed between the conversion of FA to AS and population variables, including TUP (0.294), TFUP (0,319) and PD (0215) at a low level. However, negative statistically significant relationships were found with TRP (-0.268) and TMRP (-0.353) at a low level and with NMR (-0.436) at a modest level. There was a statistically significant positive correlation observed between the conversion of FA to AA and population variables TUP (0.018-very low) and TFUP (0.274-low). Statistically significant negative relationships were found with TRP (-0.349) and NMR (-0.250) at a low level, as well as with TMRP (-0.401) at a modest level. A statistically significant positive relationship was discovered between FA to SH conversions and the population variables TUP (0.234-low) and TFUP (0.244-low). A negative relationship of statistical significance was observed between TRP (-0.242-low) and TMRP (-0.366-low). A low level statistically significant positive correlation of 0.287 was found between NMR, one of the population variables, and FA to OS conversions. Additionally, there was a statistically significant negative relationship with PD (-0.2423) at low level. Statistically significant positive correlations were detected between AS to FA conversions and the population variables TPP (0.277), TFPP (0.293), TMPP (0.259), and PD (0.246) at a low level, with TUP (0.415) and TFUP (0.451) at a modest level. Statistically significant negative correlations were recorded with TRP (-0.312) at a low level and TMRP (-0.551) and NMR (-0.465) at a modest level. Statistically significant positive correlations were identified between the conversion of AA to FA and the population variables TUP (0.225) and TFUP (0.240) at a low level. Furthermore, a statistically significant negative correlation was discovered with TRP (-0.312) at a low level and TMRP (-0.551) at a modest level. Statistically significant positive correlations were discovered between the conversion of SH to FA and population variables TUP (0.316) and TFUP (0.344) at a low level. On the contrary, a statistical analysis uncovered a significant and negative correlation between TRP (-0.273-low) and TMRP (-0.419-modest). Only TMRP (-0.227) displayed a statistically significant and negative association, albeit low, with conversions from OS to FA among the population variables.

All conversions from AS to AA, SH, OS, and from AA, SH and OS back to AS were found to have significant positive correlations with changes in TUP and TFUP, while they had significant negative correlations with TMRP.

DISCUSSION

Land use changes between 1990 and 2018 and how the population affects these changes were analysed in this study. As land use changes in Turkey were mainly analysed in small-scale areas, it was not possible to determine the actual

extent of the situation on a countrywide basis. In this context, the study analysed land use change nationally. The population-related causes of these changes have been examined at the level of the provinces, and a variety of results have been found.

Following the establishment of the Republic of Turkey, there was a rise in both urban and rural populations thanks to improvements in education, culture, and industry. However, since 1980, urbanization and industrialization have caused many towns to be converted into districts and villages into neighbourhoods. This transformation, in turn, has led to a continuous decrease in the rural population (Yılmaz 2015). Economic factors are prominent drivers of rural-to-urban migration. Moreover, insufficient access to education and healthcare services in rural regions, transportation challenges, natural disasters, terrorism, and employment opportunities are additional influencers (Özdemir 2012; Şen 2014). Furthermore, the influx of asylum seekers from neighbouring countries to escape from terrorism and civil war has augmented the adverse effects of population growth on natural resources and land use (Ryan et al. 2017). The investigation revealed a 1.38% (160749 ha) decline in forested areas between 1990 and 2018. By contrast, data released by the General Directorate of Forestry in Turkey demonstrates that the forested area grew by 1858690 hectares from 1990 to 2018 (GDF 2021). The discrepancy arises from the fact that the forest administration records display forests with low coverage and structurally damaged forests, as well as areas that hold legal forest status but have lost it in practice due to mining, construction, and other similar activities, as forests (TOD 2022). For instance, as of 2019, the total area of forest permits granted for various purposes in Turkey, including mining activities, wind power plants, hydroelectric power plants, geothermal power plants, nuclear and coal-fired thermal power plants, electricity transmission lines, and residential areas, among others, was 699,000 hectares (Tolunay 2021). Kuemmerle et al. (2016) reported a contrasting situation in Portugal and Southern Spain between 1990 and 2006. Despite statistical data demonstrating a forest increase, deforestation occurred during this period.

Between 1990 and 2018, forested areas in Brazil decreased by 89,846,600 hectares, Mexico by 4,644,040 hectares, and other wooded regions by 7,871,100 hectares and 1,057,800 hectares, respectively, similar to Turkey. Conversely, forest areas increased by 558,050 hectares in Romania and 577,000 hectares in Poland, while other wooded areas decreased by 298,430 hectares in Romania. In several developed countries, there was an increase in forested areas: Greece, 603,250 hectares; Spain, 4,658,930 hectares; France, 2,650,200 hectares; and Bulgaria, 540,000 hectares. On the other hand, other wooded areas decreased by 576,180 hectares, 2,688,990 hectares, 1,215,800 hectares, and 106,000 hectares in the same countries, respectively (FAO 2023). In contrast to Turkey, forest areas in the European Union increased by 7,063,000 hectares between 1990 and 2006. A European study conducted in 1990-2006 reported that forest areas decreased in many countries due to urbanisation and rural migration, while forest areas increased in the United Kingdom and Ireland, where afforestation activities were implemented. Pastures in many countries also decreased during the same period (Kuemmerle et al. 2016).

Forests have a significant place with the services and products they provide to prevent climate change and ensure the continuation of sustainable living conditions. The fact that the areas of FA decreasing on a country basis are transformed into SH and AA at the highest rate, respectively, shows that forests are structurally degraded and declining spatially. It is seen that the transformation towards AA areas is generally in urban environments (Canıberk et al. 2015; Şen et al. 2018). A study conducted in Kastamonu revealed that productive forest areas increased by 281 hectares. In comparison, degraded forest areas decreased by 355 hectares between 1970 and 2008, resulting in a total decrease of approximately 75 hectares of forest area. The study attributes the reduction of degraded forests to reduced pressure caused by migration from rural to urban areas (Kaptan et al. 2019). Large-scale agriculture in crucial areas, such as tropical forests, leads to a decline in flora and fauna and damages forest structure. This damages make it more difficult for forests to adapt to climate change (IPCC 2022).

Between 1990 and 2018, our examination of other land uses reveals striking findings. There has been a significant increase (approximately 63%, or 1,458,280 hectares) in areas designated as AS. This growth highlights the transformation of various land uses. In this period, 0.4% (41,606 ha) of FA, 0.9% (172,141 ha) of SH, 1.8% (569,313 ha) of AA, and 0.5% (7,445 ha) of WS in 1990 were converted into AS areas. When evaluating the condition of the agricultural regions amidst changes in land use preferences, the outlook appears unfavourable. The period covering 1990 to 2018 exhibits adverse effects on attaining sustainable food security and supply. During this time frame, around 10 per cent of Turkey's agricultural territories underwent conversion to other land utilizations. In a study conducted in the European Union, similarly, it is stated that while agricultural areas are abandoned in some areas due to migration, the effects, such as the establishment of new settlements, are observed in some places (Bell et al. 2010; Süreli 2017). Similarly, a study in Trabzon reported that agricultural areas surrounding settlements are under construction pressure, leading to their conversion into residential areas through changes in zoning plans (Öztürk and Erdoğan 2022). A study

conducted in Ankara and Kastamonu have indicated that the expansion of the city is placing undue pressure on natural areas (Işınkaralar et al. 2022; Işınkaralar 2023).

At a time when discussions on sustainable development are ongoing, and efforts are being made in line with the goals set in this context, the changes in land use and reduction in forested areas are hindering our efforts in combating climate change. Furthermore, converting agricultural land, which is crucial for ensuring food security, to residential and other uses goes against the development objectives established by the United Nations. On the contrary, these findings achieved across Turkey may vary on the regional level. Particularly in and around urban areas with significant migration, these rises are more noticeable. For instance, during the identical period, AS and W zones increased in Istanbul while all other land uses decreased. Another study conducted in Istanbul states that the proportion of urban areas in the province increased from 20.71% to 39.17% between 1993 and 2013, while the agricultural regions decreased from 13.25% to 2.04% (Canıberk 2015). The shift from subsistence agriculture to commercial agriculture was observed to rise with the growth of urban population, female rural population and population density. The significant contribution of women in agricultural pursuits lends credence to this finding. (Peker and Kubar 2012; Görmüş 2019). The changes mentioned above are evident not only in regional centres but also in the shape of persons who migrate back to their towns after retiring and constructing vacation homes in the uplands. The structural zone increased by 21.5%, and the road system rose by 7% in the mountainous regions of Gümüşhane, according to a study conducted between 2013-2018 (Döner 2012). According to a study in Kastamonu, 519.5 hectares of farmland and 86 hectares of woodland were converted to AS between 1999 and 2014 (Şen et al. 2018). The study conducted in two basins of Poland revealed significant decreases in tree and shrub groups, arable lands, and grasslands between 1954-2004, due to migration from rural areas. Concurrently, forest areas increased from 65.18% to 76.70% in the Jaszcze basin and from 37% to 55.5% in the Jamne basin (Bucala 2014). During a 26-year period, a study conducted in Malawi in South Africa found that forest loss transpired at an average rate of 4.3% per annum due to swift population growth and an upsurge in gross domestic product (Kapute Mzuza et al. 2019).

Although the total area of wetlands in W increased by 25% during the study period, this increase was not evenly distributed across all provinces. The construction of dams and ponds for irrigation and fire extinguishing have had a notable impact on this increase. However, the decline in wetlands poses a significant risk to achieving the sustainable development goal of providing accessible water and wastewater services and ensuring sustainable water management for all. This decline also threatens the habitats and ecosystems of wetlands. It has been identified that 7.2% (105176 ha) of W areas have been converted to other land uses. Despite being a party to the Ramsar Convention for the protection of wetlands, Turkey has witnessed the drying up of 36 large lakes (URL-1) and 60% of nearly 300 large and small lakes in the last 50 years. The major causa mortis of this drying up is the result of unplanned agricultural activities, wild irrigation and the use of the streams that feed these lakes in mines and cities (Ocak 2020; Kantarcı 2008).

Population growth, together with economic and industrial development, has significant effects on land use and change according to several studies (Wu et al. 2013; Twisa et al. 2019). Our study shows that the effects of population growth on changes in land use are particularly noticeable in large cities with a population of over one million. The impact of population on land-use change is more apparent in the analysis of metropolitan cities with a population exceeding one million. Thirty major cities accounted for 76% of the total increase in agricultural land (456670 ha). However, despite the country-wide increase of 223,294 hectares in FAs, a total decrease of 16,073 hectares was observed in metropolitan cities. In the field of agriculture, 43% (70286 ha) of the decline took place in metropolitan cities, with the remaining 90463 ha in the other 51 provinces. In the SHs, the total increased overall. However, metropolitan cities saw a decrease of 145,494 hectares, while other cities experienced an increase of 340,119 hectares. Of the decline in OSs, 32% (389257 hectares) took place in metropolitan cities while the remainder of 829044 hectares declined in other cities. A study conducted in Ankara, which is the capital of Turkey and a province receiving migration, shows that there has been an increase in settlements and a decrease in agricultural areas, while forest areas have increased between the years 2000 and 2012. Our findings are in line with these results (Bayar and Karabacak 2017). The forest increases observed in this study are primarily attributed to afforestation. In a separate investigation carried out in Denizli, the decline observed in areas characterized by stony terrain and grazing land is consistent with our own findings (Ayyüce et al. 2020).

Coastal provinces experienced significant migration after the 1990s, thanks to tourism incentives. Additionally, the rising demand for summerhouses altered land utilization along the coastlines. During the period from 1990-2018, there was a total increase of 41.4% in AS areas throughout 28 provinces that are situated on the coastline. The average decrease per province for FA areas in Turkey is 1,567 hectares, whereas in coastal cities, it is 2,775 hectares and 1,567

hectares in other provinces. In the same provinces, there was a decrease of 84,566 hectares in FA areas, while in other provinces; there was an increase of 307,860 hectares.

Moreover, SH areas experienced an increase of 430,661 hectares in coastal provinces and a decrease of 236,038 hectares in other provinces. These findings indicate that the forested regions in coastal areas have experienced a decline in their structural quality due to migration and excessive tourism pressure. Conversely, it has been reported that the ecosystems have experienced a structural improvement in other provinces due to reduced population pressure. Further reinforcing these results are the negative correlation between forest area and rural population variables, and the positive correlations with urban population variables. Similarly, a study in European countries suggests that population growth due to immigration and rural migration has led to increased urbanisation and alterations in land use across various parts of Europe (Bell et al. 2010).

Conclusions

The research findings indicate a significant alteration in land use and cover in Turkey, both nationally and provincially, from 1990 to 2018. Regrettably, this change has harmed forests. Furthermore, there is an alarming rate at which agricultural and forested land is converted to built-up and other artificial areas. Forests are vital ecosystems that require protection and sustainable development, incorporating the valuable products and services they provide and their resources. To this end, it is imperative to prevent the conversion of agricultural and pasture lands to alternative uses, such as power generation, construction, and industrial activities. As a result of the evaluations carried out with unclear criteria, it has been facilitated to change the qualification of forests for tourism, settlement, mining and many other purposes under the pretext of public interest.

Furthermore, the outlook for protected areas is bleak, as they have been converted from national park status to alternative statuses to facilitate increased construction and tourism investments. Forests in this context should be appraised and monitored, mainly via remote sensing techniques, while considering the criteria of organizations like the FAO. A focus must be placed on accelerating research into the socio-economic and other factors responsible for triggering land use changes. Broadening and amplifying comparable national, provincial, district, and village studies is imperative to enhance land management.

COMPLIANCE WITH ETHICAL STANDARDS

a) Author Contributions:

G. Ş. : Conceptualization, GIS analysis, statistical analysis, methodology, writing-original draft writing-review and editing, visualisation.

b) Conflict of interest

No conflict of interest.

c) Statement on the Welfare of Animals

This study does not involve animals.

d) Declaration of Human Rights

This study does not involve humans.

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