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Quantification of the Impact of Land Use/Land Cover Changes on Ecosystem Services: A Case Study in Adana-Karaisalı

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ABSTRACT

Global scale changes in land use affect biodiversity, global climate, and ecosystem services. Integrating a local and regional ecosystem service approach into plans and policies levels is essential for sustainable land management. In this study, land use/land cover differences in Adana-Karaisali district of Turkey were investigated using Normalized Difference Vegetation Index (NDVI). Landsat satellite images of the area from 2000 and 2016 were analyzed using ISODATA method and 16 land use were identified based on the third level of the CORINE classification framework. The results showed that the biggest changes occurred in agricultural areas, 2.57% decrease in non-irrigated arable land while a 7.14% increase was observed in permanently irrigated lands. In spite of the decrease in the number of inhabitants in the area, continuous urban fabric increased at the rate of 0.07% and 7.62% increase was observed in forest lands. The positive or negative effects of the identified changes on ecosystem services based on the Common International Classification of Ecosystem Services (CICES) framework were evaluated. In the case of Karaisalı, in spite of the decrease in water bodies and natural landscapes, it has been observed that increases in agricultural areas, forests, and artificial surfaces positively have affected ecosystem services valuation in the district.

Arazi Kullanımı/Arazi Örtüsü Değişikliklerinin Ekosistem Hizmetleri Üzerindeki Etkisinin Sayısallaştırılması: Adana-Karaisalı Örneği

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ÖZET

Arazi kullanımındaki küresel ölçekteki değişiklikler biyolojik çeşitliliği, küresel iklimi ve ekosistem hizmetlerini etkiler. Plan ve politikalara yerel ve bölgesel bir ekosistem hizmeti yaklaşımının entegre edilmesi, sürdürülebilir arazi yönetimi için esastır. Bu çalışmada, Türkiye'nin Adana-Karaisalı ilçesindeki arazi kullanımı/arazi örtüsü farklılıkları Normalleştirilmiş Fark Bitki Örtüsü İndeksi (NDVI) kullanarak incelenmiştir. 2000 ve 2016 yıllarına ait LANDSAT uydu görüntüleri ISODATA yöntemi kullanılarak analiz edilmiş ve CORINE sınıflandırma çerçevesinin üçüncü düzeyine göre 16 arazi kullanımı tespit edilmiştir. Sonuçlar, en büyük değişimin tarım alanlarında meydana geldiğini, sulanmayan ekilebilir arazilerde %2,57'lik bir azalma, sürekli sulanan arazilerde ise %7,14'lük bir artış olduğunu göstermiştir. Bölgedeki nüfus azalmasına rağmen kesintisiz kentsel doku %0,07 oranında artmıştır ve ormanlık alanlarda %7,62 artış gözlenmiştir. Tespit edilen değişikliklerin, Ekosistem Hizmetleri Ortak Sınıflandırması (CICES) çerçevesine dayalı olarak olumlu veya olumsuz etkileri değerlendirilmiştir. Su kütleleri ve doğal peyzaj alanlarındaki azalmaya rağmen tarım alanlarındaki, ormanlardaki ve yapay yüzeylerdeki artışların ilçedeki ekosistem hizmetleri değerlemesini olumlu etkilediği belirlenmiştir.

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Introduction

Changes in land cover and land use, which are caused by global environmental changes and human activity, significantly affect the energy balance of the world and biogeochemical cycles. While such changes can result in climate changes, they can also change terrain features and the provision of ecosystem services (Turner et al., 2007; Foley et al., 2005; Soley et al., 2016). Ecosystem Services (ES) have become a focal point of interest for environmental policies and actions in recent years, and started to be included in planning and policy making processes (Costanza et al., 1997). Lam and Conway (2008) conducted a case study in Ontario, Canada in order to describe how ecosystem services were incorporated in land use plans. This study revealed the significance of incorporating a working definition of ecosystem services in policy documents and adopting a broader focus on a greater variety of ecosystem services. He et al. (2018) studied on a guidance for land use decision makers to describe ecological restoration policies and optimize land use planning. Research on ecosystem services has increased since the Millennium Ecosystem Assessment in 2005 and ecosystem services assessment research and policy have grown as fields of study (MEA, 2005). The foundation of the Economics of Ecosystems and Biodiversity (2010) initiative and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2015) are global examples indicating the importance of this topic worldwide. Economic assessment of ecosystem services are becoming regular part of practice in ecological economics in order to develop the foundations of politic and planning decisions and create a deeper knowledgebase with regards to the importance of ES (Costanza, 2006; Costanza et al., 2012; Costanza et al., 2014). ES assessment research is a tool that can contribute to increasing awareness of the importance of ES (Costanza et al., 2014).

Ecosystems, which consist of plant, animal, and micro-organism communities and unanimated environments all of which interact with each other as functional units both directly and indirectly, provide a wide array of services to human being including raw materials for food, fibre, and industry as well as water supplies (Costanza, 1997; MEA, 2005; Braat and Groot, 2012; Kındu et al., 2016; Li et al., 2017; Gashaw et al., 2018). According to Millennium Ecosystem Assessment report, 15 out of the 24 ecosystem services assessed were either broken down or disappeared, and that loss posed a direct threat to eco-security on the local and global scale (MEA, 2005). The fact that farming lands constitute 11% of global land areas and that pasture lands increased from 324 million hectares in year 1700 to 3,429 million hectares in year 2000. Pielke et al. (2011) shows the extent of the effect caused by human beings. Similarly, research underlined that changes in land use have a significant impact on an ecosystem’s service providing capacity. Global land use changes between 1997 and 2011 are estimated to have costed 4.3 to 20.2 trillion US Dollars’ worth of ES loss (Costanza et al., 2014). Understanding the link between ES and land use changes have resulted in increased interest among researchers and international groups for studying ecosystem restorations, management, and preservation (Quintas-Soriono et al., 2016). Nevertheless, in spite of the increased interest on studying ES, studies investigating this concept in relation to land use changes are still limited. The present study aimed to investigate the effects of LULC changes in Adana-Karaisalı district of Turkey on ecosystem services.

Main ecosystem services are diverse due to various kinds of land use (MEA, 2005; Baral et al., 2013). For example, while a forest ecosystem provides different services when compared to pasture or aquatic ecosystems, dense forests provide different ecosystem services in comparison to light forests (Anaya-

Romera et al., 2016; Tolessa et al., 2017). In other words, while timber production, carbon reserve, and water holding capacity is higher in forests when compared to wetlands, pasture and farm lands; provision of water and water regulation services are higher in wetlands in comparison to other kinds of land use. Pasture and farm lands, on the other hand, provide better services for food supply and feed manufacturing than other kinds of land use (Baral et al., 2013). LULC changes affect vegetation, anthropogenic factors, ecosystem type and state, and ecosystem service flow. Similarly, it has been found that changes in land use impact on main ecological processes such as energy exchange, soil erosion, water cycle, and biogeochemical cycles. Tang et al. (2014) examined the temporal variation in ecosystem services in response to land cover changes. This research study provided guidance for regional sustainable development. Srivastava et al. (2013) conducted a research study to determine the water quality status of the area and to describe its relation to seasonal variations in land use/land cover (LULC) changes. It is important to identify changes in LULC to manage ecosystems in an integrated manner in an effort to provide multiple services (Braat and Groot, 2012; Jacobs et al., 2016). Ecosystem services provided by a certain environment can be classified using various frameworks. Popular frameworks include Millennium Ecosystem Assessment, the Economics of Ecosystems and Biodiversity (TEEB, 2010), and the Common International Classification of Ecosystem Services (CICES, 2013).

According to MEA framework of classification, ecosystem services have four main categories (provisioning, regulating, supporting, and cultural services), CICES framework, on the other hand, includes three main classification categories; provisioning, regulating, and cultural services (MEA, 2005; Braat and Groot, 2012; Anaya-Romero et al., 2016; Kındu et al., 2016; Costanza et al., 2017). The present study benefitted from the CICES framework whilst relating ecosystem services to LULC. The development of remote sensing technologies facilitated the process of mapping and categorizing lands that have been changed as a result of human activity or natural causes. Changes in LULC are one of the most visible modifications of the terrestrial ecosystem by human beings. Such changes have significant impact on local, regional, and global environment (CICES, 2013). Studies to identify LULC are being conducted to develop farming economies, analyse changes in forest lands, manage natural resources, and support urban planning and archaeological research. Such studies utilize various methods and strategies to observe changes in LULC over time and one of the most commonly used methods is to compare classification results. This method compares results of satellite image classifications for different time periods and identifies land use changes (Kayman, 2015). Nevertheless, it is possible that the use of only satellite images has the potential to result in errors where surface objects cannot be distinguished from one another, thus, causing erroneous classifications. In addition to satellite images, surface characteristics can be used as auxiliary data in order to increase the distinguishability of the objects in images for a more reliable classification (Edunius et al., 2003; Wright and Gallant, 2007). One such commonly used method is the Normalized Difference Vegetation Index (NDVI) which allows differentiating vegetation on satellite images from other types of land cover. NDVI is defined as the division of the difference between near infrared (NIR) and visible red (RED) band on the electromagnetic spectrum (Gandhi, 2015).

NDVI data has been successfully used in various parts of the world by researchers especially for investigating and identifying vegetation changes in large areas of land. NDVI is more advantageous compared to traditional methods due to lower costs and expeditious processing of data regarding vegetation change. More specifically, vegetation index values obtained from daily satellite data provides substantial advantages (Yang et al., 1997). In relation to this, Karabulut (2006) has investigated main vegetation changes in Turkey using NDVI. Similarly, Mermer et al. (2011) have analysed seasonal changes of pasture lands using NDVI. Such data can be used to calculate seasonal Leaf Area Index (LAI) and biomass which extent to covers land (Tucker et al., 1980). These parameters have been found to be associated with soil fertility, soil moisture, seed-time, and plant density (Teng, 1990). The present study has analysed multi-temporal NDVI data using VAST software and aimed to map temporal and spatial changes in Karaisalı's vegetation using VAST output (Yıldız et al., 2010). Likewise, Na et al. (2010) have classified Landsat TM images and integrated the main components of the NDVI output produced from those images into their study. They have concluded that the accuracy rate of their classification significantly increased as a result of using NDVI output. In addition, Xiaodong et al. (2009) have integrated auxiliary data such as elevation and soil type. Kumar et al. (2011) have taken many auxiliary data such as digital elevation model, elevation, aspect, NDVI, configuration, and contrast into consideration and noted that such auxiliary data positively affects the accuracy of classifications. Chen et al. (2005) have underlined the importance of satellite images for observing land cover change over time in large scale areas. They have developed a new method used images that date back to different times to accurately identify land cover change. This new method is simple, effective, and repeatable in producing data sets which could be compared radio metrically. When compared to other radiometric normalization methods, Chen et al. (2005)'s method is found to not require advanced programming or statistics knowledge; nevertheless, the method is able to produce detailed data that can be used to identify changes in land. Zhang and Li (2020) have researched the landscape, plant distribution and animal distribution in a constructed wetland of the Yellow River Basin. The study has revealed that the water body has the significant impact on landscape integrity.

Understanding the link between ES and land use changes has resulted in increased interest among researchers and international groups for studying ecosystem restorations, management, and preservation (Quintas-Soriono et al., 2016). Nevertheless, in spite of the increased interest on studying ES, the studies investigating this concept in relation to land use changes are still limited. Main ecosystem services are diverse due to various kinds of land use (MEA, 2005; Baral et al., 2013). For example, while a forest ecosystem provides different services when compared to pasture or aquatic ecosystems, dense forests provide different ecosystem services in comparison to light forests (Anaya-Romera et al., 2016; Tolessa et al., 2017). In other words, while timber production, carbon reserve, and water holding capacity is higher in forests when compared to wetlands, pasture and farm lands; provision of water and water regulation services are higher in wetlands in comparison to other kinds of land use. Pasture and farm lands, on the other hand, provide better services for food supply and feed manufacturing than other kinds of land use (Baral et al., 2013). The present study has aimed to investigate the effects of LULC changes in Adana-Karaisalı district of Turkey on ecosystem services.

Materials and Methods

Study Area

Karaisalı district, the study area in this research, is located at 37° 8′ 00″ N - 37° 28′ 00″ N latitude and 34° 55′ 00″ E - 35° 25′ 00″ E longitude (Fig. 1). The district is placed on the north of Adana Province of Turkey and south edges of Toros Mountains. The land consists of mountainous, rugged, and flat areas. Çatalan and Nergizlik dams located in the area are sources of drinking water for the district (Anonymous, 2016a). Located in the Mediterranean Region, summers are hot and dry and winters are mild and rainy in the district. Rainfall generally occurs in the form of orographic rain or when two air masses meet. Average annual rainfall is 917 mm. The air is hot and humid especially during summer. 38-year average annual heat of the district is 18.3 ^{0}C (Anonymous, 2016b). Located in the flora zone of Eastern Mediterranean, the vegetation of the district includes xerophilous trees and bushes which have hard green leaves year around (Yılmaz, 1996). *Pinus brutia* also known as *Turkish pine* is the signature plant of the region. *Pinus brutia* forests, maquis, and herbaceous plants constitute the vegetation of the district. The district which consists of a total of 62 neighbourhoods had a population of 60.601 in 1985; however, the population of the district decreased over time and the census data for 2016 indicated that there were 21.250 people residing in Karaisalı (TUIK, 2016). Most of the residents makes their living from farming and animal rearing activities.

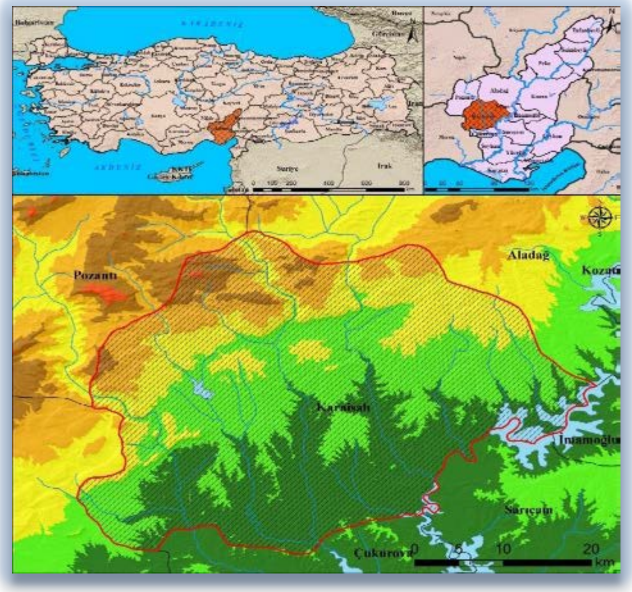

Figure 1. Study area location map

Methods

The proper land use requires taking into consideration of various characteristics, such as topography (i.e. elevation, aspect, and land forms), main materials and soil. The suitability of a piece of land to be used as farming land or forest depends on which activity (i.e. farming) would generate the maximum efficiency on that particular land. Answering questions such as which areas can be used as farms, pastures, forests, settlements, or industrial areas is possible by accurate classification and use of lands. Appropriate use of land requires revealing the natural potential of the land and administering feasibility analyses which can be realized through quantitative analysis of components in the environment. Software which has been developed using computer and satellite technologies (specifically Geographic Information Systems), based on quantitative data, facilitates the process of revealing land potential, administering feasibility analysis for land use, and observing changes in a specific area (Pektezel and Ateş, 2016).

Because of being close to Adana city centre and having high natural potential, Karaisalı district has been one of the districts which are prioritized for development. In line with this, Landsat 7 ETM images of Karaisalı from 2000 and Landsat 8 OLI images from 2016, which were provided by United States Geological Survey were used in order to create a classification map of Karaisalı, identify the changes that took place over time, and determine areas important for ecosystem services. For the consistency of the classification, attention was paid to ensure that reflection values and dates on which pictures were taken were close to each other. Images in the study were atmospherically corrected and ISODATA method was utilized to perform unsupervised classification. ISODATA is Iterative Self-organizing Data Analysis Technique, which is an iterative self-organizing data analysis technology (Zhao and Zhou, 2016). The ISODATA method is based on the minimum distance center method object meta-clustering. Method can select the initial class clustering center according to certain principles, and then calculate the standard deviation of each cluster and the distance between each class center. The smaller the distance, the larger the similarity, the easier it is to belong to the same class. If the cluster standard deviation deviation is greater than the defined threshold, the split is selected. If the class spacing is less than the defined threshold, then merge. The cluster center is continuously calculated and iterated until the average class spacing is less than the defined threshold or the average of the two iterative process class spacings is less than the threshold (Li et al., 2020). Unsupervised classification which works on the principle of minimum distance is an automatic classification method and is carried out based on the statistical groups of the models that are created by reflected values. In this study land cover classification was completed using ERDAS 9.1 and ArcGIS 10.4.1 software and land cover changes were identified. Following classification, change analyses were carried out and changes between land categories were determined and interpreted. NDVI values and land use maps that were generated were utilized as auxiliary data in order to identify changes in the area.

Normalized Difference Vegetation Index (NDVI) is a method that is used to determine whether a given area has vitality or not by using near infrared (NIR) and visible red (RED) bands of the electromagnetic spectrum. NDVI is generally directly proportional to surface cover, plant photosynthesis activity, surface water, biomass, and leaf area index (LAI) percentages (Rouse et al., 1973). Healthy vegetation reflects most of the near infrared light that falls onto it and absorbs visible light. Sparse vegetation, on the other hand, reflects more RED and less NIR, and bare soil moderately reflects both NIR and RED parts of the electromagnetic spectrum. Plants' behaviour in the electromagnetic spectrum can be obtained using Landsat bands and this way NDVI values can be calculated. The higher the reflection differences between NIR and RED, the greater the amount of green vegetation in the observed area. NDVI value is calculated by dividing the difference between NIR and RED values to the addition of NIR and RED (Osunmedewa et al., 1973). Theoretically, NDVI is a value between -1 and +1.

Results

Land use/land cover classification

The “Coordination of information on the environment” (CORINE) is an inventory of European land cover split into 44 different land cover classes (Url 1). The CORINE Land Cover (CLC) inventory was initiated in 1985 to standardize data collection on land in Europe to support environmental policy development. The project is coordinated by the European Environment Agency (EEA) in the frame of the EU Copernicus programme and implemented by national teams. The number of participating countries has increased over time currently including 33 (EEA) member countries and six cooperating countries (EEA39) with a total area of over 5.8 Mkm2 (Url 2).

The land use/land cover (LULC) maps of Karaisalı created in line with the CORINE classification system and belonging to 2000 and 2016 are presented in Figure 2 and Figure 3. Changes detected based on these maps are summarized in Table 1. The accuracy rate of the satellite map classification produced in the present study was calculated as 81.20% and accuracy rate calculations are detailed in Table 2. The results suggested that the most significant changes took place in agricultural areas. While non-irrigated arable land areas decreased 2.57% over the course of 16 years, the area of permanently irrigated farming increased 7.14%. In spite of the decline of population in the district, continuous urban fabric increased 0.07%. The decline in pasture land area in this district where animal rearing is important- is notable. Nevertheless, forestation activities in the district resulted in significant increases in forest lands. The results generated based on the classification of satellite images from 2016 indicated that agricultural areas (both non irrigated arable land and permanently irrigated land) covered an area of 1.941.92 hectares, and natural lands and forests covered an area of 80.803.29 hectares (Tokgöz, 2018).

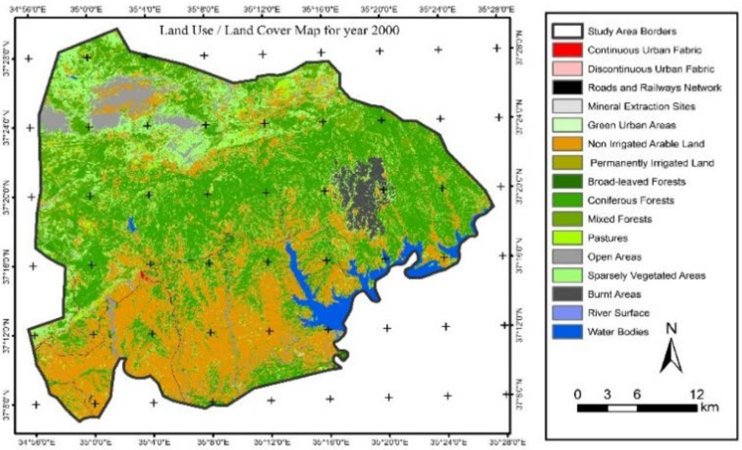

Figure 2. Land Use/Land Cover for 2000 (Tokgöz, 2018)

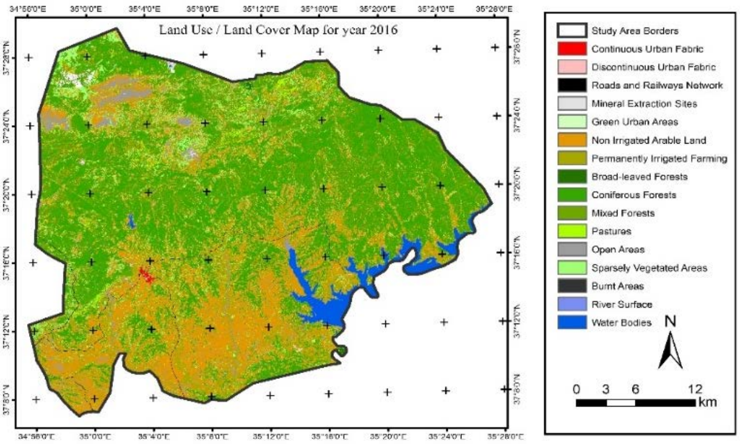

Figure 3. Land Use / Land Cover for 2016 (Tokgöz, 2018)

Table.1. Land use/land cover changes between 2000 and 2016 (Tokgöz, 2018)

1st Level	CORINE Land Cover Code	3rd Level	Year 2000 Size (ha)	Size (%)	Year 2016 Size (ha)	Size (%)	Amount of changed land (%)
1.Artificial Surfaces	1.1.1	Continuous Urban Fabric	30.85	0.02	103.81	0.08	0.06
	1.1.2	Discontinuous Urban Fabric	18.95	0.01	19.41	0.02	0.01
	1.2.2	Roads and Railways Networks	280.02	0.22	263.83	0.21	-0.01
	1.3.1	Mineral Extraction Sites	13.83	0.01	140.92	0.11	0.10
	1.4.1	Green Urban Areas	11.35	0.01	31.06	0.02	0.01
2.Agricultural Areas	2.1.1	Non – irrigated Arable Land	34.870.37	27.41	31.591.65	24.84	-2.57
	2.1.2	Permanently - irrigated Land	1.269.45	1.00	10.350.27	8.14	7.14
3.Forest /Seminatural Areas	3.1.1	Broad-leaved Forests	423.68	0.33	108.96	0.09	-0.24
	3.1.2	Coniferous Forests	37.052.99	29.13	43.690.44	34.35	5.22
	3.1.3	Mixed Forests	17.486.73	13.75	20.843.80	16.39	2.64
	3.3.3	Sparsely Vegetated Areas	21.730.29	17.08	11.738.02	9.23	-7.85
	3.3.4	Burnt Areas	2.658.91	2.09	219.25	0.17	-1.92
4.Natural Areas/Wetlands	4.1.1	Pastures	1.012.90	0.80	768.48	0.60	-0.20
	4.1.2	Open Areas	6.156.77	4.84	3.434.34	2.70	-2.14
5. Water Bodies	5.1.1	River Surface	146.52	0.12	3.633.95	2.86	2.74
	5.1.2	Water Bodies	4.033.65	3.17	259.07	0.20	-2.97
		TOTAL	127,197.26	100.00	127,197.26	100.00	0.00

Table 2. Accuracy Rate of the 2016 Satellite Image Classification (Tokgöz, 2018)

Classification Type	Total Number of References	Total Number of Classified Data	Number of "Correct" Matches	Producer Accuracy (%)	User Accuracy (%)
Continuous Urban Fabric	4	10	8	100.00	80.00
Discontinuous Urban Fabric	8	10	8	100.00	80.00
Roads and Railways Network	8	10	7	75.00	60.00
Mineral Extraction Sites	15	15	15	100.00	100.00
Green Urban Areas	15	12	9	60.00	75.00
Non –irrigated Arable Land	26	22	16	61.54	72.73
Permanently -irrigated Land	15	21	15	100.00	80.00
Broad-leaved Forests	8	10	8	100.00	80.00
Coniferous Forests	61	42	39	76.47	92.86
Mixed Forests	22	18	16	72.73	88.89
Pastures	10	10	10	100.00	100.00
Open Areas	5	6	5	100.00	83.33
Sparsely Vegetated Areas	14	14	12	85.71	85.71
River Surface	12	15	12	100.00	80.00
Water Bodies	18	18	18	100.00	100.00
Total	250	239	203		
Total Accuracy Rate (KAPPA)	(%) =81.2				

As can be seen in Figure 4, NDVI values are closer to +1 in areas where there is a healthy vegetation, and they drop and get closer to -1 in areas such as water surfaces, bare soil, and settlements. The comparison of NDVI values for 2000 and 2016 suggests that vegetation in the area has increased over the course of 16 years. While NDVI can be used as an indicator of relativistic biomass, leaf area index (LAI), and vegetation (Zhang et al., 2007). It has also been associated with functional characteristics such as primary production and carbon offset in a number of studies (Hueta et al., 2002) and has been considered as an important characteristic of ecosystem service analysis (Rocez-Diaz et al., 2014). Therefore, it is assumed that there is a linear relationship between ecosystem service value and NDVI (Wang et al., 2015). In line with CICES classification, ecosystem services identified in this study have been classified under three main headings and a total of 31 sub-categories, and these categories have been associated with LULC categories (Table 3).

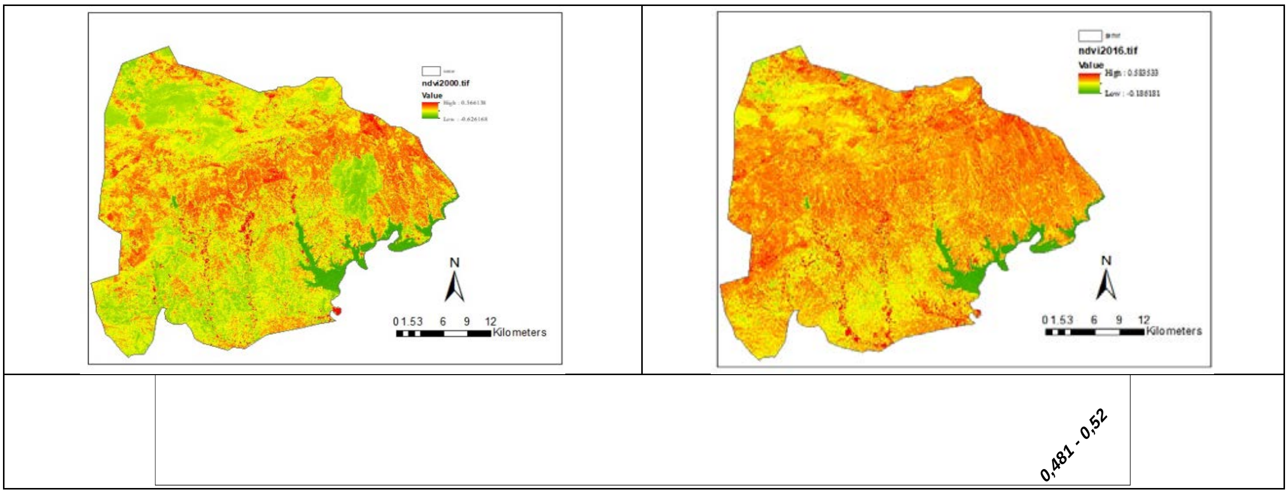

Figure 4. NDVI values for 2000 and 2016 (Tokgöz, 2018)

There are various direct and indirect methods to value ecosystem services which have their own strengths and weaknesses and require time and resources (De Groot et al., 2002; Farber ae al., 2006; Msofe et al., 2020). The present study utilized the benefit transfer method in order to transfer the worth of ecosystem services to LULC. Benefit transfer method is a method used to estimate ecosystem services values when an original valuation study is not available for a specific location or context (Coztanza, 1997; Kubiszewski et al., 2013). Two kinds of ecosystem services valuation (ESV) coefficients have been used for LULC categories. The first kind of coefficients is the one that has been used as a reference point in many studies and treated as global ecosystem coefficients by Costanza et al. (1997). And the second kind of coefficients includes the values that have been obtained from the Economics of Ecosystems Biodiversity (TEEB) valuation data base and the study reported by Sharma et al. (2019). LULC data were evaluated in a geographic information systems (GIS) environment and land use for biome types in 2000 and 2016 was calculated in hectares (ha). Value coefficients were calculated for each LULC category based on global coefficients used by Costanza et al. (1997) and coefficients modified by Sharma et al. (2019) and TEEB (2010), (Table 3 and Table 4). Afterwards, each land cover's use category (in hectares) was multiplied with related coefficient values in order to identify total ESV (Sharma et al., 2019). Lastly, changes in ecosystem services values were calculated by subtracting ESV values for 2016 from ESV values for 2000 in each use category. While positive figures indicate an increase in total value, negative figures indicate a decrease.

Table. 3 Estimated Ecosystem Service Valuations Based on Land Use/ Land Cover and Ecosystem Service Types (in US Dollars/Hectares/Year)

	Ecosystem Service Type	**Artificial Surfaces**	**Agricultural Areas**	**Forests**	**Natural Areas**	**Water Bodies**
	Regulation and Maintenance Services					
1.	Global Climate Regulation	1	4	91	0	0
2.	Local Climate Regulation	1	4	104	0	0
3.	Air Quality Regulation	1	4	54	7	0
4.	Water Flow Regulation	1	3	34	2	0
5	Water Purification	0	1	14	2	378
6.	Food Regulation	0	6	2	0	0
7.	Erosion Control	0	2	36	22	0
8	Natural Risk Reduction	0	0	12	0	0
9.	Pollination	1	8	33	24	0
1.	Pest and Disease Control	1	2	0	23	0
11.	Mediation of Wastes	0	1	65	87	81
	Provisioning Services					0
12.	Crops	1	15	7	5	50
13.	Energy and biomass	1	4	24	12	0
14.	Feed	0	8	2	25	0
15.	Husbandry	0		0	29	0
16.	Fibre	0	2	16	0	0
17.	Timber	0	0	174	0	0
18.	Wood	0	0	141		0
19.	Fish, seafood, algae	0	0	0	0	0
20.	Aquaculture	0	0	0	0	0
21.	Wild Food Sources	0	6	15	0	0
22.	Biochemicals and Medicine	0	2	6	0	0
23.	Fresh Water	0	1	8	0	1872
24.	Mineral Resources	2	1	0	1	0
25.	Abiotic Energy Resources	1	1	0	3	0
	Cultural Services					
26.	Recreation and sense of space	2	1	9	2	318
27.	Landscape Aesthetics and Inspiration	2	2	4	0	0

28	Information Systems	1	1	5	0	0
29	Spiritual and Ethical Values	2	1	5	0	0
30	Natural Heritage and Species Diversity	2	4	8	0	0
31	Cultural Heritage and Cultural Diversity	2	2	2	0	0
	Total ESV Dispersion:	: 22	92	1871	244	2699

Table 4. LULC Categories and Their ESV Which Correspond to Values in Study (Foley et al., 2005)

Corine Land Cover 1st Level	Land Cover Category	Equivalent Biome Type	Total Ecosystem Service Value (in US Dollars/ ha/ year)	
			Costanza et al. (1997)	**Adapted TEEB (2010); Sharma et al. (2019)**
1.	Artificial Surfaces	Urban areas, Mine Mineral Extraction Sites, Roads and Railways	22	22
2.	Agricultural Areas	Non-irrigated and Permanently-irrigated Lands	92	92
3.	Forests and Seminatural Areas	Broad-leaved, Coniferous Forest, and Mixed Forests	2007	1871
4.	Natural Areas	Pastures and Sparsely Vegetated Areas	232	244
5.	Water Bodies	River Surfaces and Water Bodies	8498	2699

Estimation of Ecosystem Services Values and Changes

The total ESV was calculated using the following formula:

$$\mathbf{ESV} = \sum (\mathbf{A_k} \times \mathbf{V_k})$$

ESV is the total ecosystem service value; $\mathbf{A_k}$ is the area in ha, and $\mathbf{V_k}$ is the value coefficient (US\$ ha yr^{-1}) for land-use category k (Kindu et al., 2016; Gashaw et al., 2018)

Table 5. ESV values for 2000-2016 in each use category

Corine Land Cover 1st Level	Land Cover Category	ESV(Annual in Million US Dollars)		ESV Change (Annual in US Dollars)
		2000 (approximately)	**2016 (approximately)**	
1.	Artificial Surfaces	7810	12298	4488
2.	Agricultural Areas	3325	3859	534
3.	Forests and Semi-natural Areas	47873	56304	8431
4.	Natural Areas	7700	3943	-3757
5.	Water Mass	11282	10507	-775
	Total ESV	**77990**	**86911**	**8921**

Conclusions

Detecting environmental changes using two or more satellite images of a specific geographical location or area taken at different points in time is one of the methods currently available to determine changes in land use and land cover (LULC). Such data are successfully used in various practices such as monitoring urban areas, agricultural development, and forest management. The present study investigated LULC changes between 2000 and 2016 in the Karaisalı district of Adana Province in Turkey using remote sensing and geographic information systems (GIS) technologies. Landsat images were used to conduct analyses. The analyses were conducted using Normalized Difference Vegetation Index (NDVI) which is one of the seven spectral indices that are commonly used to monitor and detect LULC changes. NDVI data and land changes were used together in order to understand ecological processes and activities in the study area over the course of 16 years (2000-2016). A total of 16 categories related to LULC was identified using the third level of the CORINE framework. ISODATA method was utilized in the present study and the Kappa statistic of the method indicated an 81.20% accuracy rate. The results suggested that sparsely vegetated areas, open areas, and burned areas decreased over the course of 16 years and farming areas and forests increased. NDVI maps for 2000 and 2016, generated in the light of the data, indicated that plant activity increased positively during the 16-year period. Forestation and irrigated farming activities contributed to this increase. The analyses also suggested that Karaisalı, a district prioritized for rural development, has natural potential for many activities such as farming, animal rearing, water sports, and eco tourism. In line with population growth, man-made changes constitute a considerable amount of LULC changes in regional environment and ecosystem services. However, awareness of ecosystem services at local and regional levels can be used as a supporting tool for stakeholders to manage sustainable land use (Anna et al., 2011). Estimated ecosystem services value (ESV) based on the analysis of the data generated taking LULC changes into account indicate that total ESV value for 2016 is higher than 2000. This is also an indicator of how temporal and spatial scale changes impact upon ecosystem services. In spite of the decrease in water mass and natural areas in 2016, it has been observed that increases in farming areas, forests, and artificial surfaces when compared to 2000 have resulted in 8,921 million US Dollars' worth of total ESV increase. Forests and water mass per hectare create a high ESV. Thus, changing LULC of a particular area whilst preserving its forests and water sources is critical to prevent ESV losses. In addition, loss of farming lands is considered as an emerging threat to food security especially in areas that are being rapidly settled. Therefore, ensuring that lands are used in line with their characteristics becomes critical to provide optimal ecosystem services in a given area. Estimated total ESV found in the present study can be used to communicate the benefits of Karaisalı ecosystems to national and international stakeholders as well as provide an opportunity for further analysis. There are various direct and indirect methods in order to increase the accuracy of ESV estimations. However, those require time and resources. Since the present study is based on a basic benefit transfer method and the values found are estimate values, a planning and management of ecosystem services would require a further and more detailed analysis of Karaisalı district. Sustainability of farming lands, forests, and water sources require innovative policy solutions. The present study can serve as an important source of information for future research and policy making and also provide an opportunity to compare values generated in different ecosystems. Moreover, it is important that local authorities include the concept of ecosystem services concept in their plans and policies as a strategy to protect ecosystems and improve sources of income.

Statement of Conflict of Interest

The authors of the article declare that there is no conflict of interest.

Author's Contributions

The authors declare that they have contributed equally to the article.

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