

Evaluation of Landscape Services with Landscape Metrics in Çıralı, Antalya

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Abstract : Understanding landscape value with different components is important to provide some benefits and information for the management and conservation of landscapes. Çıralı Region, an agricultural village in Antalya Province, southwest Turkey, with its multifunctional landscapes was chosen for the study. The aim of this paper is to evaluate Çıralı with ecological, social, cultural, visual and economic landscape services by using landscape metrics and to discuss how such multifunctionalities of the landscapes can be conserved and developed for sustainable development. As Landscape multifunctionality provides the spatial integration of land use facilities into the economic, environmental and social objectives, we hope that study outcomes would provide useful solutions for landscape related problems in Çıralı.

Keywords - Landscape services, landscape character, Çıralı, Antalya

I. INTRODUCTION

“Landscape” means an area, as perceived by people, whose character is the result of the interaction between man and nature [1]. Landscape function is defined as the capacity of a landscape to provide goods and services to the society with different environmental variations in the landscape [2]. Landscape ecology can provide useful insights into how the spatial distribution of human activities influences important landscape structures from which services that are derived.

Assessing and mapping the multitude of services that provided by landscapes at different scales is seen as a useful tool for sustainable development and sustainable landscape management. Multifunctionality as an outcome of the relationship between man and nature requires definition, planning and integration of different components and stakeholders in rural and urban landscapes.

The aim of this study was to analyse landscape services and multifunctionality landscapes in Çıralı Vicinity, Antalya. Çıralı is small rural areas located on the southern Mediterranean coast of Antalya. It has a great landscape diversity of topography, coastal plain, sand dunes, beach and coast with rare stone pines, wetlands, reed beds and watercourses with historic sites of Chimera.

However, intact size and unity of its location and landscapes comprise multitudes of functions for ecology, local people and visitors in the vicinity. Study will be conducted in 3 steps. First step landscape characters, landscape character types will be defined with regard to landscape metric. Second step landscape services based on ecological, social, cultural, visual and economic parameters will be analysed. Finally relations between landscape characters, structures and landscape services will be questioned and multifunctionality of the landscapes will be evaluated.

II. MATERIAL AND METHODS

Çıralı Region has been chosen as study area. Become a rural settlement in 1950s, economy of Çıralı is based on local tourism and agriculture. Tourism gradually started to compete for the natural grounds and resources in the area. Located on the south-western coast of Antalya, Çıralı hold landscape diversity of coastal areas, forests, rivers, wetlands unique to the Mediterranean (Figure 1). A 3.2 km. long beach in Çıralı with its width varies between 50 to 100 meters is very important habitat for Loggerhead Sea Turtle (*Caretta caretta*).

Material of the study consists of landscapes of Çıralı which can be defined with beach, dunes, remnants of coastal Stone Pines (*Pinus pinea*) patches, coastal cliffs, open fields, farmed lands, rural settlements, Calabrian Pine (*Pinus brutia*) forest, maquis, mountain cliffs from coastline to inland.

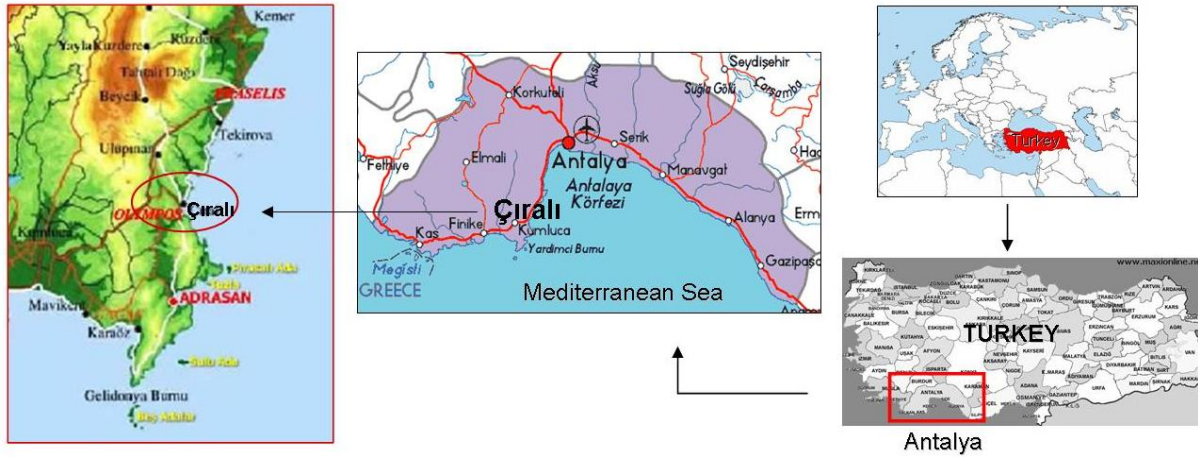


Figure 1. Location of study area, Çıralı

2.1. Method

Method of the study was based on the landscapes evaluation of Çıralı and understanding their multifunctionality. Basic steps of the method were;

- Analysis of natural layers of landscape; topography, geology, soil, vegetation
- Analysis of land-cover classes
- Definition of landscape character types
- Analysis of landscape metrics
- Definition of landscape services; ecologic, visual and aesthetic, economic, socio-cultural
- Evaluation and discussion relations between landscape metrics, landscape character types and landscape services.

The storage, processing and analysis digitally of the natural and cultural data related to the landscape characters, landscape metrics and land-cover classes were carried out with the aid of the Geographic Information System (GIS). Relations between landscape characters, metrics and landscape services were evaluated with regard to multifunctionality according to previous studies by [3], [4], [5], [6], [7], [8], [40].

III. NATURAL LANDSCAPE CHARACTERISTICS OF ÇIRALI

Alluvial deposition brought by rivers coming down from the mountains made possible the creation of Çıralı village itself, its agricultural areas and Çıralı beach. Çıralı is a kind of pocket shaped small coastal plain developed from the gravels and other alluvial deposits brought by Ulupınar, Yanar and Akçay streams. Although the topography is almost flat on the plain floor, the land soon rises a short way inland. Musa Mountain in the south west of Çıralı reaches up to 568 meters, while Chimera (Yanartaş) is at 282 meters. Such sudden changes in the topography and elevation bring great diversity to the local landscape (Figure 2).



Figure 2. Panoramic view of Çıralı

3.1. Climate

The region is under the influence of a Mediterranean climate. This is typically characterized by hot and dry summers and mild and rainy winters. However there are local characteristics depending on the location of the region and sea conditions. As there are no records for Çıralı the climatic characteristics of nearby Kumluca can be used as a proxy. Average temperature in Kumluca is around 18.5 °C, the highest temperature is recorded as 27.7 °C in July and lowest temperature is recorded as 10.4 °C in January.

3.2. Geology and geomorphology

The geology of the region is characterised by karstic rock formation and serpentine blocks. The karst geomorphology is based on limestone and the associated coastal geomorphology. There are chromium and manganese in some places. The natural methane gas vents in Chimera (Yanartaş) are in limestone and serpentine (Figure 3).



Figure 3. Chimera (Yanartaş) area

An old chromium mine is located on coast at the northern end of the region. Rich brown soils based on a variation of limestone with some material of volcanic origin in the alluvial sediments generate a kind of transition zone between the settlement and agricultural areas in the coastal part of Çıralı. The shoreline consists of alluvial, gravel and sand dunes (Figure 4).

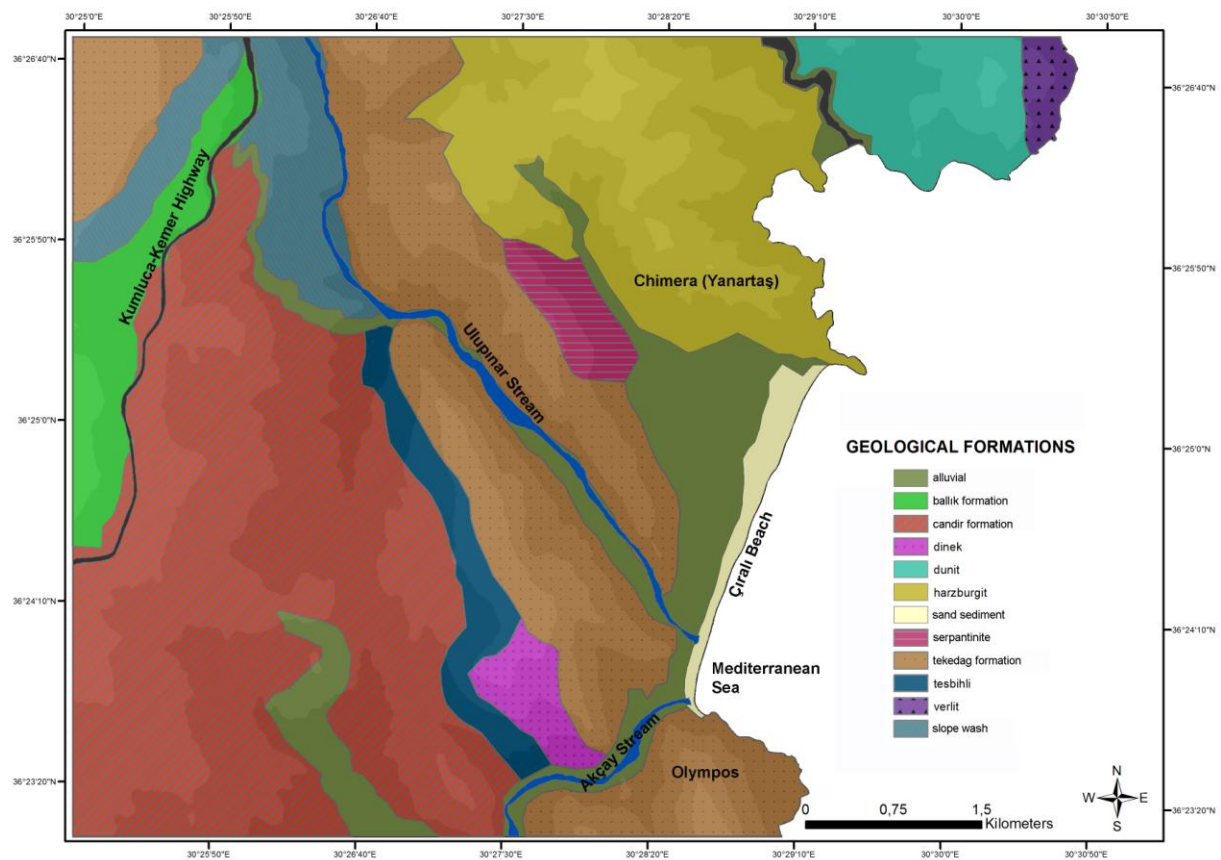


Figure 4. Geological characteristics of Çıralı

3.3. Soils

Soils are characterised by typical “terra rossa” Mediterranean soils. Created by the dissolved carbon form calcium carbonate parent material, terra rossa soils are also called red rendzina. The soil has often been lost to erosion, overgrazing and fire to be replaced by bare rocks (Figure 5). Great soil groups of Çıralı region are alluvial soils, terra-rosa, colluvial soils, brown forest soils, limeless brown forest soils and alluvial coastal soils.

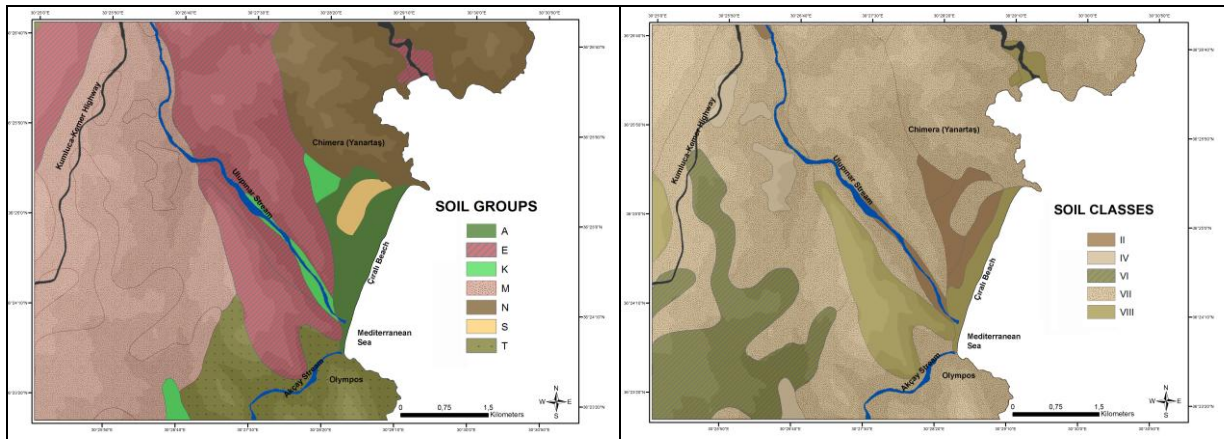


Figure 5. Soil characteristics of Çıralı; soil groups (a) and soil classes (b)

3.4. Vegetation

Çıralı is characterised by typical Mediterranean vegetation. Most of the area is covered by Turkish pine (*Pinus brutia*) forest and maquis. On the bare serpentine rocks *Pinus brutia* comprises the tree canopy while *Genista acanthoclada*, *Acantholimon acerosum*, *Calycotome villosa*, *Inula heterolepis*, *Phlomis bourgaei*, *Cistus creticus* are in lower canopy (Figure 6).

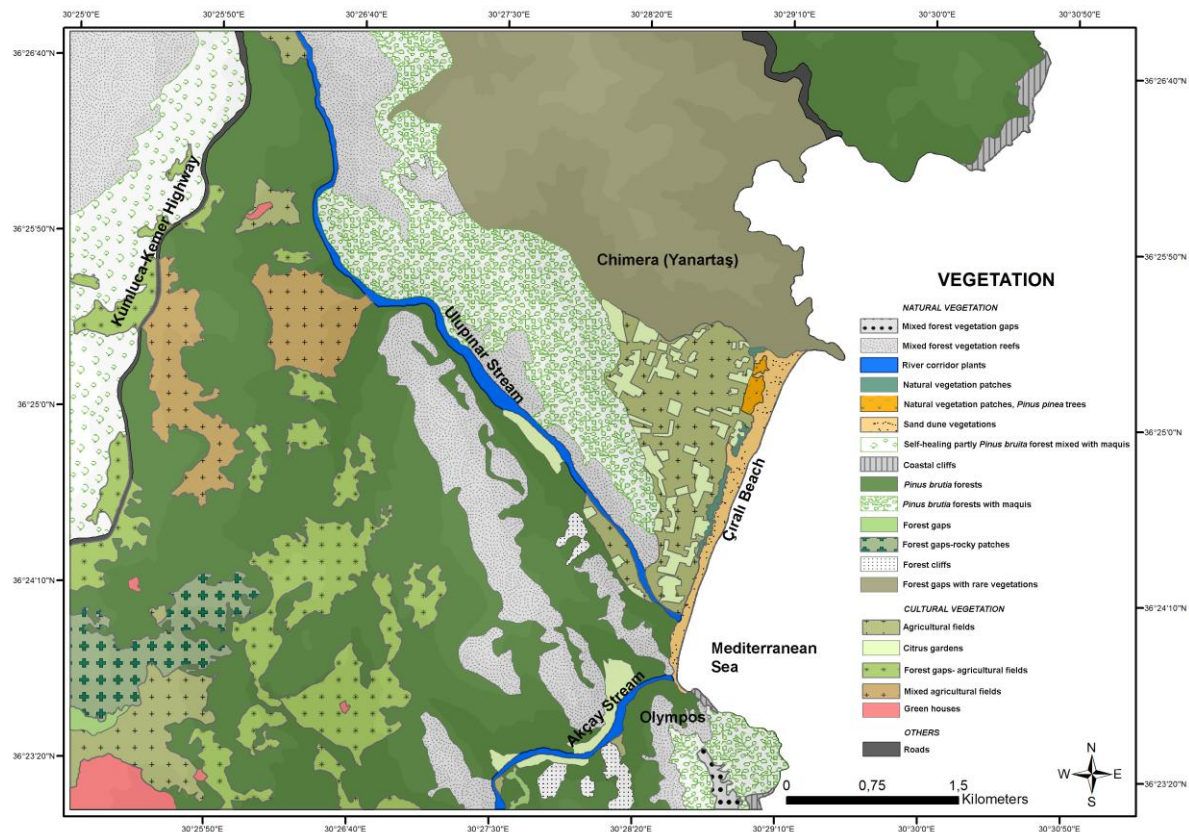


Figure 6. Vegetation characteristics of Çıralı

Çıralı sand dunes are one of the few sites where 150 year old stone pine (*Pinus pinea*), found in Antalya region. Known as Chimeranean sage *Phlomis chimerae* [9] is a local endemic plant in Çıralı. Some other localized plants are *Centaurea dichroa*, *Verbascum spodiotrichum*, *Echinops onopordum*, *Ononis serrata*, *Pancreatium maritimum*, *Pinus pinea*. Vegetation corridors are commonly found along the main streams in Çıralı, with native species such as *Platanus orientalis*, *Laurus nobilis*, *Tamarix tetrandra*, *Myrtus communis*, *Vitex agnus-castus*, *Phragmites australis*, *Nerium oleander* (Figure 7).



Figure 7. Native plants of Çıralı (*Genista acanthoclada* (a), *Cistus creticus* (b), *Acantholimon acerolum* (c))

3.5. Wildlife

Throughout history, the presence of a rich wildlife in the region was noted. Spratt recorded in 1842 that there were leopards in the region. In ancient records, one of the Roman governors ordered that leopards were to be collected in the region for a wild animal stage fight [10]. There are very diverse wildlife and plant habitats starting from sea level and extending onto the mountains. The Mediterranean monk seal (*Monachus monachus*) a critically endangered species and an important indicator of the biodiversity is living around the coastal rock caves and karstic holes around Çıralı coast.

Çıralı sand dunes and Çıralı beach are important nesting sites of the loggerhead sea turtle (*Caretta caretta*) which is endangered in Turkey and also in the Mediterranean. Another species unique to Çıralı Region is the chameleon (*Chamaeleo chamaeleon*) protected under the Bern Convention. The natural corridors of the Ulupınar, Yanar and Akçay streams in Çıralı provide habitats for fish, birds, reptiles and many other species (Figure 8).



Figure 8. Wildlife species of Çıralı (*Caretta caretta* (a), *Monachus monachus* (b))

IV. LANDSCAPE SERVICES AND MULTIFUNCTIONALITY WITH REGARD TO LANDSCAPE CHARACTER TYPES IN ÇIRALI

Landscape services are defined as the capacity of the services of the landscape which benefits to society [11] [12]. These services consist of the benefits gained from timber or harvested plants, landscaping services such as aesthetics, habitat or water supply systems.

Scientific literature holds several attempts to frame the concept of landscape services [13] [14] [15]. Multifunctionality is used to characterize the activities in the primary production and the land use systems, which refers to the fact that an economic activity may be multiple outputs and by virtue of this may contribute to several societal objectives once [14].

4.1. Landscape Character Types in Çıralı

Landscape character types are distinct types of landscape that are relatively homogeneous in character and share broadly similar combinations of geology, topography, vegetation, and historical land use and settlement pattern [16] [17].

Landscape character often reflects the state and quality of the landscape and informs planners on how to manage and maintain the landscape. Landscape evaluation is a fundamental procedure for assessing the conditions and quality of a system and it is the first step towards planning or management actions [18]. In this regard, it is important to take into account and understand all features of the landscape, both biophysical and visual in order to integrate them into land use policies.

Thirteen landscape character types were determined in Çıralı as Akçay stream, Kemer-Kumluca transportation network with mixed *Pinus brutia* forests, natural vegetation patches with *Pinus pinea*, natural coastal cliffs, dense *Pinus brutia* forests, sand dune vegetations, agricultural fields with citrus gardens, forest area with open and rocky patches, mixed forest cliffs with *Pinus brutia* patches, green houses and agricultural fields, multi-pattern farming lands, Ulupınar stream and dense residential area (Figure 9).

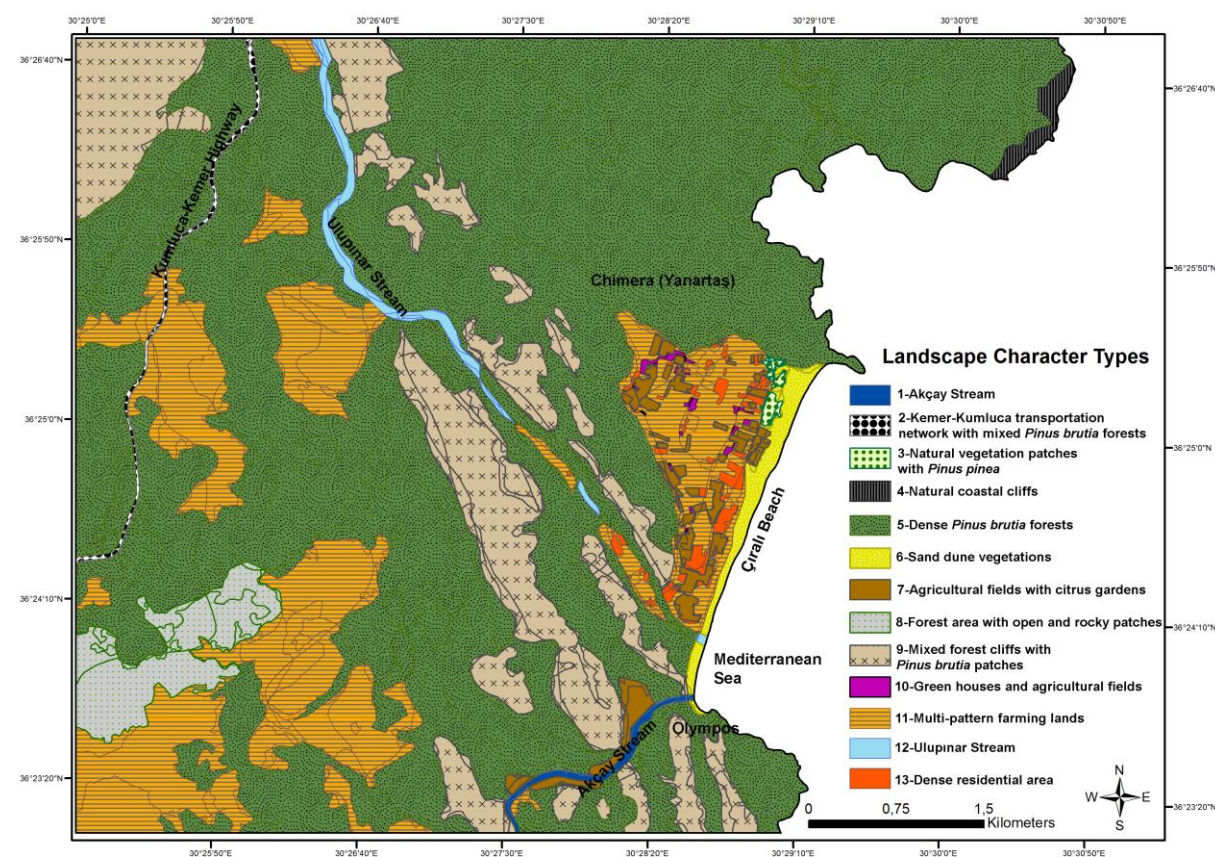


Figure 9. Landscape character types in Çıralı

4.2. Landscape Metrics

Landscape metrics provide useful information about the composition or configuration of a landscape, the proportion of each land cover type present or the size or shape of landscape elements. A major value of landscape metrics lies in their usefulness for comparing alternative landscape configurations, comparing different landscapes mapped in the same manner, evaluating the same landscape at different times, or comparing the same landscape under alternative scenarios [19]. Metrics can be analyzed at 4 levels depending upon the desired emphasis: cell, patch, class and landscape. As cell level metrics have not yet been well-developed or applied in landscape ecology, so patch, class and landscape are most used levels [20].

4.2.1. Landscape Metrics Defined for Çıralı

In frame of this study, class and landscape level metrics were analyzed for Çıralı. Number of Patches (NP), Patch Density (PD), Shape Index (SHAPE_MN) and Effective Mesh Size (MESH) values were calculated in class metrics and also Total Area (TA) and Shannon's Diversity Index (SHDI) for each of landscape character types (Table 1; Table 2).

Table 1. Class level metrics for Çıralı

TYPE	CA	LAND	NP	PD	LPI	SHAPE_MN	PAFRAC	MESH
1	12,870	0,2977	1	0,0231	0,2977	4,1944	N/A	0,0383
2	17,480	0,4044	1	0,0231	0,4044	7,7619	N/A	0,0707
3	5,960	0,1379	2	0,0463	0,0743	1,9379	N/A	0,0041
4	16,360	0,3785	2	0,0463	0,3783	1,6914	N/A	0,0618
6	37,910	0,8770	4	0,0925	0,7778	1,9066	N/A	0,2647
7	63,540	1,4700	29	0,6709	0,2723	1,6548	1,3457	0,0755
8	117,450	2,7172	1	0,0231	2,7172	2,4700	N/A	3,1913
9	546,920	12,6528	20	0,4627	3,9944	1,7887	1,2227	11,2729
10	5,920	0,1370	14	0,3239	0,0534	1,4453	1,4984	0,0016
11	569,280	15,2522	29	0,6709	4,1008	1,9548	1,2434	16,7105
12	33,110	0,7660	4	0,0925	0,6852	2,6166	N/A	0,2040
13	25,730	0,5953	41	0,9485	0,0791	1,5019	1,2247	0,0098

CA: Total Class Area NP: Number of Patches PD: Patch Density LPI: Largest Patch Index SHAPE_MN: Shape Index PAFRAC: Perimeter-Area Fractal Dimension MESH: Effective Mesh Size

Table 2. Landscape level metrics for Çıralı

TA	NP	PD	LPI	LSI	AREA_MN	MESH	SHDI	SHEI
4.322,5200 m²	148	3,4239	4,1008	3,5882	10,4225	31,9053	1,4820	0,5964

TA: Total Area NP: Number of Patches PD: Patch Density LPI: Largest Patch Index LSI: Landscape Shape Index AREA_MN: Patch Area Distribution MESH: Effective Mesh Size SHDI: Shannon's Diversity Index SHEI: Shannon's Evenness Index

4.3. Relationships Landscape Character Types and Landscape Metrics for Çıralı

To enable the pathway from landscape metrics to an improved assessment of landscape services, we introduced a number of evaluation criteria such as land use diversity, landscape fragmentation and presence of water which in our case were applied to the landscape functions ecological functioning [21] [22]. However, relationships between landscape metrics and evaluation criteria were described in several studies [23] (Table 3).

Landscape metrics are evaluated with different criteria such as Effective Mesh Size, Shannon's Diversity Index and Shape Index. In Table 3, an exemplarily chain from landscape metrics to assessment of the landscape services were discussed. For instance, the Effective Mesh Size was found to be well suited for a comparison of the degree of landscape fragmentation of various regions by [24].

Besides ecological services, the aesthetic value of a landscape strongly depends on configuration, composition and form of land cover types [25] [26]. [27] found out that there is a common ground of visual and ecological landscape indicators.

Table 3. Relationships between landscape metric, landscape types and landscape services

Landscape Character Types	Corresponding landscape service according to [3], [15] and [28]		
	Landscape Services	Potential Landscape Metric	Reference
1- Akçay Stream 2- Kemer-Kumluca transportation network with mixed <i>Pinus brutia</i> forests	Ecological functioning- Land Use Diversity	Shannon's Diversity Index (SHDI)	[29], [30]
3- Natural vegetation patches with <i>Pinus pinea</i> forests 4- Natural coastal cliffs	Ecological functioning- Landscape fragmentation	Effective mesh size (MESH)	[31], [32], [33]
5- Dense <i>Pinus brutia</i> forests 6- Sand dune vegetations	Ecological functioning- Presence of water	Total Area (TA), Number of Patches (NP)	[34], [35], [36], [37]
7- Agricultural fields with Citrus gardens 8- Forest area with open and rocky patches	Economic wealth - Machinability of agricultural areas	Shape index (SHAPE_MN)	[38]
9- Mixed forest cliffs with <i>Pinus brutia</i> patches 10- Green houses and	Economic wealth - Infrastructure provision	Effective mesh size (MESH)	[31], [32], [33]

agricultural fields 11- Multi-pattern farming lands 12- Ulupınar Stream	Aesthetic Value- Land cover diversity	Shannon's diversity index (SHDI)	[39], [34], [36], [25], [37]
13- Dense residential area	Aesthetic Value- Landscape complexity	Shape index (SHAPE_MN)	[39]

V. CONCLUSION

A multifunctionality of landscape and landscape services in relation with landscape character types and landscape metrics in Çıralı with ecological, social, cultural, visual and economic services were analysed and discussed in this study.

- Landscape level metric with Shannon's Diversity Index (SHDI) was used for Ecological functioning- Land Cover Diversity and Aesthetic Value- Land cover diversity analyses. SHDI equals minus the sum, across all patch types, of the proportional abundance of each patch type multiplied by that proportion. SHDI value for Çıralı was calculated with 1,4820 units. If there is a single unit of "0" (no diversity) in an area, a type of unit value increases but increases to SHDI. Value for Çıralı as of 1.4820 is important to have and support the diversity of landscape.

- Class level with Effective mesh size (MESH) was used for Ecological functioning- Landscape fragmentation and Economic wealth-Infrastructure provision. MESH equals the sum of patch area squared, summed across all patches of the corresponding patch type, divided by the total landscape area (m²), divided by 10,000 (to convert to hectares). The effective mesh size is suitable for comparing the degree of fragmentation in the landscape. The biggest unit of MESH for Çıralı was Multi-pattern farming lands character types. The lowest unit of MESH was found in Green houses and agricultural fields character types. The lower limit of MESH was constrained by the ratio of cell size to landscape area when the corresponding patch type consists of a single one pixel patch. MESH is max when the landscape consists of a single patch and that means landscape fragmentation is quite few in this unit. Landscape fragmentation is a process of the separation large landscape units into smaller pieces and increases isolation. To protect landscape from fragmentation will be preserved ecosystem integrity and economic infrastructure will be supported in this context in Çıralı.

- Class level metrics were calculated with Total Area (TA), Number of Patches (NP) for Ecological functioning- Presence of water. Total area was found as 4.322,5200 m². Number of Patches refers to a patch in landscape or refers to the number of patches of the entire landscape. The biggest unit for Çıralı was in Dense residential area character types. The lowest units are Akçay stream, Kemer-Kumluca transportation network with mixed *Pinus brutia* forests and Forest area with open and rocky patches character types. Decreasing of the number of patches mean that fragmentation of the region is decreasing. This is important especially for the wildlife, wildlife habitats and regional level coastal / river habitat improvement in Çıralı. Thus means that the movement of wildlife connectivity will increase and water presence of the area will be supported and maintained in 1, 2 and 8 character types.

- Class level metric were calculated with with Shape index (SHAPE_MN) for Economic wealth- Machinability of agricultural areas and Aesthetic Value- Landscape complexity. MN (Mean) equals the sum, across all patches of the corresponding patch type, of the corresponding patch metric values, divided by the number of patches of the same type. MN is given in the same units as the corresponding patch metric. To estimate patch form and size and respective costs for cultivation and harvesting at agricultural sites were used. The biggest units of Çıralı region is Kemer-Kumluca transportation network with mixed *Pinus brutia* forests character type. The lowest unit is Green houses and agricultural fields character types. Green houses and agricultural fields have lowest size of shape index that effects positively to conserve agricultural machinability and sustainability and to support landscape complexity.

In this study, landscape character types of the area with natural and cultural landscape elements, such as streams, dense *Pinus brutia* forests, *Pinus pinea* forests on coastal line, citrus gardens, multi-pattern farming lands and residential areas were perceived as wilderness, pleasant, highly valued, aesthetic and multifunctional. Çıralı region is supporting dynamic multifunctionality of landscape with its landscape diversity, landscape connectivity, water presence as ecological values; conserving agricultural systems as an economical value and to contribute landscape visual complexity as an aesthetical value. Interpretation and conservation works of Çıralı region should be done by integrating to multifunctional approaches with all values from ecological to social.

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