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An Automated Model to Evaluate Landscape Patches with Analyzing the Neighborhood Relations †

Serdar Selim [1,2], Nusret Demir [1,2,*]

[1] Akdeniz University, Faculty of Science, Dept. of Space Science and Technologies, Antalya,Turkey; (serdarselim, nusretdemir) @ akdeniz.edu.tr
[2] Akdeniz University, Graduate Program of Remote Sensing and GIS, Antalya, Turkey
* Correspondence: nusretdemir@akdeniz.edu.tr; Tel.: +90-242-310-3826
† Presented at the title, place, and date.

Received: date; Accepted: date; Published: date

Abstract: Landscape should be analyzed in segments for understanding its texture, structure, function and changes. These segments are used to evaluate landscape structure and function analysis. In this context, the most important segments which form the landscape are the landscape patches. Analysis and understanding of the landscape structure and ecological progress needs the measurement of the landscape patches and evaluation .Therefore, the neighborhood ratio between the patches should be known. In this study, we propose an automated method, which is based on Python language, to compute this ratio with consideration of neighborhood degrees between the patches. The test site is Mugla-Koycegiz town from Turkey, where there is a huge amount population of Sweetgum (*Liquidambar orientalis)* trees, and the town is important for shoreline tourism. Urban area, water surface, agricultural areas, marsh, and forest classes are defined. Sentinel 2A multispectral satellite image is used and Random Forest classification method is applied. The derived patches are produced from the classification, and then converted to the vector form. Each vector boundaries were converted to the point features with 10 m intervals. The ratio of number of points which is neighbor to the specific class to the all points along the boundary is computed automatically with developed script. Three different patches are analyzed, and the results are reported.

Keywords: Landscape patches, Landscape structure, Sentinel 2, GIS, Patch quality

1. Introduction

Landscape should be analyzed in segments for understanding its texture, structure, function and changes. These segments are used to make evaluations and comments for landscape structure and function analysis [1,2]. In this context, the most important segments which form the landscape are the landscape patches. Analysis and understanding of the landscape structure and ecological progress needs the measurement of the landscape patches [3–6] and the derived data should be evaluated in context of landscape ecology. For evaluation of landscape, several metrics are used [1,4,5,7].

Metrics provide any information regarding the components of the mosaic, the distribution of the components in the mosaic and their spatial status, the proportional state between each landscape type or the shape of the landscape elements, and support to interpret the landscape quality [1,4,8]. Landscape metrics can be classified according to patch, class, and landscape scale. Some of these metrics determine the landscape composition and others determine the landscape configuration. Landscape composition and configuration can affect ecological processes independently and interactively[5,9].

Therefore, the metrics used in the evaluation of landscapes are generally classified and measured as area metric, edge metrics, shape metrics, core metrics, contrast metrics, aggregation metrics, subdivision metrics, isolation metrics and diversity metrics [5]. This study focuses on the edge measurements. The Edge Density metric and the mean patch edge are an important indicator of habitat quality [1]. The patch edges constitute the neighboring areas of the vast zones defined as ecoton, where are areas which have the most intense of the interrelationships between different living things [1].

In one region, an increase in the edge density of a particular habitat area indicates that the edge effect is increased [10,11]. As the edge density increases, this is disadvantageous for the inner species in that habitat patch [12]. Low edge density is interpreted as high habitat quality [8]. The edge length and edge density metrics show an interpretation of the quality of the relevant landscape patch, but do not indicate the direction of other land uses adjacent to the landscape patch. That is, it does not measure how positive or negative the agricultural area or a settlement that is adjacent to a landscape patch affects the landscape. In this context, other land-uses adjacent to landscape patches is measured the neighborhood ratio between the patches.

This study proposes an automated algorithm that can be used to show what other land uses adjacent to a landscape patch which affects the percentage of the landscape patch along the boundaries. In the context of the study, the relationship between the proposed model and landscape patches can be evaluated and the effects of environmental land uses on the relevant patch can be interpreted.

2. Materials and Methods

The study area is the town center of Koycegiz, Mugla province of Turkey. The reason of selecting as test site is hosting endemic sweetgum (*Liquidambar orientalis)* tree populations and it is under pressure of environmental land-uses. Test area has the center coordinates of area 36 ° 58'17 "N and 28 ° 41'20" E, located in south-west of Turkey (Fig 1).

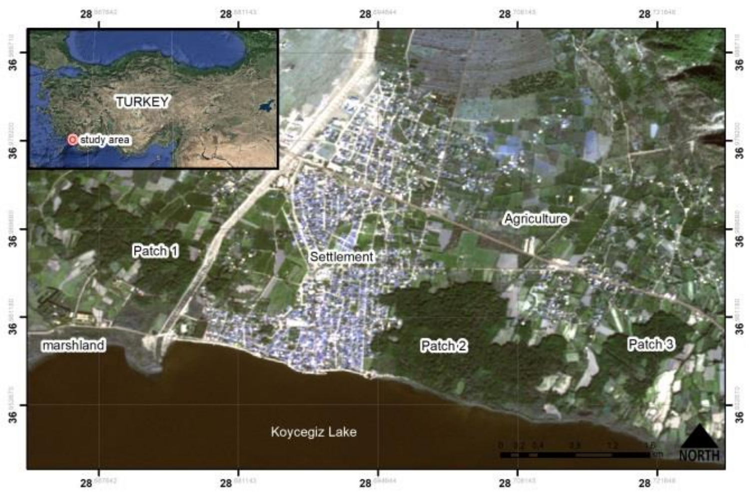

Figure 1. Geographical location of the study area

In the study, 3 sweetgum population areas were selected from the current land uses, including settlements, agriculture, water surface, swamp and stream. Patch 1 has an area of 0, 86 km2, Patch 2 1, 56 km2 and Patch 3 0, 47 km2. The land uses adjacent to the 3 landscape patches are of different size and different quality. In the study, open access Sentinel 2A satellite imagery with 10 m spatial resolution was used as an input data. Random Forest (RF) and Maximum Likelihood Classification (MLC) methods were used for the classification of satellite images, and the highest accuracy value was determined as the RF method by using the (Confusion Matrix) algorithm at the end of the classification, and the classified image obtained by this classification technique was used for each patches.

The study has three steps; Database generation, classification and neighborhood calculation (Fig.2).

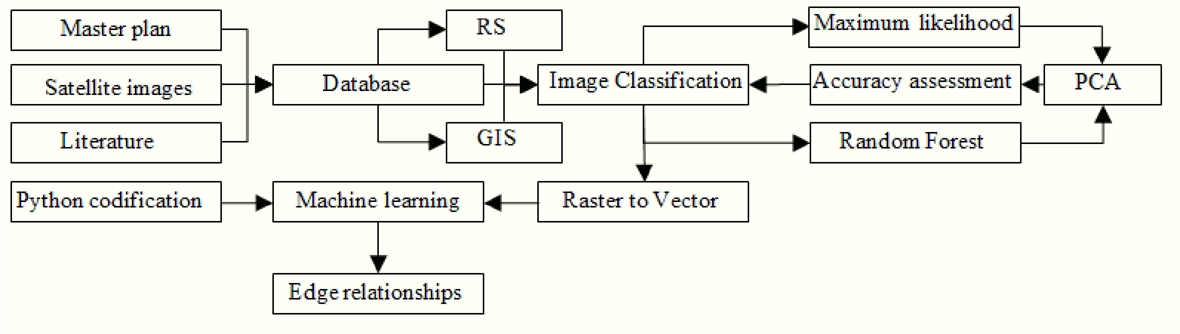

Figure 2. Satellite Image Classification Flowchart

In the first stage, zoning plans, environmental plan and satellite images of the study area were obtained and transferred to GIS and the database was created. The zoning plan and the environmental layout plan were obtained from the related public institutions and the satellite images were obtained through open access and the boundaries were determined by taking into consideration the sweetgum of the sweetgum forests. Within this scope, 3 landscape patches consisting of sweetgum populations in the study area were determined and the study focused on these patches.

In the second stage, 2 different classification techniques were used to perform the classification images on the satellite images, then the classification accuracy was calculated by using the Confusion Matrix algorithm and the raster image obtained by this method was transferred to the third stage after the RF method gave higher accuracy.

In the third stage, the derived classes from raster have been converted to the vector line data, and the lines were converted to the point features in every 10 meters. The closest neighbors of each point have been counted in a table, and then for each boundary, the percentage of neighborhood was calculated.

3. Results

The study area is composed of 6 land uses, namely agriculture, settlement, sweetgum forests, swamp, Lake Ecosystem and stream. All classes have different sized neighborhood relations. In order to determine the neighborhood relations of these classes, classification were applied by RF algorithm. The classification result is shown in Figure 3. Each class is shown in different color.

Figure 3. Image classification result with its legend

As a result of classification, neighboring edges were converted from raster to vector format. Then, the boundaries have been converted to the point features in every 10 meters (Fig.4.).

Figure 4 . Point features of the edges (left), zoomed view(right)

As seen above, the middle parts of the study area and the east are used as settlement areas. These settlements are adjacent to patches 2 and 3. This neighborhood is an indication of the fact that the sweetgum forest patches are under pressure. The patch number 1 located in the west is adjacent to agriculture and river. It can be said that the patch is under pressure in terms of its potential to be used as an agricultural area. The neighborhood ratios of the selected patches (1,2,3) can be found in Table 1.

Table 1. Neighborhood ratios of the three patches (3, 2, 1).

Patch Nr.	Neighbor	NrPCN	TNrP	Ratio (%)
3	Marshland	178	4610	3,86
	Agriculture	4154	4610	90,11
	Settlement	278	4610	6,03
2	Marshland	980	8911	11,00
	Lake	937	8911	10,52
	Settlement	2359	8911	26,47
	Agriculture	4635	8911	52,01
1	Marshland	603	7376	8,18
	Stream	722	7376	9,79
	Agriculture	6051	7376	82,03

Where NrPCN is the total number of boundary points which are neighbors with the neighbor, and TNrP is the total number of points along the boundary of the patch. The sum of the neighborhood ratios for each patch is 100 as expected.

Findings from the study show that the biggest neighbor of the selected landscape patches is the agricultural areas. It can be understood that sweetgum patches are adversely affected by these agricultural areas because it is known that especially in the agricultural areas of the region, one-year crops are grown and pesticides are used to obtain high crop yields. Sweetgum patches adjacent to swamp areas can be said to be affected positively by eliminating water demand. Similarly, the sweetgum patches adjacent to the stream and lake ecosystem are thought to be positively affected. The settlement areas are expected to affect the sweetgum patches negatively as a result of intensive human pressure and the creation of new settlements. The ratios of these positive and negative effects within the context of neighborhood relations are shown in Table 1.

4. Conclusions

The data and theory of landscape patch quality generally support the decrease of the probability of local extinction as the patch area increases [13]. Furthermore, these data show that the reduction of the patch area and the increase in the number of parts reduce the patch quality [14]. Only the evaluation of the patch area and isolation was criticized for being too restrictive. Scientists interested in ecology have used many measures of landscape structure in order to determine habitat loss and patch quality, but these measures are not well sufficient [15]. In this context, in the evaluation of patch quality, scientists emphasize the need to assess environmental variables and current land uses in addition to patch areas [16,17,18]. This study proposes a method based on neighborhood relations in the evaluation of landscape patch quality. An automatic model has been developed to evaluate the positive or negative impact ratio of other land uses adjacent to the landscape patch. The developed model transforms the neighborhood relations of landscape patches into numerical values quickly and practically by using machine learning algorithms. Using these numerical values, it can be understood and interpreted at what rate a landscape patch is affected by its neighbors. Hence, this study proposes an automated method to assist ecology scientists in assessing landscape patch quality.

Author Contributions: Conceptualization by S.S.; Methodology by both, software development and implementation by N.D., Validation and writing the article by both the authors.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest."

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