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An Approach to Comparing Different Land Evaluation Methods with NDVI

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ABSRACT

Land evaluation is a necessary process for determining the potential cabilities of the land under different uses and for sustainable soil fertility. Today, many land evaluation models have been developed and using for this purpose. But the availability of models is constantly being investigated by the researcers. In this study, Storie Index (SI) and Productivity Index (PI) models were compared with NDVI values which are a remote sensing analysis in Konya Beşgözler agricultural field using GIS. In the results of the study, SI land evaluation model was determined with higher accuracy coefficient (r^2: 0.86) compared to PI model (r^2: 0.29) in terms of the ability of the soil cability based on the density of vegetation and the use of this model is recommended for Arid region soils.

1. Introduction

Scientific identification of land resources and potential land evaluations is vital for wisely management of land use. Before build any plan about offer lands for any agricultural uses, land suitability evaluations should be implemented (Sharififar et al., 2012).

Technically each land unit should be used for an application which is suitable for that application (FAO 1976). For this purposes, there is a need for land evaluation studies to determine the best land use (Zhang et al., 2004). Many methods have been developed for land evaluation like Storie Index (Storie 1937), land capability classification system (Klingebiel et al., 1961), FAO Framework for Land Evaluation (FAO 1976), Soil Productivity Index (Delgado 2003). Following the publication of the these methods, many countries and researches was begin to try this systems or built up their own systems, based on the theory and methodology of the soil science (Dengiz, 2013; Xingwu et al., 2015). But, it is still debated that this methods of which give the best results (Li et al., 2013). Several factors affect the land capability and choosing a suitable method or methods should be careful measurement of the factors in order to determine the impact levels of soil characteristics (Dengiz and Sarioglu, 2013; Danvia et al., 2016). For this reason different models need to be tested with reliable techniques.

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Today, computing technologies that is combined with GIS and Remote Sensing software enabled such applications (Manna et al., 2009). Especially, remote sensing imaging is considered one of the main sources of information about the land vegetation (Campbell 2002).

The vegetation status is concerned with the development of plants and it is directly related to the crop potential yield of the soils (Sys and Debaveye 1991). Therefore, the compatibility of the land evaluation methods is compared with the yield values in many studies (Brinkman and Smyth 1973; Davidson 1986; Hall and Subaryono 1991; Sharififar et al., 2012). With the latest technological developments on applied of remote sensing, we have been obtaining about the product yield of lands. The most common remote sensing technique used for this purpose is the vegetation indexes (Al-doski et al., 2013), and the most widely-used vegetation index is a Normalized Difference Vegetation Index (NDVI) (Tucker 1979; DeFries and Townshend 1994; Garrigueset al., 2007; Tyagi and Bhosle 2010). NDVI is sensitive to active photosynthetic compounds and is therefore a popular way to measure the productivity of vegetation, or “greenness,” in a defined area (Tucker 1985).

In this study Productivity Index (PI) and Storie Index (SI) land evaluation methods were used and tested according to the plant biomass obtained by using NDVI in Konya - Beşgözler that has been used under intensive agricultural activity.

2. Materials and Methods

2.1. Study area and satellite image

The study area was Konya Beşgözler with an area of 5140 ha (Figure 1). It is located between 38 ° 31 '- 38 ° 16' North latitude and 32 ° 16 '- 32 ° 19' East longitude. The distance to the center of Konya province is 56 km. In addition, the study area is located in the middle of the Sarayönü and Kadınhanı district boundaries, with Cihanbeyli and Yunak in the north and Selçuklu district in the south.

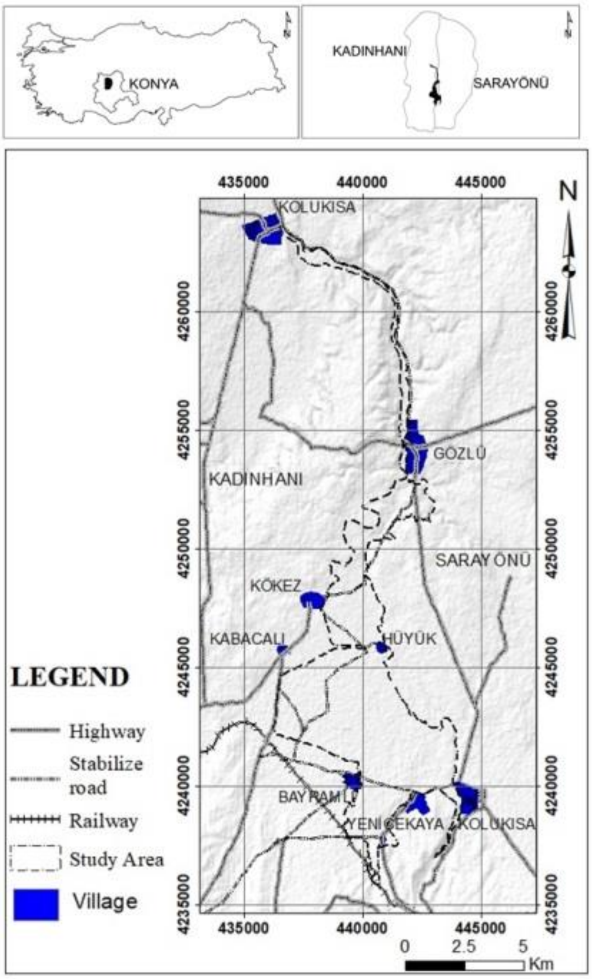

Figure 1

Study area

This area has a terrestrial climate characteristics with annual rainfall of 322.5 mm and annual temperature average is 11.5 ° C. According to the multi-year average annual temperature is carried out July with the highest 23.9 ° C (Anonymous 2015). According to the climate characteristics, it was determined that the soil is in Aridic moisture regimes and Mesic temperature regime (USDA 2014).

2.2. Soil samples and laboratory analyzes

To scoring the soil characteristics according to land evaluation methods were used laboratory analysis results obtained from laboratory analyzes of soil samples taken from six soil profiles on the basis of the horizon. The range of selected profile points where presented Figure 2. We defined 10 profile points on the 4 different physiographic units which were determined as mud flow (MF), flood plains (FP), side stream alluvium (SSA) and old stream terrace (OST).

The soil horizons and their depth, and chemical and physical properties were determined including; electrical conductivity, pH, bulk density, organic carbon, texture, available water content, phosphorus contents, exchancable potassium and sodium contents, carbonate content, structure (Soil Survey Lab. 2004). Descriptive statistics of laboratory analyzes have been presented Table 1. According to laboratory analyzes were determined that most of the study area have heavy textured and included low organic matter content, alkaline pH, high lime, high exchangeable cations and sufficient P values.

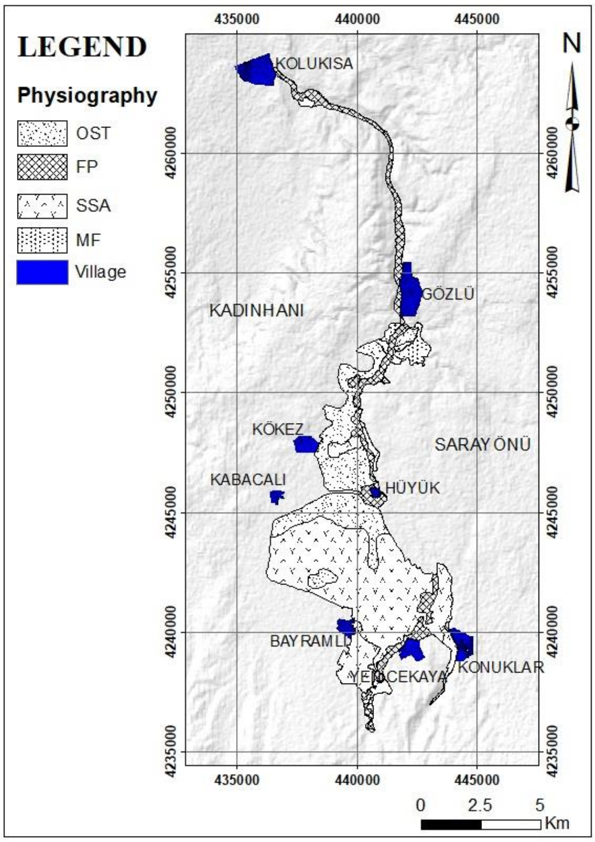

Figure 2

Profil points

It has been determined that the physical and chemical properties of soils, which have clay (C)– clay loam (CL) texture and varying depth between 30-150 cm are distributed at different levels.

2.3. Image processing, NDVI analysis and map produce

The study, we were carried out on the Landsat-5 satellite image in June 2010. The dataset has 30 m spatial resolution with 5 channels: B1 (0.45-0.52), B2 (0.52-0.60), B3 (0.63-0.69µm), Near Infrared B4 (0.76-0.90) and Short-wave infrared B5 (1.58–1.75 µm). The radiometric resolution of the dataset is 8 bit. Radiometric correcting has been done by image provider and type of product is referred to as level 1. Besides, geometric correcting was done by using Google Earth Application as manually and the spatial reference (Datum) was selected UTM/WGS 84.

The NDVI analysis was used to determine the vegetation status in the study. NDVI is sensitive to active photosynthetic compounds and is therefore a popular way to measure the productivity of vegetationin a defined area (Tucker 1985). NDVI values are calculated according to the following formula;

NDVI = (NIR – RED) / (NIR + RED)

NIR = Near infrared band

RED = Visible red band

In Landsat 5 satellite images, band combinations are selected as follows.

NDVI = (Bant 4 – Bant3) / (Bant4 + Bant3)

We used Erdas Imagine 9 (ERDAS 2009) to perform NDVI analysis, and ArcGis 9.3 (ESRI 2010) software was used to store data and generate thematic maps.

2.4. Land evaluation applications

In order to determine the qualifications of the lands were used Productivity Index (PI) and Storie Index (SI) land evaluation methods. Productivity index (PI) model developed by Delgado for erosion sensitive land in Venezuela (Delgado 2003). The main principle in the construction of this model is the necessity of optimum conditions in the root zone of the plant in order to ensure the best development of the plant in soil. For this purpose, the equality has been presented below.

$$PI = \sum_{i=1}^{n} (Ai\,.Bi\,.Ci\,.Ki)$$

Where;

PI is the Soil Productivity Index ranging from 0 to 1. Value 1 corresponds to a soil without any kind of limitation for root development. In the present approach factor Ai evaluates conditions that regulate the airwater relations of horizon i; factor Bi evaluates the conditions that determine mechanical resistances (impedances) to the crop root exploration in horizon i; and factor Ci evaluates the conditions that regulate the potential fertility of horizon i. Finally Ki evaluates the relative importance of horizon i in the soil profile (weighting factor of the respective horizon) and also the importance of soil depth. Ranking soil productivity in terms the PI shown in Table 2.

Table 1
Descriptive statistics of soil samples

Variable	N	Mean	Max.	Min.	SE Mean	StDev
% OC	27	0,63	1,55	0,034	0,092	0,48
P mg / kg	27	9,56	37,99	2,43	2,08	10,80
pH 1:1	27	8,07	8,75	7,61	0,07	0,36
EC (µmh/cm)	27	697,50	1703,0	338,0	55,7	289,3
K me/100g	27	0,67	1,68	0,23	0,07	0,37
Na me/100g	27	0,734	2,84	0,05	0,17	0,90
CaCO3	27	35,25	65,80	17,88	2,80	14,53
Pb g cm-3	27	1,29	1,36	1,21	0,01	0,04
AW V,%	27	14,73	20,22	8,42	0,50	2,59

Table 2
Evaluation of the final score for PI (Delgado, 2003)

PI	Soil productivity	Score
S1	Very High	> 0.50
S2	High	0.31-0.50
S3	Moderate	0.10-0.30
S4	Low	< 0.10

The Storie Index model, first used for tax purchases in California in 1930, it was revised in 1978 and now it is widely used a parametric land evaluation method in many research and public organizations (Storie 1937; Verheye 2009). With the SI, different soil characteristics of the study area are evaluated as a factor and the efficiency potential of the soil is graded for land. Method formulation and used factors presented below.

Storie Index (SI) = A x B x C x X

A- Soil profile group B- Surface texture

C- Land slope X- Other soil properties

The Storie Index assesses the productivity of a soil from the following four characteristics: A, the degree of soil profile development; Factor B, surface texture; Factor C, slope; and Factor X, other soil and landscape conditions including the subfactors drainage, alkalinity, fertility, acidity, erosion, and microrelief. A score ranging from 0 to 100% is determined for each factor, and the scores are then multiplied together to generate an index rating (Storie 1937).

3. Results and Discussion

Physical and chemical analysis results of soil samples and their function with land characteristics were used by SI and PI land evaluation models. With two different models have been determined addition agricultural suitability classes and their spatial distribution. Result of land evaluation has been produced the maps of suitability classification presented Figure 3 and Figure 4.

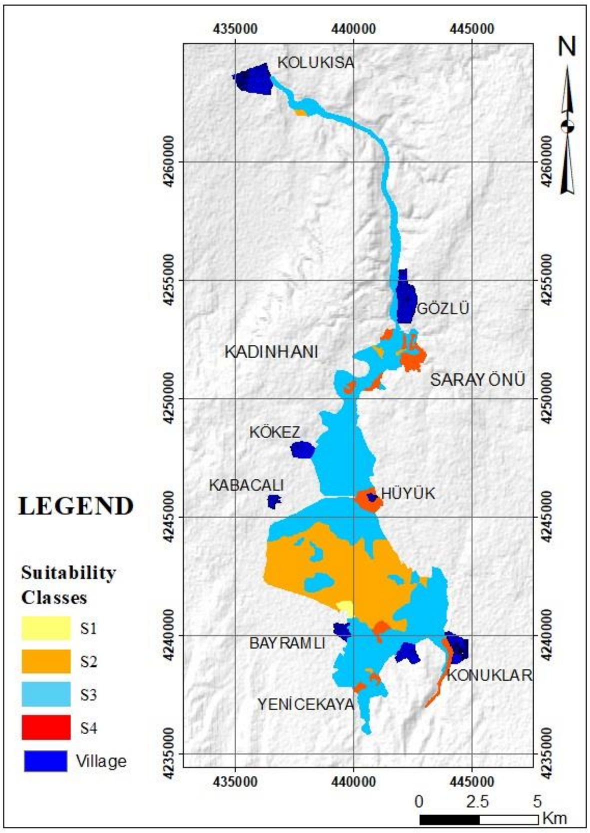

Figure 3.

Distribution of SI land evaluation classes

According to the results of suitability classifications with different land evaluations were determined that PI : 764.84 ha (%14.90), SI : 39 ha (% 0.75) for Class I (S1) elite agricultural land, PI : 4384 ha (%81.92), SI : 4845 ha (% 94.36), for Class II-III (S2-S3) good and medium quality agricultural land. Low quality and unsuitable agricultural lands were found by PI: 163.93 ha (% 3.19), SI: 251 ha (% 4.89) as Class IV (S4). It was stated that the SI model gave reliable results in the field evaluation and qualification studies but it was insufficient in determining the land use types (O'Geen et al., 2008).

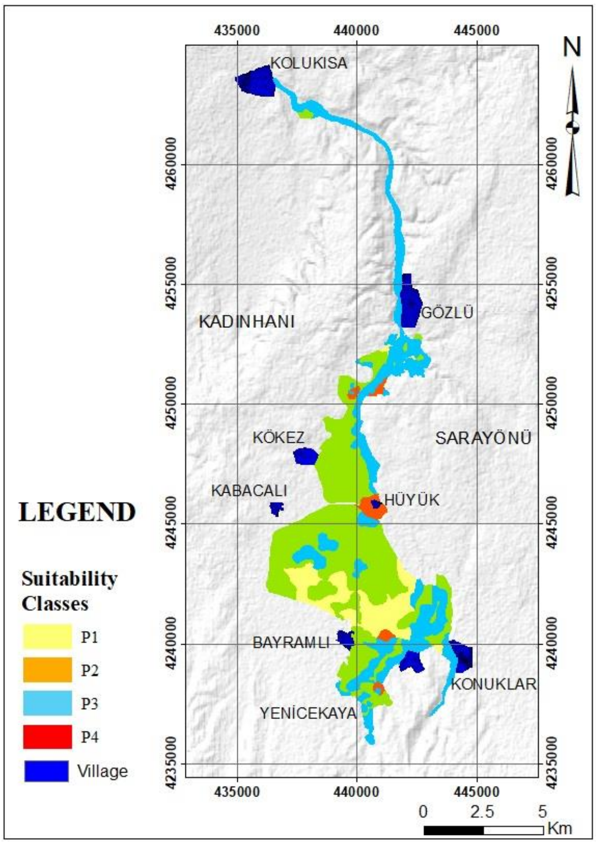

Figure 4

Distribution of PI land evaluation classes

Similarly, the SI model and the SQR model were compared in Germany and they were classified in a similar land qualities but, It has been reported that the SI model should be supported by different parametric approaches in selection of plant species (Mueller et al., 2010). PI model can be used to determine the productivity capabilities of mountainous and steep slopes area in China. The researchers found a similarity of 83% between the evaluative product yields made with the useful K and P factors added to the PI model and the agricultural suitability classes obtained from the model (Xingwu et al., 2015), and researchers indicate that this practical model has been validated in many locations, including the northeast black soil region of China (Duan et al., 2012). In a similar study has been done comparison of the storie index method with the land quality index method which can be used in determining the agricultural suitability in Samsun – Turkey and the resercears stated that SI makes different suitability classification from the LQI. This situation requires discussion of the situations in which different land rating methods are used (Dengiz et al., 2014)

In our study was investigated that, the reliability of SI and PI models has been tested with NDVI values for determining the productivity potential of the field study. With the results of the NDVI calculation was categorized according to (Tucker 1985) and this values was converted into agricultural suitibility classes (Table 3). According to the results of NDVI land quality classes, the best vegetation density are determined for Class I (S1); 39.56 ha (0.77%), good and medium vegetation density land for Class II -III (S2-S3); 4039.92 ha (78.59%) and low vegetation density for Class IV; 1061.14 ha (20.64%). NDVI spatial distribution map, which generated from Landsat 5 satellite image, was presented at Figure 5.

Table 3.
NDVI land quality classes

NDVI values	Classes
> 0.85	S1
0.61-0.85	S2
0.31 -0.6	S3
< 0.3	S4

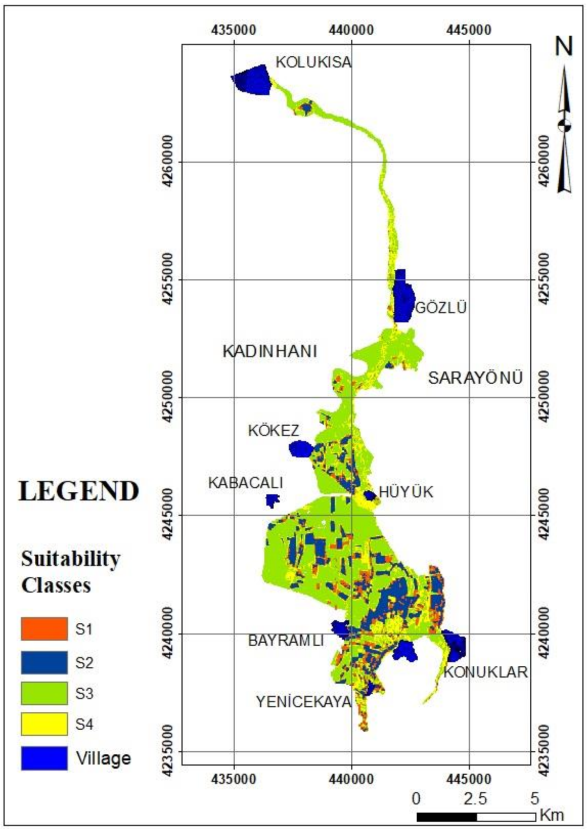

Figure 5
Map of agricultural suitability classes by NDVI

The spatial distribution of the SI and PI suitability classes was statistically compared with the classes generated from the NDVI vegetation density values. According to the results of the statistical analysis (Figure 7 and Figure 8), SI land evaluation model was determined with higher accuracy coefficient (r^2 : 0.86) as far as PI model (r^2 : 0.29) to the ability of the soil cability depends on the density of vegetation.

In recent studies also support our findings. Researchers compared the relationship between Storie Index (SI), Visual Soil Assessment (VSA), A Raw Land Evaluation (RLE), Agro-Ecological Zones (AEZ) and The Muencheberg Soil Quality Rating (M-SQR) land evaluation methods with productivity and the SI and M-SQR models were found to give high accuracy rates to determine the productivity potential of the soil (Mueller et al., 2010). Additionally, it has been reported that the SI model can be used as a reference in determining the ability of new methods (O'Geen et al., 2008).

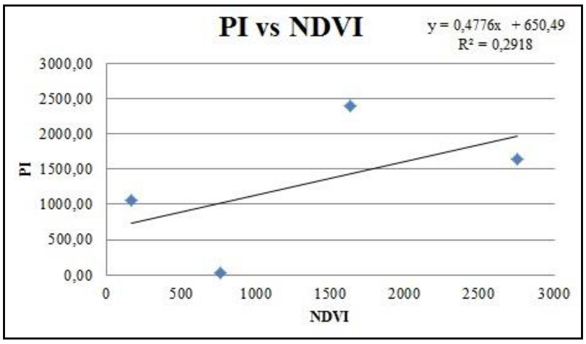

Figure 7
Comparison of NDVI and PI

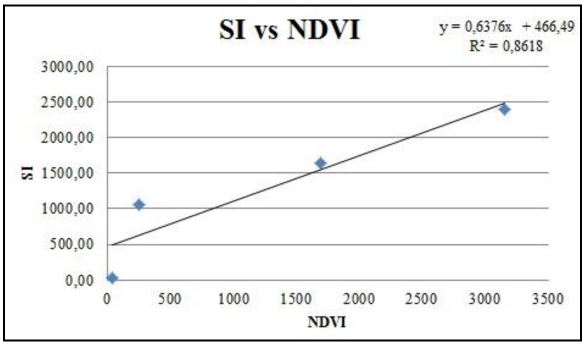

Figure 8
Comparison of NDVI and SI

Comparison of the agricultural quality classes determined using the PI model with the 40-year wheat yield values indicates that the correlation between the resultant PI model and the existing productivity potentials of the soil is low and the PI model is not suitable for use in qualified land (De Paepe and Alvarez 2013), and PI model is suitable found for determining the suitable areas for crop cultivation in mountainous regions (Li et al., 2013).

4. Conclusions

The comparison of the SI and PI land evaluation methods with the NDVI values was found that of the SI model (%86) more reliable than the PI model (29%) in identification of soil capability. As a result, although the SI model is a very old method, it can still be used to determine the productivity potential of the soil. On the other hand, it is necessary to develop for the PI model by using different parameters (for example; Soil nutrients), otherwise the PI model cannot accurately measure the quality of the soils as it exists.

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