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Agroecological land use potential of Amik Plain, Turkey

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Abstract: The loss of agricultural land due to the development of other land uses has increasingly become an issue of local, regional, and national concern in Turkey. This study was aimed at evaluating land use potential and suitability of 174 land mapping units of 72,544 ha in Amik Plain (Hatay, Turkey) for 21 different land use types. For this purpose, land suitability evaluation was carried out using soil and land data and a PC-compatible ILSEN software package program developed by the SENOL land evaluation system. Our study showed that out of 39 potential groups, 26 combined land uses and land covers (LULC) occupied less than 1% of the study area. Nearly 15.6% (11,090 ha) of the study area was found suitable for all of the horticultural crops and related land cover. The land area suitable for the entire field crops was estimated to cover 12.3% (8727 ha) of the study area.

Key words: Land evaluation, land use, agricultural land suitability class

Amik ovasının tarımsal-ekolojik arazi kullanım potansiyeli

Özet: Türkiye'de tarım alanlarının, diğer kullanımların gelişimi sonucu kaybedilmesi, yerel, bölgesel ve ulusal düzeyde büyüyen bir sorundur. Bu çalışma ile 72,544 ha alana sahip Amik ovasında (Hatay, Türkiye) yer alan 174 arazi haritalama biriminin 21 farklı arazi kullanım türü için arazi kullanım potansiyelinin ve uygunluğunun değerlendirilmesi amaçlamıştır. Bu amaçla arazi uygunluk değerlendirmesi, SENOL arazi değerlendirme sistemine göre ILSEN paket programında toprak ve arazi verileri kullanılarak yapılmıştır. Çalışma sonucunda, programca oluşturulan toplam 39 potansiyel kullanım grubundan 26 tanesinin her birinin çalışma alanının % 1'inden daha az alan işgal ettiği belirlenmiştir. Çalışma alanının yaklaşık % 15.6'sının (11,090 ha) değerlendirmeye alınan bahçe bitkileri arazi kullanım grubuna uygun olduğu bulunmuştur. Değerlendirmeye alınan tarla bitkilerinin hepsine uygun arazi miktarı çalışma alanının % 12.3 (8727 ha)'ünü kaplamaktadır.

Anahtar sözcükler: Arazi değerlendirme, arazi kullanımı, tarımsal kullanıma uygunluk sınıfları

Introduction

Changes in land use and land cover (LULC) are one of the most clearly visible consequences of the human alteration of the biophysical environment and biogeochemical cycles. Land evaluation is formally defined as "the assessment of land performance when used for a specified purpose, involving the execution and interpretation of surveys and studies of land forms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison

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of promising kinds of land use in terms applicable to the objectives of the evaluation" (FAO 1976). Conceptually, land evaluation requires the matching of the ecological and management requirements of relevant kinds of land use with land qualities, while accounting for local economic and social conditions (FAO 1977, 1980). The use of land depends on complex, interrelated factors such as qualitative and quantitative characteristics of the land, socioeconomic factors, legal and political constraints, and the needs and objectives of land users (FAO 1980; Evrendilek and Ertekin 2002; Kılıç et al. 2003; Kiliç et al. 2005; Kilic et al. 2006; Kılıç et al. 2008).

A large body of literature (Houghton et al. 1983; Turner 1990; McDonnell et al. 1993) suggests that land use and management practices are crucial for biogeochemical cycles at local, regional, and global scales. Today's environmental managers, urban planners, and decision makers are increasingly expected to examine environmental and economic problems in a larger geographic context. To accomplish this, it is necessary to understand the scale at which specific management actions are needed, conceptualize environmental management strategies, formulate sets of alternatives to reduce environmental and economic vulnerability and uncertainty in analyses, and prioritize, conserve, or restore valued natural resources, especially those that provide vital ecosystem goods and services (Kepner et al. 2004).

To ensure environmental quality, decision makers in the European Community must promote best management practices (BMPs). Given the strong interactions between pedoclimatic conditions and management practices, decision support systems are useful tools for selecting BMPs. Determination of land use potential is a necessary condition for land use planning to proceed on a rational and sustainable basis. Productivity and biodiversity of ecosystems can be maintained and secured only if land evaluation and monitoring studies are put into practice (FAO 1977; Şenol 1983, 1994; Evrendilek and Ertekin 2002).

The loss of primary farmlands to urban sprawl and other uses has increasingly become an issue of local, regional, and national concern in Turkey (Kılıç et al. 2003; Kiliç et al. 2005). It results in declined soil organic carbon pools, thus decreasing carbon sequestration (Kilic et al. 2006) as well as leading to other problems. This, in turn, will increase the net emissions of carbon dioxide (CO_2) into the atmosphere. A number of studies exist that validate the contribution of various individual, site-specific conservation practices for increased stocks of soil organic carbon. Carbon levels in the soil are determined by the balance of inputs through crop residues and organic amendments and carbon losses through decomposition and mineralization of soil organic matter. Thus, detection of changes in land use and land cover is an important monitoring activity for sustainable land management (Evrendilek et al. 2004, 2007).

The methodology and terminology of land evaluation as specified by the FAO Framework (FAO 1976) has been widely adopted and applied to the design of various land evaluation systems, such as the LECS system (Wood and Dent 1983), ALES (Rossiter and Van Wambeke 1995), MicroLEIS (De la Rosa et al. 1992), ILWIS (Meijerink et al. 1988), and ILSEN (Şenol and Tekeş 1995). A standardized database and accurate and dynamic quantifications of natural resources are the foundation on which land use decisions should be based (Şenol 1994; Dinç and Şenol 1997; Evrendilek and Ertekin 2002).

This study was aimed at evaluating the use potential and suitability of 174 land mapping units of about 72,544 ha in Amik Plain (Hatay, Turkey) for 21 different land use types. For this purpose, land suitability evaluation was carried out using soil and land data and a PC-compatible ILSEN software package program developed by the SENOL land evaluation system (Şenol 1983, 1994; Şenol and Tekeş 1995).

Materials and methods

Study area

The study area (35°48′-36°37′N, 35°47′-36°24′E) covers about 72,544 ha and is surrounded by Nur Mountain (1073 m) in the west, Syria in the east, the towns of Hassa and Kırıkhan in the north, and the city of Antakya and the town of Altınözü in the south. Climate data from between 1950 and 2000 were obtained from the existing meteorological stations in the area. The climate regime prevalent in the study area is a Mediterranean climate characterized by a hot, dry summer and a mild winter, during which about 67% of the annual precipitation of 1124 mm falls. The mean monthly temperature reaches a maximum of 44 °C in August and a minimum of −15 °C in January, with a mean annual temperature and evaporation of 18 °C and 1877 mm, respectively (Kılıç et al. 2003; Kiliç et al. 2005; Kilic et al. 2006).

Parent materials of the study area consist mostly of alluviums and lacustrines. Lacustrines are relatively flat and often have parent materials with uniform properties. The alluvial soils formed by the Orontes, Afrin, and Karasu rivers are the most productive soils. Lake Amik, approximately 53 km^2 in the northwestern part of Amik Plain, was drained into the Orontes River in order to increase the area of croplands. The availability of irrigation water from surface or subsurface sources is a crucial factor for the growth of crops. The seasonal variability of water availability has resulted in 2 main categories of crops: rainfed crops (sown in autumn) and irrigated crops (sown in spring). Current land use is almost entirely agricultural in Amik Plain. The dominant crops consist of cotton, wheat, and corn (Kılıç et al. 2008).

The major soil orders include Entisol, Inceptisol, Vertisol, Alfisol, and Mollisol (Figure 1). The soils of Entisol were classified as belonging to suborder Fluvent and great group Xerofluvent. The Aşağıoba, Tuzluköy, and Hamda series were classified in subgroup Aquic Xerofluvent. The Apaydın, Muratpaşa, Kayıbucak, Arpalı, Bektaşlı, Keçebek, and Bereket series were included in subgroup Vertic Xerofluvent. The Saçaklı, Asi, Sırdan, and Kumlu series were classified in subgroup Oxyaquic Xerofluvent. The Günova, Karasu, Kurtuluş, Huzurevi, Serinyol, Narlıca, and Afrin series were included in subgroup Typic Xerofluvent. A total of 9 soil series in the study area were classified as belonging to the order Vertisol. These series with high percentages of clay content have cracks that shrink and swell periodically. The Yılanlı series was classified as suborder Aquert, great group Epiaquert, and subgroup Xeric Epiaquert. The other Vertisol soil series included subgroup Xeric. The Karacanlık and Suvatlı series were classified in subgroups Chromic Calcixerert and Aquic Haploxerert, respectively. The Çiftlice, Akkuyu, Akkerpiç, and Samsunlu series were included in subgroup Chromic Haploxerert. The Reyhanlı series were included in subgroup Typic Haploxerert. Twelve soil series in the study area were classified as belonging to the order Inceptisol. The Eşrefiye, Comba, and Kazkeli series were included in suborder Aquept and subgroups Histic Humaquept and Aeric Halaquept. Bağlama was included in suborder Xerept and subgroup Vertic Calcixerept. The Kangallar, Üçtepe, Gençovası, Karatepe, Topboğazı, Sazyurdu, Karali, and Mursaloğlu series were classified as suborder Xerept and subgroup Typic Calcixerept. As the Süleymanlı, Acarköy, Aktaş, Suluköy, Karabatak, and Yeniköy series have an ochric epipedon and argillic horizon while the Süleymanlı, Acarköy, and Aktaş series have a calcic horizon, these series were classified as order Alfisol, suborder Xeralf, and great group Haploxeralf. The Paşaköy, Mahmutlu, and Arpahan series were classified as belonging to order Mollisol by virtue of their mollic epipedon. These series were included in suborder Xeroll, great group Haploxeroll, and subgroup Fluventic Haploxeroll (Kılıç et al. 2003; Kiliç et al. 2005; Kilic et al. 2006).

In the study area, 9 physiographical units and 51 different soil series were delineated. A total of 174 land mapping units (LMUs) differing in 1 or more land characteristics were identified from the 51 different soil series for land evaluation. The physiographical units consisted of an alluvial clay trough, alluvials by the Orontes and Afrin rivers, the young terraces of the Orontes and Afrin rivers, the bed of the old Amik Lake, alluvial fans, bajadas, colluvials, and mountain foot slopes. The soil surveys revealed that orders Entisol, Inceptisol, Vertisol, Mollisol, and Alfisol accounted for 24.6%, 19.7%, 32.7%, 6.2%, and 14.0% of the study area, respectively (Figure 1). The remaining 2.8% for urban area was not surveyed (Kılıç et al. 2008).

Process of land evaluation

A land evaluation system developed in light of FAO principles (1977) by Şenol (1983, 1994) and a PC-compatible ILSEN package program developed by Şenol and Tekeş (1995) were used in the quantitative assessment of the biophysical potential of the ecosystems in the study area (Kılıç et al. 2003; Kiliç et al. 2005). The process of land evaluation used in this study is presented in Figure 2. This study was aimed at determining the land use and land

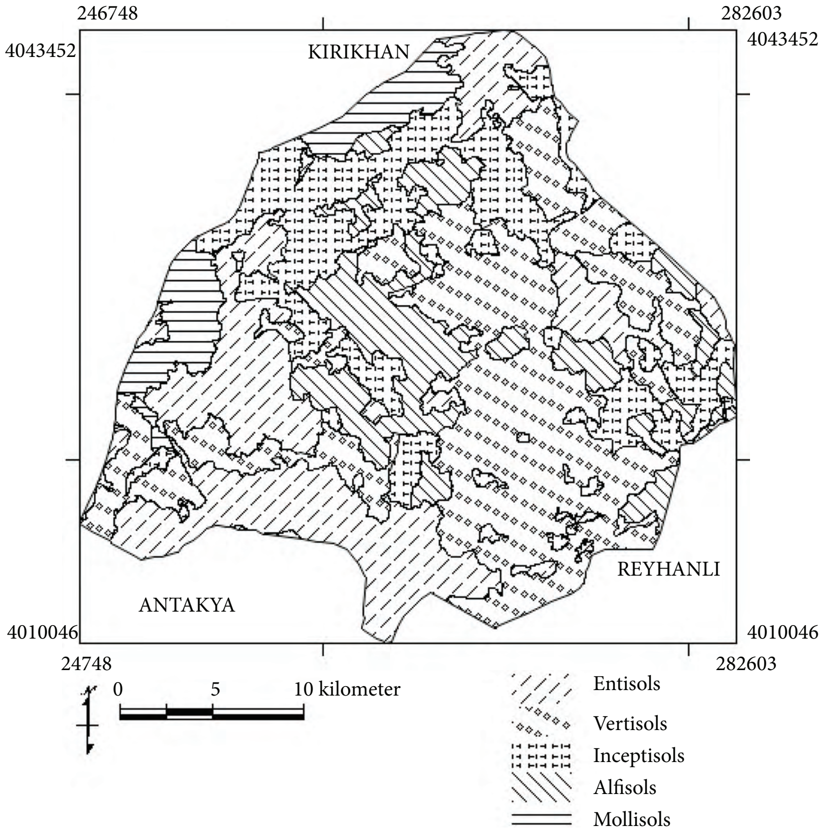

Figure 1. Soil classification map of Amik Plain.

cover (LULC) potentials of Amik Plain (Antakya, Turkey), 72,544 ha, for a total of 26 different LULC types: 10 horticultural crops, 11 field crops, and 5 nonagricultural lands were identified for land evaluation by assessing ecologically, socially, and economically compatible LULCs in the study area.

Potential LC types were classified as 10 horticultural crops including plum-apple trees, olive trees, strawberries, tomato-eggplant-pepper, melon-zucchini-cucumber, beans-peas-kidney bean-okra, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, carrot, and onion-garlic; and 11 field crops including wheat, cotton, potato, corn, soybean, peanuts, chickpea-lentils, alfalfa-vetch, rapeseed, sunflower, and flax. LULC requirements (LULCRs) refer to the demand side of the land use or a land area matching procedure, namely to the conditions of the land necessary for sustaining a specified LULC productivity (Rossiter 1996). LULCRs were determined using expert local knowledge, related literature information, and available data.

Land mapping units (LMUs) and their associated land characteristics (LCHs) were identified using a soil survey and topographical and geological maps at a scale of 1:25,000 in combination with aerial photos and Landsat-7 ETM satellite images. The soil survey was conducted to derive a detailed soil map of Amik Plain (72,544 ha) within the province of Hatay (5403 km^2). Physiographic units were derived from black and white aerial photos at a scale of 1:25,000, after which a ground-truth survey was carried out in representative areas. In each physiographic unit, different LMUs were differentiated based on air photo interpretation techniques for the interrelationships among soil, topography, geology, and physiography, and the classification of the Landsat imagery. Soil profile descriptions for each LMU polygon were recorded according to the manual of the USA Soil Survey Division Staff (1993) with the inclusion of parent materials, topography, soil depth, drainage, presence of gravel, slope, aspect, and erosion.

Soil samples taken in each LMU were analyzed for the following soil characterizations as outlined by Page et al. (1982): soil organic matter, calcium carbonate, pH, soil texture, cation exchange capacity, and total salt content. The delineations of LMUs (polygons) were confirmed with an auger.

Insignificant differences were observed in the values of pH. All series were slightly alkaline, ranging from pH 7.2 to 8.3, and had a very high base saturation. Soil organic matter (SOM) for a depth of the upper 2 horizons ranged from 0.6% to 3.9%, except for the SOM-rich histic epipedon (20%-22%). Bulk density (BD) of the soils varied between 0.68 and 1.58 g cm^{-3}. The high clay content of the soils, ranging from 21.9% to 87.3% for all horizons, causes poor drainage conditions in about 70% of Amik Plain. Although a salic horizon did not exist in the soils of the study area, some soil series had slightly and moderately soluble salt content. Soil CEC varied between 23 and 68 meq 100 g^{-1}. Except for only 2 soil series (Paşaköy and Karasu), all of the series had high $CaCO_3$, ranging from 22.5% to 58.7%. Five soil series (Kangallar, Karacanlık, Bağlama, Comba, and Acarköy) had a calcic horizon (Kılıç et al. 2008).

Soil orders, suborders, and great groups were classified based on the above analyses of the soil profiles and samples (Soil Survey Division Staff 1998). The ILSEN computer program, a land evaluation system developed in light of FAO principles (FAO, 1976) by Şenol and Tekeş (1995), was used to quantify the potential suitability of LULCs ecologically and economically in the study area (Şenol and Tekeş 1995). The above LCHs were coded into a computer according to the number of subcategories of the LCHs (e.g. slope classes). Similarly, each LMU was coded according to the values of the LCHs that the LMU took on.

The suitability rating index (SRI) is a function of LULCRs and LCHs:

$SRI = ¦\{LULCR_{LULC}, LCH_{LMU}\}$.

Matching values of the LULCRs of a given LULC and the LCHs of a given LMU, based on a group of local experts' knowledge, results in SRI values. All values of SRI were standardized to the common scale [0…1]; the least favorable SRI value is 0 and the most favorable SRI value is 1. All SRI values were assumed to be of equal weight. The higher SRI values represented the greater suitability of LMUs for each LULC (Kiliç et al. 2005).

The biophysical suitability index (BSI) of each LMU and LULC was calculated as the product of the SRI, as follows (Rossiter 1996):

$$BSI_{LMU\_LULC} = \prod_{i=l}^{n} SRI_{LCHi\_LMU\_LULC},\ SRIi \in [0\ldots1].$$

The BSI values showed the extent to which the biophysical requirements of each LULC matched the biophysical characteristics of each LMU. In other words, each LMU was assigned a BSI value expressed on a discrete classification scale of suitability for a specific LULC. In addition to biophysical assessment, economic assessment was carried out by gathering statistical data on expenses and income for all of the specified agricultural LCs. A standardized agricultural profitability index (API) for each LC was calculated as follows:

Standardized API_{LC} = each API_{LC} / maximum API_{LC},

where API_{LC} = [crop yield (kg ha^{-1}) × sale price (US\$ kg^{-1})] – expenses (US\$ ha^{-1}).

The classification approach of the FAO Framework for land evaluation was adopted in terms of land suitability classes (S for suitable and N for unsuitable) (FAO 1976). Suitability of a LMU for a given LULC was expressed on the following standardized scale: class S1 refers to highly suitable (1.00-0.90), class S2 to moderately suitable (0.89-0.75), class S3 to marginally suitable (0.74-0.50), class N1 to currently not suitable (0.49-0.25), and class N2 to permanently not suitable (0.24-0.00). The data for individual LMUs were assessed to determine whether they achieved the conditions for S1 land, and, if not, the process was repeated for the S2 conditions and subsequent classes as necessary. Potential groups of highly and moderately suited LULCs were produced based on biophysical evaluations of LMUs (Kılıç et al. 2003; Kiliç et al. 2005).

An agricultural land suitability index (ALSI) was calculated using the multiplicative combinations of biophysical and economic assessments (Figure 2). Biophysical assessment of the land refers to the use of such ecosystem characteristics as soil, physiography,

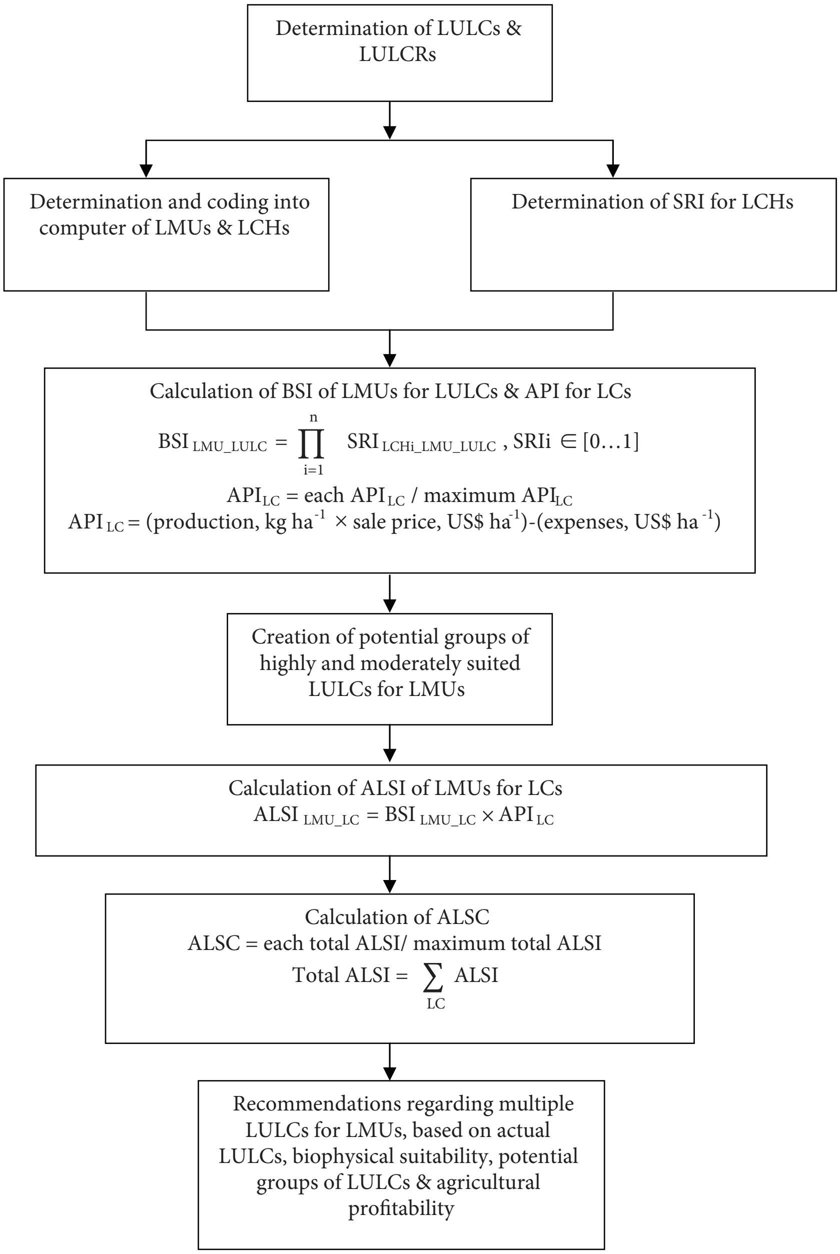

Figure 2. Flow charts of evaluation process of suitability of land uses (LUs) and land covers (LCs). LULCs: land uses and land covers, LULCRs: requirements of land uses and land covers, LMUs: land mapping units, LCHs: land characteristics, SRI: suitability rating index, API: agricultural profitability index, ALSI: agricultural land suitability index, and ALSC: agricultural land suitability classes (Kiliç et al. 2005).

climate, LULCs, and biological productivity as inputs to the procedure of land evaluation (FAO 1976, 1977, 1980). Agricultural land suitability classes (ALSC) were derived by standardizing total ALSI values for LCs as a ratio of total ALSI to maximum total ALSI. Some LMUs were determined suitable for agricultural LCs, some LMUs suitable for nonagricultural LUs, and some LMUs suitable for both horticultural and field crop-related LCs. Finally, recommendations regarding multiple LULCs for LMUs of the study area were posed based on actual LULCs, BSIs, potential groups of LULCs, ALSIs, and ALSCs.

Results

According to the requirements of the LULCs, SRI values were estimated for each LULC. Based on the multiplicative combination of SRI values, BSI values revealed the suitability classes of the 174 LMUs for the 5 LUs and 21 LCs. For the study area, 39 potential combinations of LULCs were identified based on the relative BSI values. Out of the 39 potential groups, 26 combined LULCs occupied less than 1% of the study area (Table 1). Nearly 15.6% (11,090 ha) of

Table 1. Potential groups of land uses (LUs) and land covers (LCs).

Potential groups of LULCs	Land area (%)	Potential groups of LULCs	Land area (%)
H0F0L0	12.88	H8F12L0	0.56
H0F0L2	0.04	H8F17L0	1.28
H0F0L3	0.05	H9F3L2	0.11
H0F2L0	15.26	H10F16L0	2.41
H1F7L0	0.21	H11F12L0	0.62
H1F8L0	1.90	H12F4L2	0.20
H2F11L0	5.53	H13F5L2	0.19
H2F13L0	3.50	H14F1L1	0.13
H2F7L0	0.37	H15F11L0	0.21
H2F8L0	0.43	H16F11L0	0.31
H2F9L0	7.46	H17F15L0	0.25
H3F8L0	0.47	H17F16L0	1.09
H4F12L0	14.16	H18F16L0	9.91
H4F13L0	0.12	H18F16L1	0.03
H4F14L0	0.11	H20F6L2	0.004
H4F16L0	0.46	H20F16L0	2.93
H5F10L0	0.42	H20F18L1	0.39
H6F13L0	2.93	H20F19L0	12.00
H6F16L0	0.23	H20F19L1	0.29
H7F17L0	0.56		
Study area (ha)		(72,544 ha) 100%	

H: suitability for horticultural crop-related LCs; H0: not suitable for horticultural crops; H1: tomato-eggplant-pepper; H2: tomato-eggplant-pepper, cos lettuce-parsley-cabbage; H3: tomato-eggplant-pepper, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, onion-garlic; H4: tomato-eggplant-pepper, melon-zucchini-cucumber, cos lettuce-parsley-cabbage; H5: tomato-eggplant-pepper, melon-zucchini-cucumber, cos lettuce-parsley-cabbage, onion-garlic; H6: tomato-eggplant-pepper, melon-zucchini-cucumber, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, onion-garlic; H7: tomato-eggplant-pepper, melon-zucchini-cucumber, beans-peas-kidney bean-okra, cos lettuce-parsley-cabbage, onion-garlic; H8: tomato-eggplant-pepper, melon-zucchini-cucumber, beans-peas-kidney bean-okra, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, onion-garlic; H9: olives, tomato-eggplant-pepper, cos lettuce-parsley-cabbage; H10: olives, tomato-eggplant-pepper, melon-zucchini-cucumber, cos lettuce-parsley-cabbage; H11: olives, tomato-eggplant-pepper, melon-zucchini-cucumber, beans-peas-kidney bean-okra, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, onion-garlic; H12: olives, strawberry, tomato-eggplant-pepper, beans-peas-kidney bean-okra, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, carrot, onion-garlic; H13: olives, strawberry, tomato-eggplant-pepper, melon-zucchini-cucumber, beans-peas-kidney bean-okra, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, carrot, onion-garlic; H14: plum-apple trees, olives, carrot; H15: plum-apple trees, olives, tomato-eggplant-pepper, cos lettuce-parsley-cabbage; H16: plum-apple trees, olives, tomato-eggplant-pepper, melon-zucchini-cucumber, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage; H17: plum-apple trees, olives, tomato-eggplant-pepper, melon-zucchini-cucumber, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, onion-garlic; H18: plum-apple trees, olives, tomato-eggplant-pepper, melon-zucchini-cucumber, beans-peas-kidney bean-okra, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, onion-garlic; H19: plum-apple trees, olives, tomato-eggplant-pepper, melon-zucchini-cucumber, beans-peas-kidney bean-okra, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, carrot, onion-garlic; H20: plum-apple trees, olives, strawberry, tomato-eggplant-pepper, melon-zucchini-cucumber, beans-peas-kidney bean-okra, cauliflower-broccoli-spinach-chard, cos lettuce-parsley-cabbage, carrot, onion-garlic; **F:** suitability for field crop-related LCs; F0: not suitable for field crops; F1: soybean, peanuts, chickpea-lentils, rapeseed, flax; F2: cotton; F3: wheat; F4: wheat, potato, chickpea-lentils; F5: wheat, potato, peanuts, chickpea-lentils; F6: wheat, potato, soybean, peanuts, chickpea-lentils, rapeseed, sunflower, flax; F7: wheat, cotton, rapeseed; F8: wheat, cotton, chickpea-lentils, rapeseed; F9: wheat, cotton, corn, chickpea-lentils, rapeseed; F10: wheat, cotton, corn, chickpea-lentils, rapeseed, flax; F11: wheat, cotton, corn, chickpea-lentils, rapeseed, sunflower; F12: wheat, cotton, corn, chickpea-lentils, rapeseed, sunflower, flax; F13: wheat, cotton, corn, chickpea-lentils, alfalfa-vetch, rapeseed, sunflower; F14: wheat, cotton, corn, chickpea-lentils, alfalfa-vetch, rapeseed, sunflower, flax; F15: wheat, cotton, corn, soybean, chickpea-lentils, rapeseed, sunflower, flax; F16: wheat, cotton, corn, soybean, chickpea-lentils, alfalfa-vetch, rapeseed, sunflower, flax; F17: wheat, cotton, corn, soybean, peanuts, chickpea-lentils, alfalfa-vetch, rapeseed, sunflower, flax; F18: wheat, cotton, potato, corn, soybean, peanuts, chickpea-lentils, rapeseed, sunflower, flax; F19: wheat, cotton, potato, corn, soybean, peanuts, chickpea-lentils, alfalfa-vetch, rapeseed, sunflower, flax; **L:** suitability for nonagricultural LUs; L0: grassland; L1: reforestation, grassland; L2: reforestation, grassland, recreation ; L3: reforestation, grassland, recreation, urban residential.

the study area was found to be suitable for all of the horticultural crop-related LCs. The area of land suitable for the entire field crop-related LCs was found to cover 12.3% (8727 ha) of the study area.

Currently unproductive lands with the potential to be productive once ameliorated were also taken into consideration in the evaluation of the LMUs for agricultural production. Approximately 12.88% (9151 ha) of the study area was determined as biophysically suitable for grassland only. Only 4 potential groups of LULCs (H0F0L0, H0F2L0, H4F12L0, and H20F19L0) occupied 54.3% (38,580 ha) of the total area.

The agricultural profitability index (API) for each LC revealed that strawberry production was the most profitable agricultural LC in the study area (Table 2). The APIs of chickpea-lentil and cotton production were the lowest (80%). Among agricultural land suitability classes (ALSC), based on the combination of biophysical and economic evaluations in the study area, 12.46% were classified as prime farmlands (S1, highly suitable), 30.58% as moderately productive croplands (S2, moderately suitable), 28.78% as marginally productive croplands (S3, marginally suitable), 26.64% as currently unproductive lands (N1, provisionally unsuitable), and 1.54% as nonagricultural lands (N2, permanently unsuitable). Land evaluation results for the specified LULCs showed that 71.82% and 28.18% of the study area was suitable for agricultural LCs and nonagricultural LUs, respectively (Table 3, Figure 3).

Discussion

The most significant reason for the study region to be suitable for the cultivation of most horticultural and field crops is because the local climate, soil, and topographic factors have no or little limiting effect on productivity (FAO 1977; Şenol 1983, 1994; Saygın and Yüksel 2008). In suitability evaluation of nonagricultural land uses, geology and geomorphology also play a significant role (Şenol 1994; Rossiter 1996).

In the present state of the study area, lands not suitable for agricultural uses that have issues of salinization and poor drainage can be rehabilitated and reclaimed so as to select and grow ecologically proper horticultural and field crops. Mismanagement practices leading to poor drainage and salinization are one of the most important issues that restrict agricultural production (Şenol 1983; Rossiter 1996; Saygın and Yüksel 2008).

The process of quantifying the use and cover potentials of lands based on their biophysical attributes plays an important role in the rational and

Table 2. Profitability index for agricultural land cover (LC) types.

Horticultural crop-related LC	Profitability Index[a]	Field crop-related LC	Profitability Index[a]
LC1 Plum-apple trees	0.85	LC11 Wheat	0.85
LC2 Olive trees	0.95	LC12 Cotton	0.80
LC3 Strawberries	1.00	LC13 Potato	0.95
LC4 Tomato-eggplant-pepper	0.90	LC14 Corn	0.85
LC5 Melon-zucchini-cucumber	0.90	LC15 Soybean	0.85
LC6 Beans-peas-kidney bean-okra	0.90	LC16 Peanuts	0.95
LC7 Cauliflower-broccoli-spinach-chard	0.90	LC17 Chickpea-lentils	0.80
LC8 Cos lettuce-parsley-cabbage	0.95	LC18 Alfalfa-vetch	0.85
LC9 Carrot	0.95	LC19 Rapeseed	0.85
LC10 Onion-garlic	0.90	LC20 Sunflower	0.85
		LC21 Flax	0.85

[a]Profitability index value of 1.00 = US$ 150 t^{-1} ha^{-1}, based on average US$ exchange rate in 2006.

Table 3. Classification of agricultural land suitability of the study area.

Class	Agricultural land suitability	% of the total area
1.00-0.90	Prime farmlands	12.46
0.89-0.75	Moderately productive croplands	30.58
0.74-0.50	Marginally productive croplands	28.78
0.49-0.20	Currently unproductive lands	26.64
0.19-0.00	Nonagricultural lands	1.54
	Total	100% (72,544 ha)

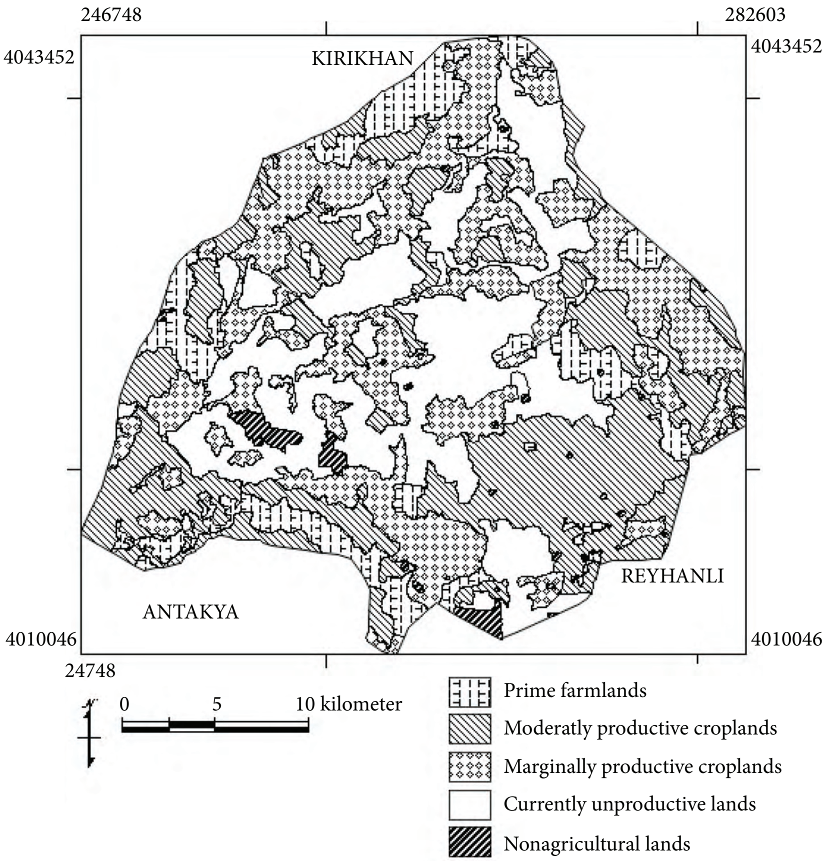

Figure 3. Map of agricultural land suitability classes of study area.

sustainable uses of natural resources. This would enable prime farmlands to not be degraded or lost irreversibly, residential areas to be formed away from areas with a high earthquake risk, environmentally important and sensitive ecosystems to be protected, and damaged ecosystems to be rehabilitated back to their productive states.

This methodology may assist related institutions in the formulation of land use policy, planning and management, adoption of sustainable LULC systems, rehabilitation of damaged ecosystems, monitoring of environmental quality, and reduction of social costs and uncertainty in the selection of land use strategies. The process of quantifying land use potential on the basis of its biotic and abiotic attributes plays an important role in the sustainable use and management of natural resources.

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