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Evaluation of Land Use Potential and Suitability of Ecosystems in Antakya for Reforestation, Recreation, Arable Farming and Residence

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Abstract: It is essential that land use decisions made by local administrations be compatible with sustainable use and management principles of natural resources. In this study, we evaluated the use potential and suitability of 27 land mapping units of 4,891 ha in Antakya for three different land use types: (1) recreation- reforestation, (2) residence and (3) arable farming. For this purpose, land suitability evaluation was carried out using soil and land data, the ŞENOL land evaluation system, and a PC compatible ILSEN software package. The study showed that a total of 478 ha of land had the potential for residential use in the west and north of Antakya. The urban growth of Antakya needs to be directed accordingly to these recommended areas instead of to the prime farmlands of Amik plain. It was determined that the majority of the land suitable for reforestation and recreation uses were in the north and north-west of Antakya, and their total land area was 1,511 ha. The quantification of both expected benefits due to sustained productivity of natural resources and environmental degradation due to unsustainable land uses assists decision makers in ensuring that land is used according to its capacity to satisfy human needs for present and future generations.

Key Words: Land suitability evaluation, land use planning, urban residence, reforestation, recreation, arable farming.

Antakya Ekosistemlerinin Ağaçlandırma, Rekreasyon, Tarım ve Konut için Arazi Kullanım Potansiyeli ve Uygunluğunun Değerlendirilmesi

Özet: Yerel yönetimler tarafından alınacak arazi kullanım kararlarının, doğal kaynakların sürdürülebilir kullanımı ve yönetimi ilkeleri ile uyumlu halde olması gereklidir. Bu çalışmada, Antakya çevresinde 4891 ha alana sahip 27 arazi haritalama biriminin, (1) ağaçlandırma-rekreasyon, (2) kentsel yerleşim ve (3) işlemeli tarım olmak üzere üç farklı arazi kullanım tipi için kullanım potansiyelinin ve uygunluğunun değerlendirilmesi amaçlanmıştır. Bu amaçla arazi uygunluk değerlendirmesi, toprak ve arazi verileri, ŞENOL Arazi Değerlendirme Sistemi ve PC uyumlu ILSEN paket programı kullanılarak gerçekleştirilmiştir. Çalışma sonucunda Antakya'nın batısında ve kuzeyinde toplam 478 ha alanın gelecekte yerleşime açılabilecek nitelikte olduğu belirlenmiştir. Bu nedenle verimli Amik Ovasına doğru olan kentsel büyümenin engellenerek, önerilen yeni alanlara kaydırılması gerekmektedir. Ağaçlandırma ve rekreasyona uygun alanların büyük bir çoğunluğunun Antakya'nın kuzeyinde ve kuzeybatısında yer aldığı ve toplam 1511 ha alana sahip olduğu saptanmıştır. Bu çalışmada da amaçlandığı gibi, hem doğal kaynakların sürdürülebilir verimliliğine bağlı faydaların hem de sürdürülebilir olmayan arazi kullanımlarına bağlı çevresel bozulmaların sayısallaştırılması, karar vericilerin, arazilerin şimdiki ve gelecek kuşakların ihtiyaçlarını karşılamada kapasitelerine göre kullanıldıklarından emin olmalarına yardımcı olacaktır.

Anahtar Sözcükler: Arazi uygunluk değerlendirme, arazi kullanım planlaması, kentsel yerleşim, ağaçlandırma, rekreasyon, tarım arazileri

Introduction

The ecosystem goods and services that natural resources provide us with are the ultimate source of wealth upon which present and future generations all depend. Local and regional human activities have altered air, water, soil and land by an unprecedented magnitude and the rate of adverse effects on human well-being on scales from local to global. A loss of biodiversity, deforestation, pollution of air, water and soil, depletion of stratospheric ozone layer, and global climate change

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are the major adverse environmental consequences of past and present human activities. It is likely to take years or even several decades to reduce uncertainties about the environmental impacts on human well-being. In so doing, we may be late in taking preventive and mitigative measures and may end up being able to do nothing but endure the consequences (Yücel, 1995; Wali et al., 1999). The determination of the use potential of land is a necessary condition for land use planning to proceed on a rational and sustainable basis. The 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).

Irrational land uses and the over-exploitation of natural resources associated with Turkey's rapid industrialization and urbanization have resulted in irreversible losses and the degradation of prime farmlands and other ecologically significant ecosystems around urban settlements (Mermut et al., 1989; Evrendilek and Doygun, 2000). One of the root causes of this is the inadequacy of qualitative and quantitative assessments of ecosystem properties during of land use planning. Sustainable development in Turkey primarily depends on the formation of a standardized database, the accurate and dynamic quantification of its natural resource base, and the communication of data, information and knowledge to decision makers (Dinç and Şenol, 1997). There is a pressing need to establish a balance between national economic growth and nature conservation.

Antakya has both ecologically significant prime farmlands, such as Amik plain, and a great potential for the development of industry and tourism, and the expansion of urban areas. This necessitates providing the foundation for land use planning through a multi disciplinary study. The objective of the study was to determine and quantify the land use potential and suitability of surrounding ecosystems in Antakya for residence, recreation-reforestation, and arable farming in order to assist local administrative institutions and planners in making rational and sound decisions.

Materials and Methods

The study was conducted for a land area of 4,891 ha surrounded by Nur mountain (1073 m) in the west, Nacar mountain (350 m) and the town of Narlıca in the east, the town of Kuzeytepe in the north, and the town of Dursunlu in the south. The delineation of the study area was determined based on considerations of morphological restrictions for the land use types and the present growth trajectory of the urban areas. The climate regime prevalent in the study area is Mediterranean, characterized by a mild winter during which about 67% of the annual precipitation of 1,124 mm occurs, and a hot dry summer. The average annual temperature reaches a maximum of 31 °C in the summer and a minimum of –15 °C in the winter, with an average annual temperature of 18 °C. The parent materials in the study area consist mostly of sedimentary rocks of highly calcareous clays, limestone, dolomites, and sandstones. The major soil orders in the study area include entisols, inceptisols, and vertisols. The alluvial soils formed by the River Tigris are the most productive soils occupying the north-east of the study area. The dominant Mediterranean vegetation consists of maquis, characterized by woody shrubby plants with evergreen sclerophyll leaves, and garrigues, a regressive successional stage of maquis under drastic human-induced disturbances such as overgrazing, overcutting, and cultivation.

An interdisciplinary study was conducted, seeking information and advice from environmental scientists, soil scientists, geologists, landscape architects, and agronomists. Land evaluation was performed in two steps: (1) collection and (2) evaluation of data (Figure 1).

A land evaluation system developed in light of the FAO's 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 ecosystems in the study area for the land use types (LUTs) of residence, reforestation-recreation, and arable farming.

A detailed 1:25,000 scale soil map developed by Şenol et al. (1999) showing different soil series and phases for the study area was used as the basis for the derivation of land mapping units (LMUs) and land characteristics (LCs) during the collection of data. The conditions of the land necessary for successful and sustained implementation of the specified LUTs, namely land use requirements (LURs), were determined using related literature information and available data. Land suitability (LS) is a function of a set of LURs defined for LUTs ($LURs_{LUTs}$) and a set of LCs measured for LMUs (LCs_{LMUs}) as follows:

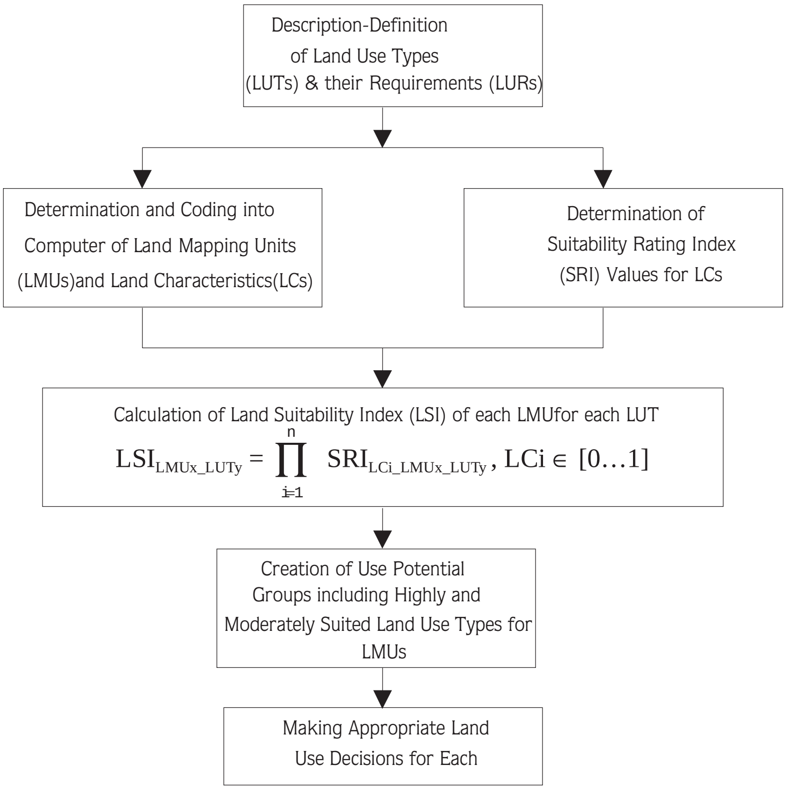

Figure 1. Flow diagram of land evaluation process.

$$LS_{\text{LMUs for LUTs}} = f\{LCs_{LMUs}, LURs_{LUTs}\}$$

The land suitability index (LSI) of the LMUs for each LUT was calculated using the multiplicative combination of suitability rating index (SRI) as follows (FAO, 1977; Şenol, 1983):

$$LSI_{LMUx\_LUTy} = \prod_{i=l}^{n} SRI_{LCi\_LMUx\_LUTy}, \; LCi \in [0\ldots1]$$

where LSI values showed the degree to which the requirements of the LUTs matched each LMU. In other words, each LMU was assigned a LSI value expressed on a discrete scale of suitability classification for a specific LUT (Table 1). Similarly, all LCs were standardized to the common scale [0…1]; the least favourable LC value is 0, and the most favourable LC value is 1. All LCs were assumed to be of equal weight. The higher SRI values represented the greater suitability of LMUs for each LUT. The process of land evaluation was carried out using the ILSEN package program loaded on a PC (Şenol, 1994; Şenol and Tekeş, 1995).

Table 1. Land Suitability Index (LSI) and suitability class for a Land Use Type (LUT).

LSI	Symbol	Suitability class
1.00-0.90	S1	Highly suited
0.89-0.75	S2	Moderately suited
0.74-0.50	S3	Marginally suited
0.49-0.25	N1	Unsuited
0.24-0.00	N2	Completely unsuited

On the other hand, the locations of fault lines in the study area were taken into account as one of the major criteria through which the use potential of the land for urban residence was determined (Pişkin, 1985). Providing that other requirements of residential land use were satisfied by the LMUs, residential areas were planned away from fault lines. Similarly, the LMUs closer to the existing residential areas were assigned a higher SRI value when evaluated for residential and recreational land uses. Thus, a map showing land use potential and suitability for the land uses was derived for the study area.

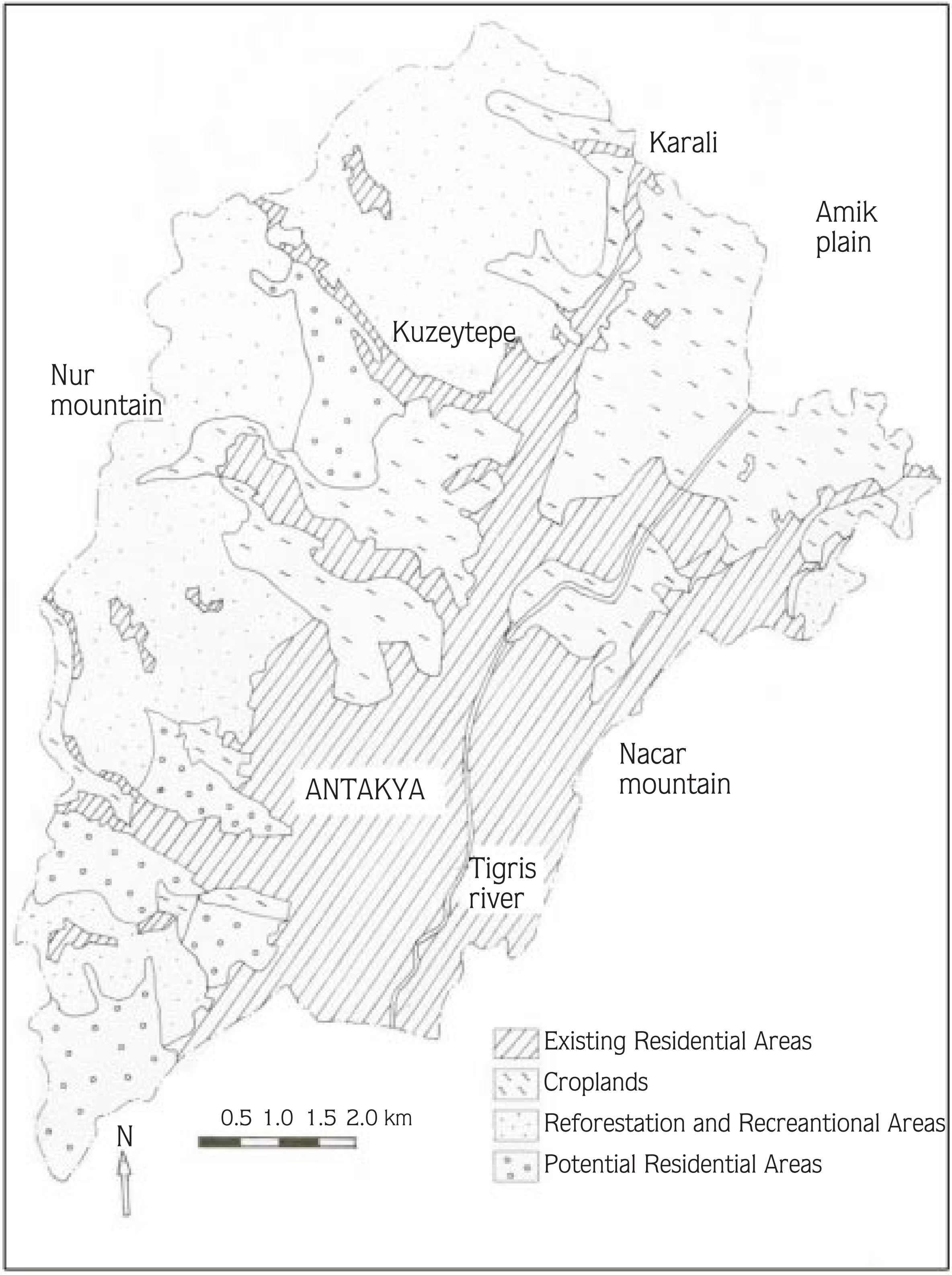

Figure 2. A map showing land use potential and suitability for reforestation and recreation, arable farming and residence in Antakya.

Results and Discussion

Six LCs and their 25 different sublevels of nine soil series derived from the detailed soil map of the study area are shown in Table 2. Based on the existing soil series and phases, a total of 27 LMUs differing in one or more LCs were identified and delineated in the study area. Land evaluation was carried out for three LUTs: (1) urban residence, (2) reforestation and recreation, and (3) croplands. According to the LURs of the LUTs, SRI values were estimated for 25 different sublevels of the LCs (Table 3). Based on the multiplicative combination of SRI values, LSI values revealed the suitability classes of the 27 LMUs for the three LUTs (Table 4). The above FAO-style terminology and framework has been 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), and ILWIS (Meijerink et al., 1988).

Urban residential areas (LUT1) may be defined as locations not suited or the least suited to agricultural use and situated close to urban residential areas. The most important criterion for land to be used for non-agricultural and forestry activities such as residence is that the land has very low productivity and fertility. The geological and geomorphologic structures of the land mapping units should also be suitable for residential use in that geological material should be strong, fault lines should not exist, and hazards such as floods and landslides should not adversely affect the land (FAO, 1977; Şenol, 1983, 1994; Gündoğan, 1993). The suitability of the 27 LMUs for residential use was thus determined based not only on the LSI values but also on the location of fault lines and the proximity of existing settlements. A geological map of Antakya with a scale of 1:25,000 developed by Pişkin (1985) shows that there are fault lines in the south of the study area. Eight LMUs (Du1, Du2, Kc1, Kc4, Kc5, Ob2, Ob3 and Ob4) were evaluated as suitable for residential land use by virtue of their being away from fault lines and close to existing residential areas despite having lower LSI values than the other LMUs (Table 4). These LMUs were located to the west and north of Antakya city centre (Figure 2). The land area suitable for urban residence amounted to 478.5 ha (9.8% of the study area). The total land area of the existing residence as urban, suburban, town and villages was about 1,686 ha (34.5% of the study area).

Reforestation and recreation areas (LUT2) as non-prime farmlands in the study area serve to (1) prevent run-off after heavy rainfall from damaging agricultural land and residential areas, (2) provide timber and fuel wood in the long term, and (3) meet the urban and rural populations' needs for green and recreational spaces. One other significant ecosystem service that these LUTs provide is to prevent water- and wind-induced soil erosion on land with steep slopes. LMUs to be used for these LUTs should have a slope range of gentle to steep, with LCs not suited to agricultural use such as shallow soil depth. Close proximity to settlements was a significant requirement in the suitability of LMUs for recreational use. Eight LMUs (Ka3, Ka4, Ka6, Ka7, Ka9, Kc2, Kc3 and Kc6) appeared to be "highly suited (S1)" and "moderately suited (S2)" for reforestation and recreation uses (Table 4). These units were concentrated to the north and north-west of Antakya city centre (Figure 2). The land area suitable for reforestation and recreation uses consisted of about 1,511 ha (30.9% of the study area).

Lands with a level to moderate slope and a moderate to deep soil profile without productivity-reducing factors such as alkalinization and salinization in arid and semi-arid regions result in an environment suitable for the growth of crops. Field and horticulture crops suitable to the local environmental conditions can be grown in rainfed and irrigated ways on land proposed as suitable for arable farming (LUT3). Şenol et al. (1991) assessed the land use potential and suitability of soils of Harran plain for different crops by using a similar land evaluation method and described the method as a useful quantified predictor of land performance. Currently non-agricultural lands with the potential to be productive lands once ameliorated were also taken into consideration in the land evaluation of LMUs for arable farming. Eleven LMUs (Bd1, Bd2, Bd4, Ka2, Kr2, Kt1, Na1, Na2, Na3, Ob1 and Sa2) were evaluated as "highly suited (S1)" for croplands (Table 4). The total land area suitable for arable farming was about 1,214 ha (24.8% of the study area) to the north and north-east of Antakya city centre (Figure 2).

Conclusions

This study revealed that some of the areas located in the west and north of Antakya had qualitative and quantitative potential for residential use. The present urban sprawl towards the productive prime farmlands of Amik plain should be curbed and directed towards the

Table 2. Land characteristics (LCs) and their sublevels considered in the land evaluation.

Land Characteristics	Class	Description
Drainage class and water table depth(DRN)	DRN1	Inadequate drainage, water table depth of 90-120 cm
	DRN2	Moderate drainage, water table depth of 60-90 cm
Soil depth (SD)	SD1	Deep-very deep (>90 cm)
	SD2	Moderately deep, (60-90 cm)
	SD3	Shallow (30-60 cm)
	SD4	Very shallow (<30 cm)
Slope class (SLP)	SLP1	0-2%
	SLP 2	2-4%
	SLP 3	4-6%
	SLP 4	6-8%
	SLP 5	8-12%
	SLP 6	12-20%
	SLP 7	20-30%
	SLP 8	> 30%
Surface stoniness (SS)	SS1	Non-stony
	SS2	Little stony
Parent material (PM)	PM1	Alluvial
	PM2	Alluvial fan, Bajada
	PM3	Claystone
	PM4	Marn
Aspect (ASP)	ASP1	Level
	ASP 2	South, south-west, south-east
	ASP 3	East, north-east
	ASP 4	West, north-west
	ASP 5	North

Table 3. Suitability rating index (SRI) values of the land characteristics (LCs).

Land Characteristics	LUT1 Residence	LUT2 Reforestation / Recreation	LUT3 Cropland
DRN1	1.00	1.00	0.90
DRN2	1.00	1.00	0.85
SD1	0.00	0.70	1.00
SD2	0.60	0.85	0.95
SD3	0.85	0.95	0.75
SD4	1.00	0.98	0.50
SLP1	1.00	0.80	1.00
SLP 2	1.00	0.90	1.00
SLP 3	1.00	0.95	1.00
SLP 4	1.00	1.00	1.00
SLP 5	1.00	1.00	1.98
SLP 6	1.00	1.00	0.95
SLP 7	0.80	1.00	0.65
SLP 8	0.50	1.00	0.30
SS1	1.00	1.00	1.00
SS2	1.00	1.00	1.00
PM1	0.80	1.00	1.00
PM2	0.95	1.00	1.00
PM3	0.90	1.00	1.00
PM4	1.00	1.00	1.00
ASP1	1.00	1.00	1.00
ASP2	1.00	1.00	1.00
ASP3	1.00	1.00	0.98
ASP4	1.00	1.00	1.00
ASP5	0.90	1.00	0.95

Table 4. Land suitability index (LSI) and suitability class reflecting the suitability of the land mapping units (LMUs) for the land use types (LUTs).

LMU	LUT1 Residence		LUT2 Reforestation / Recreation		LUT3 Cropland		Proposed Land Use
Bd1	N2	0.00	S3	0.64	S1	1.00	LUT3
Bd2	N2	0.00	S3	0.72	S1	1.00	LUT3
Bd4	N2	0.00	S3	0.64	S1	1.00	LUT3
Du1	S2	0.80	S2	0.85	N2	0.24	LUT1
Du2	S2	0.75	S2	0.85	N2	0.12	LUT1
Ka2	N2	0.00	S2	0.85	S1	1.00	LUT3
Ka3	S2	0.85	S1	0.95	S3	0.63	LUT2
Ka4	S3	0.68	S1	0.95	N1	0.45	LUT2
Ka6	S3	0.63	S1	0.95	N2	0.22	LUT2
Ka7	N1	0.42	S1	0.95	N2	0.00	LUT2
Ka9	S3	0.60	S1	1.00	S1	0.90	LUT2
Kc1	S3	0.60	S1	1.00	S2	0.80	LUT1
Kc2	S3	0.60	S1	1.00	S1	0.93	LUT2
Kc3	S3	0.60	S1	1.00	S2	0.80	LUT2
Kc4	S3	0.68	S1	0.95	N1	0.45	LUT1
Kc5	S2	0.85	S1	0.90	S2	0.75	LUT1
Kc6	S3	0.50	S2	0.85	N2	0.00	LUT2
Kr2	N1	0.48	S1	0.95	S1	0.95	LUT3
Kt1	S3	0.57	S1	0.90	S1	0.95	LUT3
Na1	N2	0.00	S3	0.72	S1	1.00	LUT3
Na2	N2	0.00	S3	0.72	S1	1.00	LUT3
Na3	N2	0.00	S3	0.72	S1	0.90	LUT3
Ob1	N2	0.00	S2	0.81	S1	0.98	LUT3
Ob2	S3	0.60	S1	0.90	S1	0.93	LUT1
Ob3	S3	0.60	S1	0.90	S1	0.90	LUT1
Ob4	S2	0.85	S2	0.85	S3	0.73	LUT1
Sa2	N2	0.00	S3	0.64	S1	1.00	LUT3

proposed residential areas. This would enable, on the one hand, prime farmlands not to be lost irreversibly, and on the other hand, more secure residential areas to be formed in Antakya, away from the region involved in the present trend of urban expansion with the highest earthquake risk. Most land suitable for recreational activities and reforestation was in the north and north-west of Antakya. These areas also serve to provide significant ecosystem goods and services other than aesthetic and recreational values such as regulation of hydrological and micro climate regimes, sequestration of greenhouse gases, stabilization of landslide and soil erosion, and maintenance of biological diversity.

The process of quantifying the use potential of land on the basis of its biotic and abiotic attributes plays an important role in the rational and sustainable use of natural resources. Local administrations should ensure that economic growth is not occurring at the expense of the public and environmental health of present and future generations. A fundamental challenge of sustaining the productivity, biodiversity and integrity of ecosystems regionally and globally is to ensure that local decision makers including individual land users, groups, or institutions use the quantification of the biophysical potential of ecosystems obtained by land evaluation.

References

De la Rosa, D., J.A. Moreno, L.V. Garcia and J. Almorza. 1992. MicroLEIS: A microcomputer-based Mediterranean land evaluation information system. Soil Use Manage. 8: 89-96.

Dinç, U. and S. Şenol, 1997. Toprak Etüd ve Haritalama, Çukurova Üniversitesi, Ziraat Fakültesi Yayınları, Genel Yayın No: 161, Ders Kitapları Yayın No: 50, Adana.

Evrendilek, F. and Doygun, H. 2000. Assessing major ecosystem types and the challenge of sustainability in Turkey. Environmental Management 26(5): 479-489.

Evrendilek, F. and Ertekin, C. 2002. Agricultural sustainability in Turkey: integrating food, environmental and energy securities. Land Deg. & Develop. 13(1): 61-67.

FAO, 1977. A Framework for Land Evaluation, International Institute for Land Reclamation and Improvement/ILRI, Publication 22, Wageningen, The Netherlands, 87 p.

Gündoğan, R. 1993. Çeşitli Arazi Değerlendirme Yöntemlerinin Arazi Toplulaştırma Çalıışmalarında Kullanılma Olanakları. Doktora Tezi. Çukurova Üniversitesi Fen Bilimleri Enstitüsü, p. 179.

Meijerink, A.M., C.R. Valenzuela and A. Stewart (Editors). 1988. ILWIS: The integrated land and watershed management information system. ITC Publication number 7. International Institute for Aerospace Survey & Earth Science (ITC), Enschede.

Mermut, A., M. Başal, V. Katkat and M. Yüksel. 1989. Marmara Bilimsel ve Endüstriyel Araştırma Enstitüsü Arazisi Alan Kullanım Planlaması. Türkiye Toprak İlmi Derneği, 10. Bilimsel Toplantı Tebliğleri, No: 5, Ankara, pp. 1-13.

Pişkin, Ö. 1985. Suriye'nin Kuzeybatısının ve Hatay'ın Jeoloji Haritası. Ophiyolitler üzerinde araştırma yapan grup. Genove Üniversitesi. Mineraloji Bölümü.

Rossiter, D.G. and A.R. Van Wambeke. 1995. Automated Land Evaluation System: ALES Version 4.5 User's Manual. SCAS Teaching Series No. T93-2 Revision 5. Cornell University, Department of Soil, Crop & Atmospheric Science, Ithaca, NY.

Şenol, S. 1983. Arazi Toplulaştırma Çalışmalarında Kullanılabilir Niceliksel Yeni Bir Arazi Dereceleme Yönteminin Geliştirilmesi Üzerine Araştırmalar. Doktora Tezi. Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, p. 122.

Şenol, S., İ. Yeğingil, U. Dinç, O. Dinç and N. Öztürk. 1991. Potential land use planning of the Harran Plain. TÜBİTAK Tarım ve Ormancılık Araştırma Grubu, Soils of the Harran Plain, Proje No: TOAG-534, Ankara, pp. 47-57.

Şenol, S. 1994. Bilgisayar Destekli Bir Model Yardımıyla Göksu Deltası Topraklarının Tarımsal Kullanıma Uygunluk Sınıflaması. Tr. J. of Agriculture and Forestry. 18(5): 437-443.

Şenol, S. and Y. Tekeş. 1995. Arazi Değerlendirme ve Arazi Kullanım Planlaması Amacıyla Geliştirilmiş Bir Bilgisayar Modeli. Türkiye Toprak İlmi Derneği, İlhan Akalan Toprak ve Çevre Sempozyumu, Yayın No: 7, Cilt 1, Ankara, pp. 204-210.

Şenol, S., Ş. Kılıç, M. Aydın, U. Dinç, L. Başayiğit and H.H. Tekin. 1999. Antakya İli Çevresinin Şimdiki Arazi Kullanım Durumu ve İdeal Arazi Kullanım Planlaması. TÜBİTAK, Tarım ve Omancılık Araş. Grubu, Proje No: TOGTAG-1618, Ankara.

Yücel, M. 1995. Doğa Koruma Alanları ve Planlaması. Çukurova Üniversitesi Ziraat Fakültesi Yayınları, Genel Yayın No: 104, Adana.

Wali, M.K., F. Evrendilek, T. West, S. Watts, D. Pant, H. Gibbs and B. McClead. 1999. Assessing terrestrial ecosystem sustainability: usefulness of regional carbon and nitrogen models. Nature & Resources 35(4): 20-33.

Wood, S.R. and F.J. Dent. 1983. LECS: a land evaluation computer system. AGOF/INS/78/006. Vols. 5 (Methodology) & (User's Manual), Ministry of Agriculture, Government of Indonesia, Bogor.