African Journal of Agricultural Research Vol. 4 (9), pp. 847-851, September 2009
Available online at http://www.academicjournals.org/ajar
ISSN 1991-637X

Full Length Research Paper

Mapping soil drainage classes of Amik Plain using Landsat images

Şeref Kiliç

Department of Soil Science, Faculty of Agriculture, Mustafa Kemal University, Antakya-Hatay, 31034, Turkey. E-mail: skilic@mku.edu.tr or skilic69@yahoo.com. Tel.: +90-326-245-5845. Fax: +90-326-245-5832.

Accepted 3 August, 2009

Soil drainage is one of the important soil properties affecting plant growth, water transfer and solute transport in soils. Soil drainage is also an environmental component affecting irrigation and soil reclamation, land capability for agriculture, flood control systems, engineering, health and infectious diseases. The objective of this study was to map soil drainage classes by using Landsat image in Amik Plain (Hatay, Turkey). Terrain and vegetation are characterized by digital terrain attributes, and vegetation indices using a LANDSAT-7 Enhanced Thematic Mapper Image. The study benefits from five data sources: Landsat ETM image, topographic maps, soil maps, State Hydraulic Works (DSI) land cover records and ground data from field surveys. Image classification was carried out using Maximum Likelihood (ML) Classification with supervised training. Soil drainage classes were determined, thus finalizing the process of mapping after each mapping unit and drainage class prepared as a result of the ML classification were validated on site. According to the drainage map prepared using satellite image and ground data, 51,4% (37,234 ha) of Amik Plain are well drained and moderately well drained. 48,6% (35,192 ha) of Amik Plain are somewhat poorly drained, poorly drained, and very poorly drained.

Keywords: Soil drainage, remote sensing, Landsat images.

INTRODUCTION

Soil drainage is one of the important soil properties affecting plant growth, water transfer and solute transport in soils. Soil drainage is also an environmental component affecting irrigation and soil reclamation, land capability for agriculture, flood control systems, engineering, health and infectious diseases (Campling et al., 2002). Accurate and inexpensive mapping of soil drainage classes and conditions is of great significance for both agricultural and environmental management and modeling (Kravchenko et al., 2002).

There is a strong correlation among vegetation, topography, slope and soil drainage characteristics (Troeh, 1964; Acton, 1965). Amik plain has a relatively plain ground surface, with a slope range of 0 to 2% in a large part of the plain. Determining soil drainage classes is laborious, time-consuming and costly because it requires the excavation and examination of soil profiles across the field. Typically, a soil pit must be excavated and filled with water to produce saturation, allowed to drain naturally, and then refilled in order to measure the time it takes for the water to recede. A level of subjectivity is also included because the drainage class is determined based on this direct observation and on inference from other local landscape observations. These difficulties have led investigators to seek alternate methods of mapping drainage classes (Cialella et al., 1997).

Remote sensing data have been used for soil drainage classification by several researchers (Lee et al., 1988a,b; Levine et al., 1994; Cialella et al., 1997; Campling et al., 2002). Soil drainage is often related to other soil properties, such as soil water content and soil texture which could be mapped using remote sensing data (Kravchenko et al., 2002). In optical remote sensing, the characteristics of the reflectance spectrum from a soil surface are related to soil color and brightness, as well as other properties, such as soil texture composition, moisture and organic matter content (Huete and Escadafal, 1991; Mattikali, 1997). For instance, soil reflectance was found to change exponentially as a function of volumetric soil moisture (Lobell and Asner, 2002). The objective of this study was to map soil drainage classes by using Landsat image in Amik Plain. Terrain and vegetation are characterized by digital terrain attributes and vegetation indices using a LANDSAT-7 Enhanced Thematic Mapper

Figure 1. Location of the study region.

Image.

MATERIALS AND METHODS

Study area

The study region (Amik plain) (35° 47′-36° 24′ E; 35° 48′-36° 37′ N) covers *ca.*72,500 ha and is delimited by Nur Mountain (1073 m) in the West, Syria and Reyhanlı town in the East, Hassa and Kırıkhan towns in the North, Ankatya city and Altınozu town in the South (Figure 1). The climate regime prevalent in the study area is Mediterranean climate characterized by a hot dry summer and a mild winter during which about 67% of the annual precipitation of 1,124 mm occurs. 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.

Amik Plain (Hatay-Turkey) has two growing seasons in a year. Winter season starts in October or December and ends in between April and June. Main crops are wheat, barley, maize and potato. The summer crops of cotton, maize, beans and sunflower are sown from March to June and harvested from August to November. Irrigation water is partly supplied from Asi, Afrin and Karaçay rivers, while some is provided from underground water.

The parent materials in the study area (Amik Plain) consist mostly of alluviums and lacustrines. Lacustrines are relatively flat and often have parent materials with uniform properties. The alluvial soils formed by Orontes, Afrin and Karasu rivers are the most productive soils. Lake Amik of *ca*. 53 km^2 in the North-west of the Amik Plain was drained into the Orontes River in order to increase the area of croplands (Kilic et al., 2008).

Soils of the Amik Plain were classified as Entisols, Vertisols, Inceptisols, Alfisols and Mollisols and as Fluvisols, Vertisols, Calcisols, Phaeozems ans Luvisols according to Soil Taxonomy (Soil Survey Staff, 2003) and FAO/UNESCO (1990), respectively (Kilic et al., 2008). The majority of the soils were Vertisol (34%), Entisol (25%) and Inceptisol (20%) since they were developed on young fluvial and lacustrine deposits (Figure 2).

Soil organic matter (SOM) for a depth of the upper two horizons ranged from 0.6% to 3.9% except for SOM-rich histic epipedon (20 - 22%). Bulk density (BD) of the soils varied between 0.68 and 1.58 g/cm^3. High clay content of the soils ranging from 87.3% to 21.9% for the entire horizons causes poor drainage conditions in about 50% of the Amik Plain (Kilic et al., 2004).

To increase the amount of croplands for food production in the Amik Plain, the Lake Amik was channeled into the Orontes River. The report for drainage project of the Lake Amik (IEC, 1966) stated that the Lake Amik of 6700 ha and its surrounding wetlands of 6800 ha in 1965, once several times bigger in the past, were projected to be drained.

Data processing

The study benefits from five data sources: Landsat ETM image, topographic maps, soil maps, State Hydraulic Works (DSI) land cover records and ground data from field surveys. Radiometric correction of the image had already been carried out. The Landsat image was geometrically corrected and geocoded to the Universal Transverse Mercator (UTM) coordinate system by using 1:25,000 scale topographic maps. 15 regularly distributed ground control points (GCPs) were selected from the image. It was then spatially resampled to a spatial resolution of 30 m. Resampling was done using a nearest neighbour algorithm. The transformation had a root mean square (RMS) error 0.7 indicating that the image was accurate to within one pixel.

Image classification was carried out using Maximum Likelihood (ML) Classification with supervised training. The classifier was provided with the spectral reflectance properties of each class in the form of the mean reflectance for each spectral waveband and the associated covariance matrix. The data were generated from a selection of sample training pixels for each class provided from ground data. All texture measures were extracted from the first principal component of the six wavebands and these were used to create 'texture waveband(s)'. Then, per-pixel ML classification was applied. Evaluation of the utility of this classifier and associated

Table 1. Total area of drainage classes in Amik Plain.

Drainage classes	Area (ha)	% of total area
Well drained	26024	35.9
Moderately well drained	11210	15.5
Somewhat poorly drained	17560	24.2
Poorly drained	14178	19.5
Very poorly drained	3554	4.9
Total	72526	100

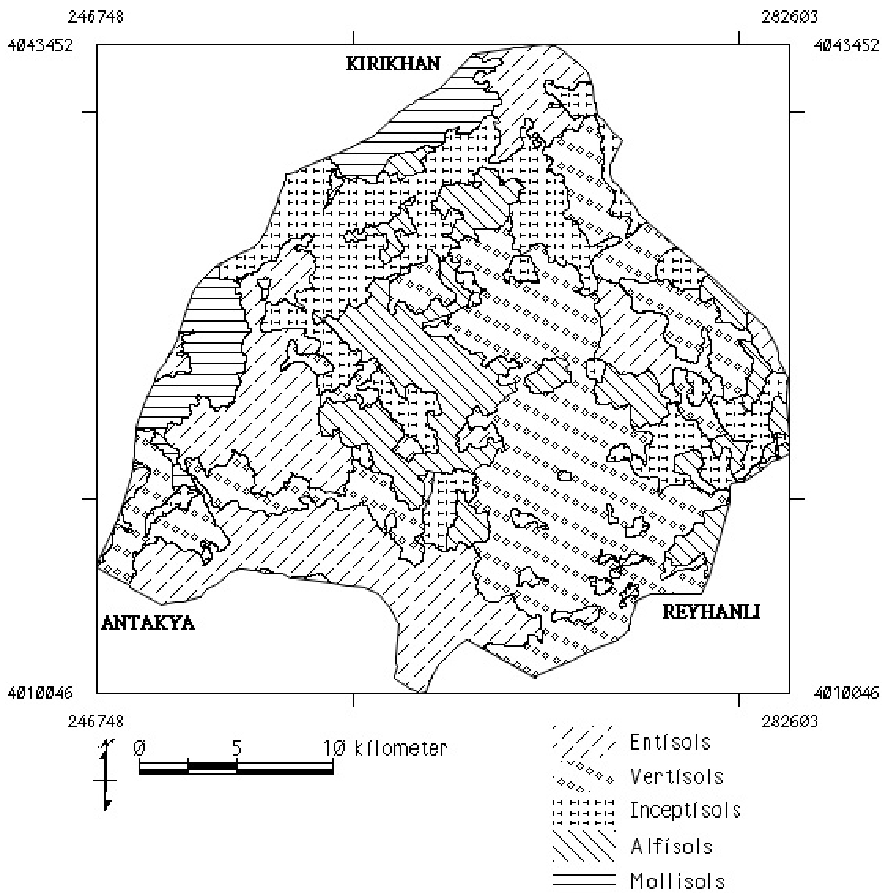

Figure 2. Soil classification map of Amik Plain.

texture measures was based on classification accuracy. Variogram and variance, an algorithm based on the variogram computer code in the geostatistical software library GSLIB (Deutsch and Journel, 1992), was used to compute the variogram and variance. Soil drainage classes were determined, thus finalizing the process of mapping after each mapping unit and drainage class prepared as a result of the ML classification were validated on site.

RESULTS

According to the drainage map prepared using satellite image and ground data, 51.4% (37,234 ha) of Amik Plain are well drained and moderately well drained. 48.6% (35,192 ha) of Amik Plain are somewhat poorly drained, poorly drained and very poorly drained (Table 1). Amik lake in the middle of Amik Plain was started to be drained in the 1960s and opened to agricultural activities in the mid 1970s. Most land at the bottom of the old Amik lake is as Entisol and Vertisol according to Soil Taxonomy (Soil Survey Staff, 2003) and is assigned to poorly and very poorly drained classes (Figures 2 and 3). The poor drainage of this land is due to high clay content, low organic matter and degraded structure of soils.

The soil classified as Entisol surrounding Orontes river, the most important water resource of the plain, in the South border of Amik Plain is moderately well drained.

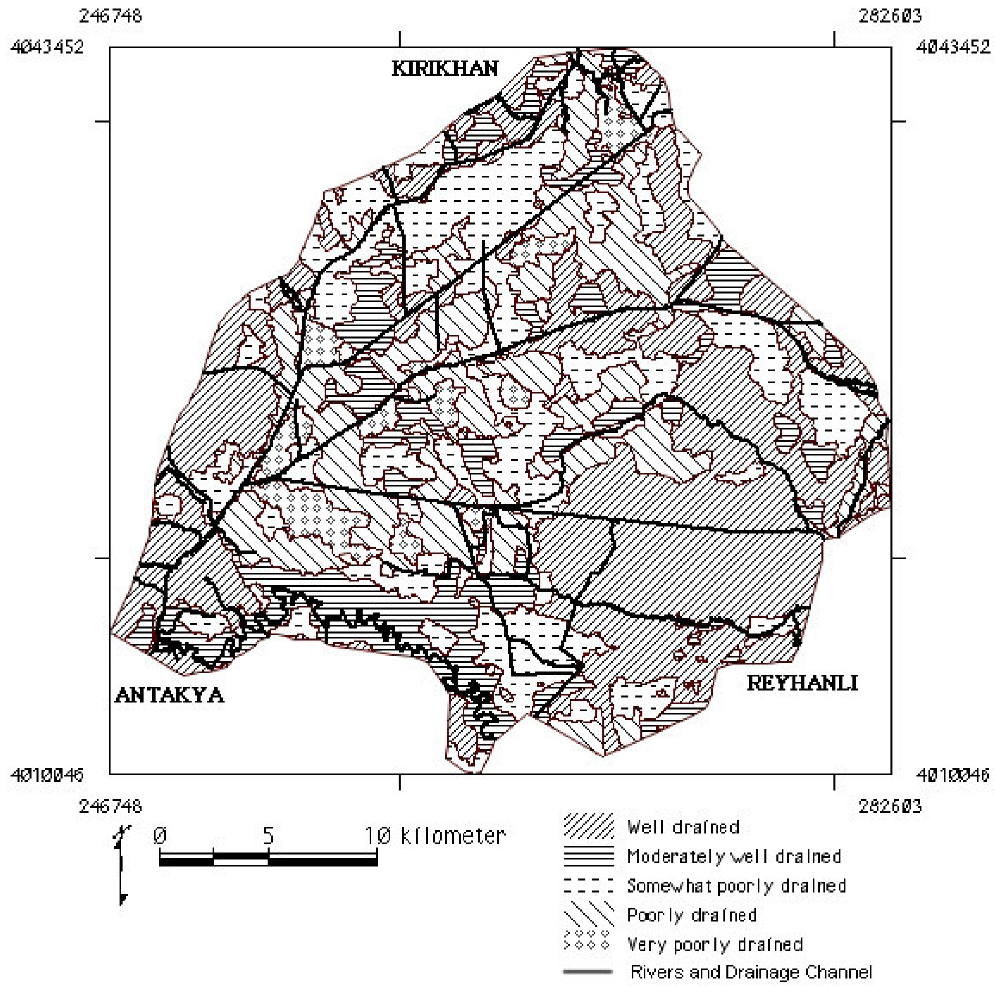

Figure 3. Distribution of drainage classes in Amik Plain.

The soil classified as mollisol in the West Amik Plain amounting to 6% of the plain area is well drained) and moderately well drained. Vertisols in the East Amik Plain have good drainage. The reason for this is that Vetisols in the East Amik Plain have kaolinit clay minerals with high water infiltration capacity. Vertisols on the slopes do not have a drainage problem due to water movement along the terrain slope. Alfisols in the Middle and East parts of the Amik Plain have somewhat poor, poor and very poor drainage classes (Figures 2 and 3).

Drainage conditions in the mid Amik Plain show a significantly more variation and are worse than those along the border of Amik Plain. This can be attributed to the presence of hummocky topography of Amik Plain. More than half of Amik Plain have somewhat poorly drained-to-very poorly drained drainage problems. Based on the present survey, the reason for this appears to be inadequacy of drainage systems built by farmers in addition to high clay content of soils where drainage problem exists.

Field crops are commonly grown in the soils of Amik Plain. Irrigation needs for crops are met from Asi, Afrin and Karaçay streams and from groundwater withdrawals through deep wells. Irrigation method is by wild irrigation and sprinkle. Drip irrigation, an effective method for water conservation and efficiency, is not common in Amik Plain.

DISCUSSION

Land opened to agriculture due to drainage of Amik lake has poorly and very poorly drainage due to high clay content of soils, the presence of hummocky topography, and inadequacy of secondary drainage systems. Destruction of Amik lake and its surrounding wetlands, once an ecological hotspot, has adversely affected not only the surrounding ecosystems but also has not provided productive farmlands. Poor drainage and high salinity are two important factors that adversely affect agricultural activities in this land portion. There is no linear correlation between soil orders and drainage classes detected in this study. Drainage conditions in the same soil order vary same soil order vary depending on topography, soil structure, clay content and clay type.

The main reason for the presence of drainage problems with about half of Amik Plain is inadequacy of secondary drainage systems. Therefore, the extension of open and closed drainage systems by farmers and State Hydraulics Work should be encouraged. Also, agricultural extension works about how to overcome drainage problems in agricultural areas should be carried out to inform farmers. The conventional irrigation methods should be abandoned and new water-conserving and –efficient irrigation methods such as drip irrigation should be adopted as early as possible. Better water management for irrigated and rainfed agriculture in Amik Plain requires a holistic approach to controls over environmental processes of erosion, infiltration, iirigation, leaching, waterlogging, salinization, drainage and bad planting. There is an urgent need for farmers in Amik Plain to apply best agricultural management practices such as the use of conservation tillage systems (no tillage and reduced tillage), crop residue conservation, rotation of mutually nourishing crops, establishment of windbreaks, and cover crops against wind and water erosion.

ACKNOWLEDGEMENT

I would like to gratefully acknowledge funding for this project by the Turkish State Planning Organization (DPT-2002K1204802002).

REFERENCES

Acton DF (1965). The relationship of patterns and gradient of slopes to soils. Can. J. Soil Sci. 45: 96–101.

Cialella AT, Dubayah R, Lawrence W, Levin E (1997). Predicting soil drainage class using remotely sensed and digital elevation data. Photogramm. Eng. Remote Sensing. 63(2): 171–178.

Campling P, Gobin A, Feyen J (2002). Logistic Modeling to Spatially Predict the Probability of Soil Drainage Classes, Soil Sci. Soc. Am. J. 66:1390–1401.

Deutsch C, Journel AG (1992). GSLIB: Geostatistical Software Library and User's Guide. Oxf. Univ. Press, New York.

FAO/UNESCO (1990). Soil Map of The World. Revised Legend. World Soil Resource Report, 60, Rome.

Huete AR, Escadafal R (1991). Assessment of biophysical soil properties through spectral decomposition techniques. Remote Sens. Environ. 35: 149–159.

IEC (International Engineering Company) (1966). 'Technical and feasibility report of Amik development: projects of Lake Amik and Tahtaköprü Dam',. Ministry of Energy and Natural Resources, General Directory of State Hydroulic Works, Ankara.

Kılıç Ş, Agca N, Yalçın M (2004). "Soils of Amik Plain (Turkey): Properties and Classification", J. Agron. 3(4): 291-295.

Kılıç Ş, Ağca N, Karanlık S, Şenol S, Aydın M, Yalçın M, Çelik I, Evrendilek F, Uygur V, Doğan K, Aslan S, Çullu MA (2008). Detailed soil survey, land use planning and productivity study of Amik plain, Research Project of Turkish State Planning Organization (SPO), project number: DPT-2002K120480, Hatay.

Kravchenko N, Bollero GA, Omonode RA, Bullock DG (2002). Quantitative Mapping of Soil Drainage Classes Using Topographical Data and Soil Electrical Conductivity. Soil Sci. Soc. Am. J. 66: 235–243.

Lee KS, Lee GB, Tyler EJ (1988a). Determination of soil characteristics from Thematic Mapper data of a cropped organic–inorganic soil landscape. Soil Sci. Soc. Am. J. 52, 1100–1104.

Lee KS, Lee GB, Tyler EJ (1988b). Thematic Mapper and digital elevation modeling of soil characteristics in hilly terra. Soil Sci. Soc. Am. J. 52, 1104–1107.

Levine ER, Knox RG, Lawrence WT (1994). Relationships between soil properties and vegetation at the Northern Ex.

Lobell DB, Asner GP (2002). Moisture effects on soil reflectance. Soil Sci. Soc. Am. J. 66, 722–727.

Mattikali NM (1997). Soil colour modelling for the visible and near infrared bands of Landsat sensors using laboratory spectral measurements. Remote Sens. Environ. 59: 14–28.

Soil Survey Division Staff (2003). Keys to Soil Taxonomy, U.S. Department of Agriculture. Natural Resources Conservation Service, Ninth Edition.

Troeh FR (1964). Landform parameters correlated to soil drainage. Soil Sci. Soc. Am. J. 28:808–812.