Determining Major Orchard (Pistachio, Olive, Vineyard) Areas in Gaziantep Province using Remote Sensing Techniques

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ABSTRACT

Land use and land cover characteristics of an area supply important information for decision-makers in many disciplines. One of these areas is agriculture that obtains the benefits of these kinds of spatial information in order to plan future production effectively and efficiently. On the other hand, collecting, compiling, managing, analyzing, and displaying the field data are cumbersome duties without spatial understanding. In this study, remote sensing was employed to evaluate spatial data of Gaziantep which is one of the most important provinces of Turkey considering the agricultural activities and its contribution to national economy. Pistachio, grape, olive, maize and cotton constitute the main production areas in Gaziantep. Consequently, land use map that shows spatial distribution and amount of area in different activities is very important for agricultural planners, importers, and exporters in this province. Depending on the request and funding of the Governorship of Gaziantep Province, this project was developed and applied by the Geographic Information Systems and Remote Sensing Department (GISRSD) of Central Research Institute for Field Crops (CRIFC) between the years 2000 and 2001. Land use maps for main agricultural activities were produced by using coordinated field data and LANDSAT-7 ETM images. The satellite images belong to two different periods have been evaluated with the ground truth data collected by Global Positioning System (GPS). Field data were collected for three main groups which are (1) agriculture (field and orchard), (2) forest-pasture, and (3) non-agricultural. The area statistics obtained from the image classification have been given on county base in this paper.

Key Words: Agriculture, Geographic Information Systems, Land Use, Pistachio, Remote Sensing,

1. Introduction

The location of Gaziantep province can be defined as 30^0 28' and 30^0 01' longtitude, and 36^0 38' and 37^0 32' north latitude. Gaziantep is located at the place where Mediterranean and Southeastern Anatolia meet. Majority of the land of Gaziantep takes part in southeastern Anatolia. Gaziantep has an area that covers 6216 square kilometers. The mean altitude is 850 meters above sea level but it ranges between 250 and 1250 meters. Approximately 52% of the total area covered by mountains and 27% of total area is plains. The mountains in the area are the extension of the southeastern Toros range. The mountains surrounding the western portion of the province line up nicely and separate Gaziantep province from the Hatay-Kahramanmaraş depression. Gaziantep has been located in the transition zone of Mediterranean and Continental climates. While the north part of city is displaying the impacts of continental climate, the south parts have the characteristics Mediterranean climate. Generally summers are hot and arid, winters are mild and rainy. Also, the existence of the olive trees in south part of city denotes that the Mediterranean climate has its impact in some certain zones. The annual average temperature is $14{,}4^o$ C and average rain amount is around 500 kg/m^2. These geographical and climatic properties of the city allow a great variety in agricultural products. A great deal of garden products, cereals and industrial plants have been produced in the city. According to type of soil and climatic attributes, some plants such as pea nuts, olive and vineyard have been forming the coverage areas in some certain zones.

Gaziantep, located on a wide and fertile plain cultivated with extensive olive groves and vineyards, produces a variety of agricultural crops. It is especially known throughout Turkey for its excellent pistachios. Consequently, the importance of agriculture in the economical structure of city can not be ignored.

When compared with past years, it can be seen that the agricultural share in national income is decreasing gradually. Despite of this, it is obvious that agriculture will maintain its important role in meeting the nutrition requirements of the increasing population.

Determination of the quantity and dispersion of current agricultural areas will play an important role in better planning of all kinds of agricultural activities. The collection of statistical data which belong to agricultural areas of Turkey has been conducted by the Ministry of Agricultural and Rural Affairs. These studies are generally being done according to the declarations of farmers because of the absence of the cadastral records. For this reason, there are sometimes great differences between statistics and real situations.

At present, developing technology with remote sensing techniques has been extended into various areas including agriculture. Remote sensing technique is simply based on the perceiving of the electromagnetic energy from earth surface by the sensors at satellites and then its evaluation in computer environment. Consequently, lots of information about the physical structure of earth surface can be easily obtained and updated. The usage of remote sensing in agriculture sector has found a wide working area. In collecting data, usage of remote sensing techniques in addition to traditional methods can provide more accuracy and speed.

The accurate information about agricultural areas and agricultural production is essential for Ministry of Agriculture and Rural Affairs as well as decision makers in other sectors.

Reliable information is one of the most important components for efficient and effective management.

2. Materials and Methods

2.1. Materials

This project has been implemented by Geographical Information Systems and Remote Sensing Department of Central Research Institute of Field Crops (CRIFC) in General Directorate of Agricultural Research. The study conducted between the years 2000 and 2001. In the realization of project, there has been administrative and financial supports of local government authorities.

Pentium III work station and Unix based HP series computers have been used as computer hardware. Erdas Imagine and Arc/Info software were employed to process the images and to digitize the topographical maps, respectively. For the district based studies of project, a database with 1:25000 scale was chosen to comprise the city and district boundaries and village centers of whole country. For this aim, topographical maps with 1:25 000 scale were obtained from the General Commandership of Mapping of Turkish Army. Then, digital elevation model was developed by digitizing these topographical maps.

Satellite images are the main materials of the project. Multi band LANDSAT-7 ETM and single band IRS images covering the whole city with high resolution have been purchased. For implementing the project, satellite images, field data, digital cartographic maps with 1/25 000 scale including province and county borders, and statistical data were used. Parts of two LANDSAT-7 ETM scenes are needed to provide complete coverage for the study area. For this aim, full two scenes having path-row of 174-34 and 173-34 were chosen (Figure 1). It is expected that the phenological differences of a specific plant would give the advantages in determining the pistachio areas by means of remote sensing imagery (Campbell, 1987). To select suitable image dates where most changes occur, a phenological calendar was prepared with regard to knowledge and experience of local people and government persons. Based on this calendar and cloudiness, the scene dates were determined as 10th of September-10th of August for fall season and 26th – 27th March for spring season in the year 2000. Good quality and cloud free images that contain the both of these two periods were purchased. The satellite data had been already rectified to UTM coordinate system with WGS 84 datum.

Collection of field data was performed from mid September to the end of October in 2000, and GPS devices were used to collect ground truth data in the field. Field data was planned to be used for

- final reprojection
- image analysis and classification
- accuracy assessment

Collecting reference data is performed not only for pistachio areas but also other land cover classes such as; crop, pasture, urban, bare lands etc. Since the study area was large, county-based sampling is done by taking into consideration.

The following criteria were considered;

- selection of sample sites was based on accessibility (closeness to the road network)
- intensity of pistachio farming in the county,
- mostly point sampling, sometimes polygons were created by visiting all of the corners of the field
- representation of other major classes of each county

Total 3440 GPS records were taken from the study area. Approximately, 30% of total records was set aside for accuracy assessment. Remaining GPS data were used to select training samples in classification process. All GPS data were downloaded to the PC and exported to the GIS format (Arc/Info file). As for cartographic data, digitized administrative boundaries and village locations in county level of Gaziantep province were used. This data had been digitized from 1/25 000 scale base maps of Turkey and provided as Arc/Info vector coverage file. This is only digital vector layer we have in our data at this scale level. It is quite accurate for national and regional but not as accurate as in provincial and county level (Figure 2).

Agricultural statistics for the main crops grown in the study area were taken from the provincial directorate of agriculture. In basic, these agricultural statistics had been collected by direct contact with farmers and field survey accomplished by government department for the year 1999.

2.2 Method

The method employed for this project was basically dependent upon the supervised classification of image data by using GPS data and then testing of classification performance. LANDSAT7-ETM image for fall season were base data used for classification. Two different date scenes were mosaiced to output image from which final data covering the study area was obtained. This data was produced by subsetting the mosaiced image with Arc/Info coverage of province borders (Figure 1).

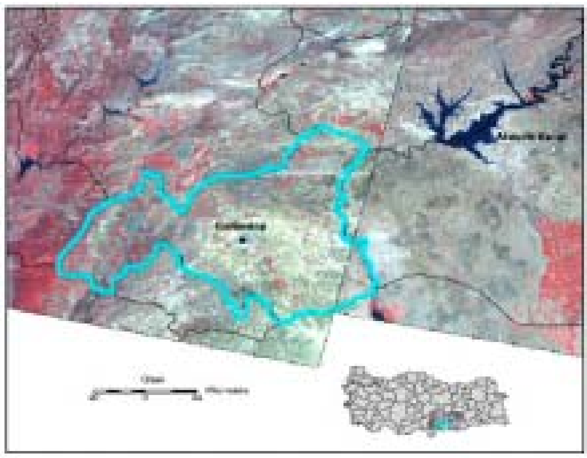

Figure 1. Study area.

Even though the province image is in the UTM coordinate system, collected field data (in UTM projection system) did not match with the GCPs over image. Average shifting was 240 m for x, and 180 m for y coordinates. The image was reprojected one more time using GPS coordinates (Cook and Pinder, 1996), and resampled to 30 meter resolution with affine coordinate transformation (Verbyla, 1995). In the final reprojection, total

rectification accuracy (measured by root-mean-square error) based on a 2nd order transformation model was 1.7 pixel unit. Since the study area is quite flat with average elevation of 600 m, there is no need for topographic normalization.
The purpose of the classification is to create meaningful information class value from image by providing pixels of similar spectral characteristics. The supervised classification approach that requires priori information about land cover was used to categorize the pixels in a group. The GPS data and visual interpretation was used as the priori knowledge in this study.

Instead of a specific land-cover classification system, a new one was prepared and applied in the area in terms of predominant crops. The scheme firstly categorized into three main classes as (1) agricultural area, (2) forest and pasture land, and (3) non-agricultural areas. These major classes are then divided in sub-classes (Table 1), The pistachio areas are included in orchards sub-classes of agricultural areas.

2.2.1 Collection of spectral signatures:

A signature is a range of brightness values of pixels for each band of digital images. These values have statistical meaning (mean, standard deviation etc.) so that each pixel is assigned to a class based on how well it matched with this signature. Collection of signatures can be done by selecting training pixel samples that are to be representative of particular class. Training samples for the study area were collected using ERDAS-IMAGINE`s area of interest (AOI) tools. Training samples were tried to be selected from spectrally pure pixels representing target class. Training sites were determined with visual inspection and by overlying the locations of GPS data onto image. Approximately ten to fifteen training sites for each land-cover class were chosen by considering a good spatial distribution. As a result, only the signatures left in signature files were going to be assigned to the specific classes after running classification algorithm. These classes are accepted as real land cover of study area and used for the estimating of pistachio areas. Creation of signature files by means of training samples is performed separately for each county. So there were nine different signature files ready for supervised classification process.

2.2.2 Classification Process: A variety of classifications algorithm methods have been used in remote sensing. One of these methods is maximum-likelihood classification algorithm which assumes that the data are normally distributed and based on the probability that a pixel belongs to a particular class (Jensen, 1996).

In this project, the maximum likelihood classifier is used because it is still accepted as the most accurate time intensive classification algorithm compared to the others (Weber and Dunno, 2001). Maximum likelihood classifier algorithm takes into account class variability by using the covariance matrix for each signature (ERDAS, 1999). This algorithm was applied to previously subseted images of each county for which signature files had been created. Some photo interpretations were also used to increase the accuracy of digital classification.

To determine the accuracy of the classification process, an accuracy assessment test was conducted for all classified images. Classification results are usually summarized as matrices which presents classification errors. These errors includes omission and commission errors. A common error, appears when a pixel wrongly assigned to a class of classified image, is measured by user accuracy (Zhuang, 1995). Kappa statistics is also important parameter for evaluation of classification errors. It express "proportionate reduction in error generated by a classification process compared with the error of a completely random classification" (ERDAS, 1999).

3. Results and discussion

Area statistics for main crops in both province and county basis were produced from classified images. Total agricultural land was determined as 309213 ha in the province. Field crops constituted 148477 ha area, while orchards and vineyards covered 160735 ha (Table 1).

Table 1. Disrtribution of agricultural lands by county.

	Total agri. land (ha)	Arable land		Fruit crops	
		Area (ha)	(%) in total agric. area	Area (ha)	(%) in total agric. area
Ş.Kamil	47926	12873	27	35053	73
S.Bey	49837	20833	42	29005	58
Araban	21028	16107	77	4921	23
Islahıye	15046	11905	79	3141	21
Kargam	28480	10923	38	17557	62
Nizip	55985	12989	23	42996	77
Nurdagı	22835	21096	92	1739	8
Oğuzeli	48118	32443	67	15675	33
Yavuzeli	19956	9308	47	10648	53
TOTAL	309213	148477	48	160735	52

Wheat, barley, pulses and chickpea cover 125101 ha (84 % of field crop areas). Rest of the field crop area is covered by cotton, maize, vegetables and other crops. Pistachio areas constitute 58% of the total orchards in the province. Vineyards and olive groves together cover 35% of the area. The rest of the area is other fruits. Accuracy assesment test results were given in Table 2 for each county. Overall accuracy changes between 74.5% and 85.6%.

Table 2. Overal accuracy for each county.

County	Overall Accuracy (%)	County	Overall Accuracy (%)
SEHITKAMIL	82,10	NIZIP	77,10
SAHINBEY	80,86	NURDAGI	85,59
ARABAN	77,44	OGUZELI	75,98
ISLAHIYE	74,71	YAVUZELI	81,10
KARGAMIS	79,60	Average	79,38

With this project remote sensing technology has been used to support area statistics for important crops. Since there was only county boundaries for project area as a base map, analysis were carried out on county basis. Cadastral maps that could supply more details were not available in digital format. Moreover, high resolution satellite images would be more effective to get more accurate statistics and maps.

Similar crop calendars of different crops (cotton, second crop maize, pepper) caused some classifying errors in the study area.

On the other hand, main agricultural crops of pistachio, olives and vineyards showed similar reflectance because of background soil reflectance. These crops are grown without irrigation with sparse stands. For this reason, bare ground affects the reflectance of those three crops similarly. Images of different dates (spring time, summer time) didn't help to differentiate between pistachio, vineyards and evergreen olive groves in the classification process. To overcome this problem, as many as ground truth data were used and the number of training signatures in supervised classification algorithm was increased and extended across the image. Photo interpretation was also used to increase accuracy of digital classification. Wrongly classified pixels whose real class type are known are manually edited to include in related class.

4. Conclusion

Agricultural management highly depends on knowledge land use information. There are many agricultural surveys and land use maps prepared and completed in the past. Undoubtedly all of them are important sources giving the idea about agricultural land but they are far from giving up-to-date information for effective management.

Remotely sensed data has filled a gap about the needs of up-to-date land use information. Basically, the use of this kind of data is getting to spread in Turkey. This study is one of the pioneering projects that use remote sensing techniques effectively. Although

This study showed that remotely sensed data, especially LANDSAT-TM images, are highly suitable to determine the current land cover and land use characteristics in a cheap, fast, and accurate way.

Applied supervised classification with maximum likelihood parametric rule and LANDSAT-TM images were found suitable to display the land cover and land use characteristics of the area. Therefore, decision makers who are studying on agriculture can utilize this kinds of information satisfactorily. This study showed how a complete agricultural spatial database could be a good starting point for many planning applications.

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