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A study on the determination of electromagnetic reflection values of agricultural crop pattern to improve accuracy of land use map by remote sensing technique

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Abstract

With this study, using remote sensing technique, a data base which covers data on the electromagnetic energy reflections of various kinds of plants has been formed with the purpose of determining crop patterns. A 1/5.000 scale cadastral map was used as topographic map for the purpose of using remote sensing technique more effectively and sensibly for such crops as cotton, maize and sun flower of which the agriculture is exercised widely in Torbalı township and in this context in all the Aegean Region.

In the current study, August 2001 dated Landsat 7 satellite images of the region were interpreted and ground realities and satellite images of the agricultural crops with high economic value which are widely cultivated in the region were overlapped and their values of reflection were determined. Images thus obtained were overlapped with 1/5.000 cadastre maps and product varieties could be determined at the basis of large section of a map, plot and parcel. Separately collaboration with technical personnel from the Directorate of Torbalı Township Agriculture was achieved in field and lab studies, and by transferring the data obtained into their computers, tangible steps were taken in the direction of applying technology at the basis of the Township. As a result, an important and basic database was formed that could be used for the payout of incentive premiums to the local organization for various crops or that could render functionality to the implementation of Agricultural policies based on record system.

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Introduction

Today, used for various purposes, each of the satellites has different resolutions. There is a need for satellite images of different agricultural applications such as determining the areas of plantation, monitoring crop improvement and agricultural fields.

Since the advent of multi-spectral remote sensing in the 1970s with the launching of the first satellite of the Landsat series, agriculture has benefited from this technology, being one of the first domains in which operational applications were developed. Crop identification and surface estimation for the purpose of agricultural statistics, through the combination of area frame sampling and estimation by regression with supervised classification of remote sensing data, are perhaps some of the best examples (Pinter et al. 2003).

Remote sensing data have been increasingly applied along the last three decades to assess agricultural yield, production and crop condition (Wiegand et al. 1979; Ren et al. 2008). Thanks to this technique, it is possible to reach the data required for the natural resources and the results aimed in a short time with great accuracy

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and low cost. Satellite images which are used especially in agricultural areas with great functionality are on the agenda as an important data source for monitoring agricultural areas, getting area-based information about soil and crop patterns. Hansen et al. (2000) derived temporal metrics from a full year of AVHRR data and exploited the temporal changes in reflectance/ NDVI/brightness temperatures to successfully discriminate global land cover types. The use of Landsat scenes acquired at different seasons and/or years to improve land cover classifications is certainly not a new concept.

This would particularly apply to the agricultural sectors (Wardlow and Egbert, 2002), although the continuously changing character of agricultural areas at various spatial and temporal scales in response to management decisions, agricultural policies, prices, irrigation water availability and environmental factors, among others, makes remote sensing technology a useful tool for application in this field. One particular example of the underutilization of remote sensing data in agriculture is the application to map multi-year cropping patterns and/or crop rotations. Although it is well known that one of the main advantages of remote sensing from satellites is the synoptic and repeated collection of data, which allows time-series of accurate information on the spatial distribution of crops over large areas (Bastiaanssen et al., 2000; Panigrahy and Chakraborty, 1998).

Panigrahy and Sharma (1997) based their method on the definition of the spectral signatures of crop rotations and subsequent supervised classification from four multi-spectral images corresponding to four crop seasons within an agricultural year. On the other hand, Raupenstrauchk and Selige (1998); Paoli et al. (2003) first derived multi-temporal crop maps produced by supervised classification of remote sensing data. Then these maps were used to derive crop rotation maps by means of GIS analysis. In order for a contemporary and effective national agricultural policy to be applied, there is a need for databanks containing information about different product patterns. Extensive vegetation surveys allow the combination of floristically defined plant communities with satellite data in order to map spatial distribution of vegetation (Aragon and Oesterheld, 2008; Zak and Cabido, 2002). With the use of satellite technology at the parcel basis for attaining agricultural inventory, crop patterns and their values were formed for the first time and as a whole in computer.

Material and Methods

Material

Preparing topographic maps : In order to work out satellite images and to form a database in conformity with a structure based on geographical features, a digital topographic map was established. 115 sections of big maps in 1/5.000 scale which involve parcels and topographic data about the region were used. Data on the scales and the coordinates of sections of big maps were registered by using software Geomedia, and the mosaic of the township Torbalı was formed (Fig. 1).

With the help of this GIS-featured software, cadastre maps were formed by drawing the roads, canals, beds of streams and rivers by using screen digitalization method. Data given on the topographic map (Fig. 2) were digitalized in the form of layers for each element following the rules of geographical data system. Rectification of the satellite images were realized by using digital topographic maps (Fig. 3).

Data collection: Types of crops were determined in the parcel basis through field studies in order to determine different crop patterns, also ratios of accuracy of the satellite images, of different crops which were cultivated between spring and Autumn in 2008. Lab and field studies were realized by using 1/5.000 scale cadastre maps.

Depending on the calendar of crop development of some crops that show distribution in the study field, the earth-covering ratios of the green vegetation and their features of reflecting electromagnetic energy were determined by the help of hand spectrometer in harmony with satellite sensing instruments.

Comparing the measured degrees of electromagnetic reflection and the reflection values in the satellite images, reflection features of the elements were determined. Processes of image rectification, forming false color composite, enrichment, filtration etc. were conducted respectively. Cadastre maps which were corrected and which involve parcel data in AO dimensions of cadastre sections of big maps were used in determining crop patterns in parcel basis by overlapping them with satellite images.

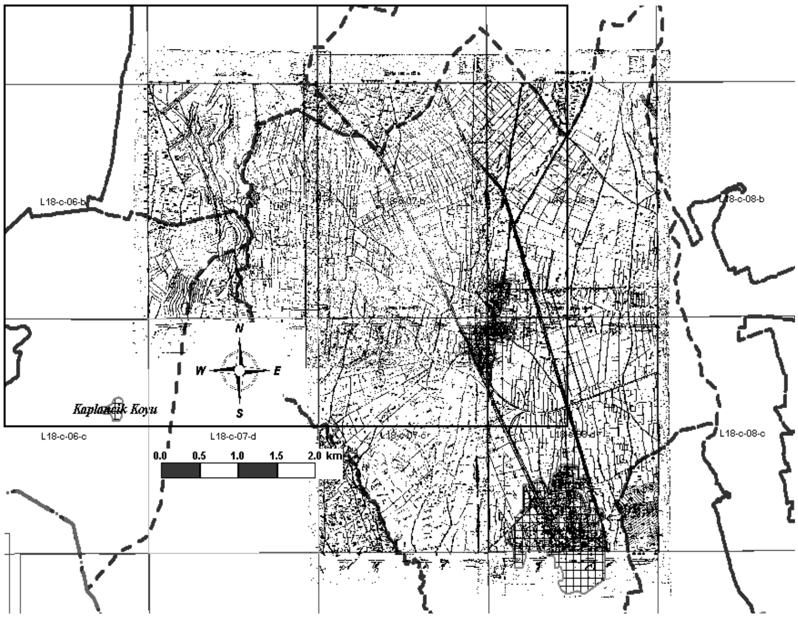

Figure 1. The stage of forming a mosaic of sections of big maps turned into geotiff format by giving coordinate data.

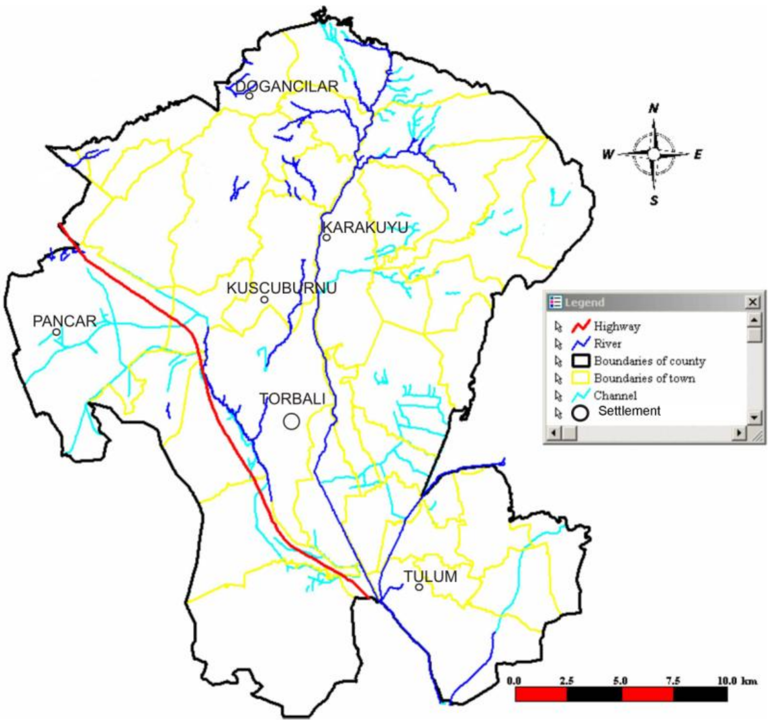

Figure 2. Topographical map of the Township of Torbalı formed by using cadastre sections of big maps, 1/5 000 in scale.

Forming Database: Places of crop patterns determined by field studies were also determined on the satellite images. Digital reflections of each crop pattern, being at least 100, were determined for 3 band and data tables were prepared. Their evaluation was made by using SPSS statistical software and their arithmetical means, standard deviations, most/least recurrences and minimum/maximum reflection were investigated. Analyzing the data obtained this way, intervals of reflection values of both crops in the satellite images were determined in regions of near, middle infrared and visible red light. In order to predict the plant cover through satellite images without in situ observation, in other words, for the purpose of better understanding the content of satellite images, a database was formed using Geomedia-Access(GIS) software taking reflection intervals for every crop as basis. So, within the framework of questioning rationale, it became possible to reach crop varieties when intervals of reflection are entered and to reach intervals of reflection when crop varieties are entered.

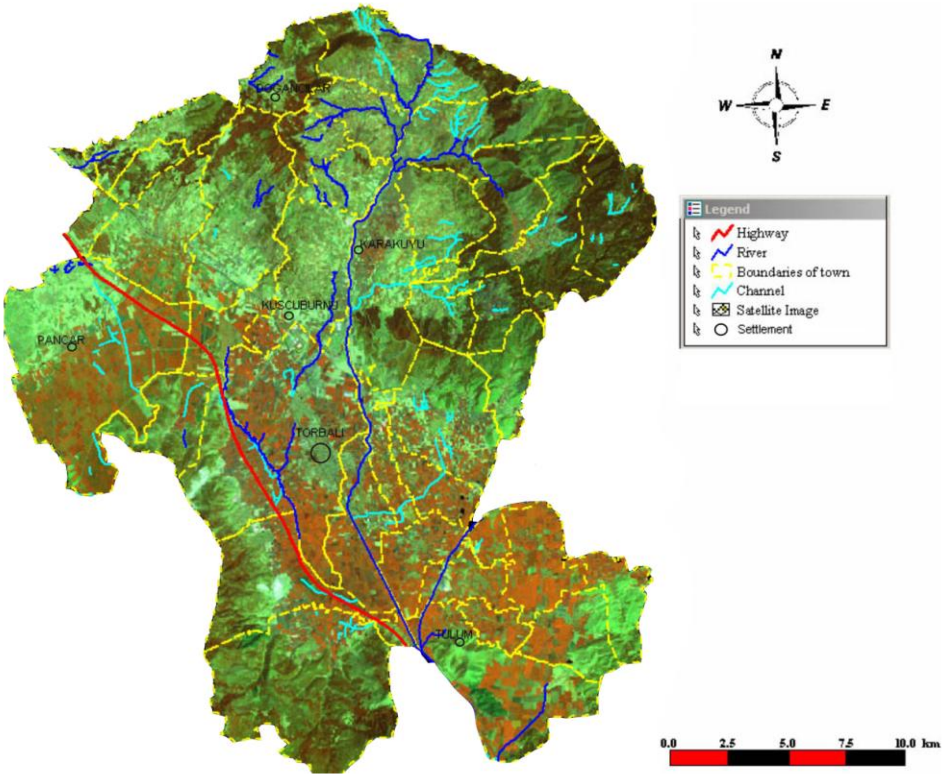

Figure 3. Landsat 7 ETM image cut on the basis of the borders of Torbalı township (August 2001, 453 band combination).

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Results and Discussion

In areas of Torbalı township which have survived their ecologic life under the effect of Mediterranean climate, a number of cultural plant cover find life during the periods of summer and winter. In the current study, concentration was on plant cover in the interval of the wavelength of 0.76-0.90 µm which the crops reflect most. The interval of 1.55-1.75 µm covering middle and far infrared and 0.63-0.69µm wavelengths which involve together the reflection data about plant and soil in the visible region were taken into consideration. Reflection values about the plants mentioned were determined in bands 3, 4, and 5 of Landsat 7, which involve energy in wavelengths of red, near and middle infrared region.

Casasnovas et al. (2005) investigated that at Zaragoza, 7-year time-series (1993, 1994, 1996, 1997, 1998, 1999 and 2000) of crop maps derived from Landsat 7 ETM images were used to obtain the implicit spatial relationships between crops in the study area, from which the cropping patterns were mapped. For each year, the crop maps were produced by supervised classification of spring and summer scenes (two or three scenes/year) in order to better characterize the different crops and land uses present during the year. The images were processed and classified in the CITA (DGA). The method used was the maximum likelihood classifier. The ground-truth areas were automatically selected from field-sampled segments. The land use classes mapped were: winter cereals, rice, sunflower, maize, alfalfa + forage, uncultivated land (includes mainly fallow and other uncultivated enclaves), pines and other classes. This last class includes pixels that were not classified in any other of the established classes because of their low probability of belonging to any of them. Water and urban areas were digitized from existing maps and superposed in the final crop maps. Confusion matrices used the same ground truth to both train and evaluate the supervised classifications. After the classification process, a 95% confidence level threshold and a 3×3 majority filter were applied (Barbosa et al. 1996; Mart´ın-Ord´onez et al. 2000).

Once the typical-location areas of the crops have been mapped, it is necessary to know which other crops were present at these locations in any of the years in which the main crop was not present. To achieve this, GIS cross-classification operations in Idrisi32 were applied to map all existing combinations between the typical-location crop maps and the frequency distribution maps of each crop. Crossclassification can be described as a multiple overlay showing all existing combinations of the logical operation (Eastman 2002).

Multispectral and hyperspectral imaging systems (i.e., satellites, spectroradiometers, and digital cameras) capture digital images at specific wavelengths of light reflected from plant leaves (Hansen and Schjoerring 2003; Schuerger et al. 2003; Huang et al. 2004). A variety of spectral measures that relate to nitrogen and chlorophyll content or other plant stresses have been developed (Curran et al. 2001). As leaves become more chlorotic, reflectance increases and the reflectance peak normally centered at about 550 nm, broadens towards the red as absorption of incident light by chlorophyll decreases. These changes are perceived visually as a yellowing of the leaf (Adams et al. 1999).

Cerqueira Leite et al. (2010) propose a Hidden Markov Model (HMM) based technique to classify agricultural crops. The method uses HMM to relate the varying spectral response along the crop cycle with plant phenology, for different crop classes, and recognizes different agricultural crops by analyzing their spectral profiles over a sequence of images. The HMM based method achieved 93% average class accuracy in the identification of the correct crop, being, respectively, 10% and 26% superior to multi-date and single-date alternative approaches applied to the same data set.

Traditional approaches to land cover classification from remotely sensed data have typically relied on statistical classifiers such as supervised Maximum Likelihood Classifiers (MLC) or unsupervised isoclustering techniques. Increasingly, advances in the fields of pattern recognition and machine learning have led to the application of decision tree and neural network classifiers, particularly with regards to land cover classifications at global to continental scales (Friedl et al. 2002; Hansen et al. 2000) classifiers.

With this goal in mind, of the plant specious of which the places of growth were determined at the parcel basis at the end of the field study, places in the satellite images were determined in lab and in electronic medium (Fig. 4). Pixel samples were formed for each kind crop from every part of Torbalı and reflection values of each pixel in the bands of 3, 4, and 5 were determined. The highest and the lowest values of these data were omitted with statistical evaluation logic and they were transferred to SPSS statistical software. At the end of the current study of which the aim was determining plant cover through satellite images using numeric values, the least and the highest intervals of reflection for each crop were determined within 3 bands and at the same time, numerical data on the values of most frequent repetition and arithmetic means were determined.

Sampling was made by investigating pixel reflection values of each crop pattern in satellite images. As a result of this study, when reflection values of the above mentioned crops in near infrared region (band 4) were examined, it was determined that cotton gave the highest reflection in summer period and wheat gave the highest reflection in winter season. It is also determined that trefoil is another crop that gives the highest reflection values but since its areas of cultivated are small, it was not included in the current study (Fig. 5, 6).

Feature of electromagnetic reflection of some of agricultural crops cultivated intensively in Torbalı region and features of being seen numerically in the satellite images are explained below taking two crops as basis.

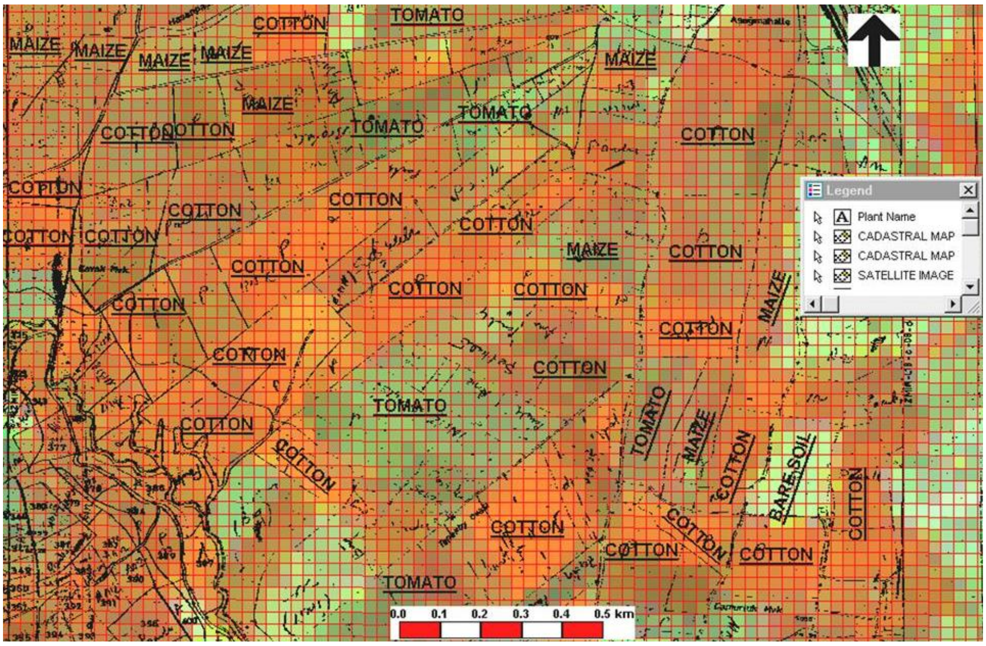


Figure 4. Parcel-based crop differentiation with 1/5.000 scaled cadastral map using Landsat 7 ETM images

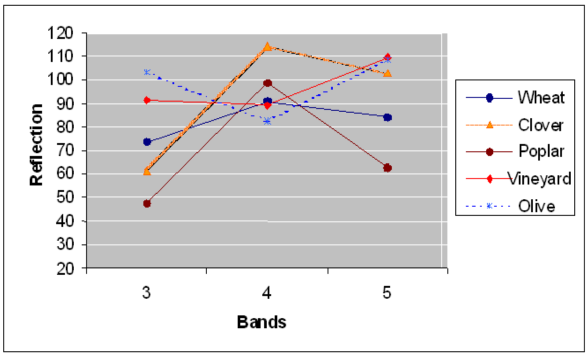


Figure 5. Reflection features of plant coverage in winter season in Torbalı region

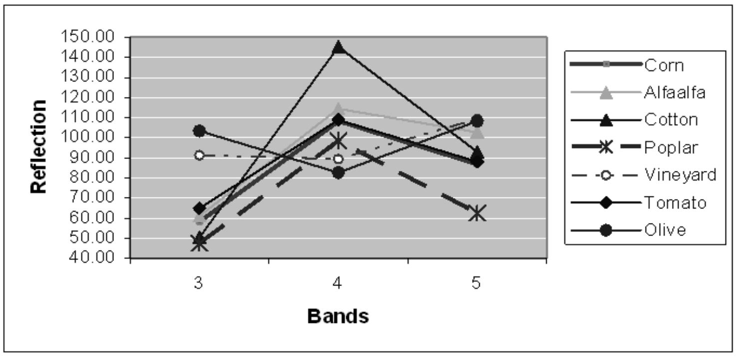


Figure 6. Reflection features of plant coverage in summer season in Torbalı region

More than 200 pixel sampling were made for both types of crops. When resulting data were examined, it was observed that the crop with the highest rate of earth covering has the highest near ultra-red wave length. On the other hand, crops with reflections of medium ultra red wave length had the lowest numeric values.

The use of temporal information for classifications provides benefits at both fine and coarse resolutions. These benefits can easily be explored with decision tree classifiers, as they can provide indications of the relative importance of particular attributes or dates for certain land cover classes, and their interactions, or be used as a tool for data reduction or feature space exploration (Hansen et al. 1996).

Karagüllü et al. (1998), within the framework of the Project of In-situ Preservation of Genetic Diversity, have formed databases in regions of Kazdağları National Park, Ceylanpınar Agricultural Business Unit, Bolkar Mountains and Aladağlar for grass species like wheat, barley, chick peas and lentil; and trees like plum, chest nut, fir tree, cedar, pine tree, pear, apple, wall nut; and pistachio. Databases for the distribution areas of these crop patterns, distributions of areas in square meter, and water needs climate were determined.

Roy and Tomar (2001), in Meghalaya Region in Northeast India, determined quantitatively the changes and different tree patterns in forest covered areas during the period of 1980-1995 using ERS satellite images. As a result, they found out that the percentage of forest covered areas fell from 69.06 % to 63.09% and of the areas not covered with forest increased from 27.51% to 36.80.

Delli (1998) tried to determine, from Landsat TM images of April and October 1996, poplar planted areas and the amount of wood in a region of 14870 ha in Konya-Ereğli. As a result, insufficiency of resolution of

Landsat TM images led to the orchards in the region to have similar spectrums. Due to this confusion, it was concluded that it would not be fruitful to try to determine poplar plantations using Landsat images.

Tuğaç et al. (2001), in a study they conducted in Central Anatolia, formed an agricultural database involving information about the geographical location of the research area, soil and land use geology, climate, topography and production in the past years. Using these data and different modules of three dimensional Arcview software, they determined different modules for the purpose of establishing parcels and crop patterns that will build up a basis for the present agro-centered land-use planning; of bringing about important soil components that are important in determining the structure of soil and the distribution of elements in the soil; and of finding appropriate areas involving optimum conditions for the type of crop.

Oldeland et al. (2010), try to a new approach that uses high spatial resolution hyperspectral datasets to map vegetation units of a semiarid rangeland in Central Namibia. In their opinion, there is a great potential for the communities of remote sensing and ecological scientists to use these types of predictor variables for improving vegetation mapping approaches based on multivariate relationships.

Ercan et al. (2002) formed the inventory of the hybrid poplar planted areas in plains of Adapazarı and Düzce by making use of remote sensing data. As satellite data, they used SPOT IV (Multi-spectral-4 band) images belonging to June, 2000.

Jakabauskas et al. (2002), in a study they conducted in Kansas (USA), determined crop patterns in an of approximately 1300 km^2 where irrigated and rain fed agriculture is applied using Meteosat satellite images. As a result of their study, they classified the oat and maize planted areas that form the crop patterns for irrigated regions, and wheat planted areas that form the crop patterns for dry cultivation regions. Areas of weed plantation were determined as 25% while pasture areas were determined to be a 50%. In irrigated areas maize was 44% and oat was 48%. Remaining 8% belonged to other irrigated crops.

Of the plant covers taking place in Torbalı, and of which the reflection values have been examined within the framework of this study, cotton and clover give the highest reflection values compared with digital reflection features that can be sensed through remote sensing devices of Landsat 7 (Table 1).

Wheat: Effective coverage of the areas by wheat in Torbalı occurs only in April and May. In May, crops begin to turn yellow in places and in June nearly all of the crops turn yellow and they are harvested. It has been observed that high reflections seen in near infrared (NIR) portion of electromagnetic spectrum determined in sample reading are directly related with wheat covering the areas completely at the time the satellite images have been taken.

Vineyards: The most important factor affecting discrimination of vineyard coverage in satellite images is the ratio of green texture covering the soil. But even in the most matured state it covers 50-55 % of the soil. For this reason, it has been observed that the electromagnetic reflection feature of the soil in between the rows is a very effective parameter.

Tomatoes: Tomatoes which are planted during summer months show a fast increase in the ratio of covering the soil with leaves from May onwards. The ratio of covering the soil reaches up to 80 % as of the end of June and this level maintains itself until the end of August. Although soil properties which affect reflection 20 per cent leads to a little decrease in the reflection aftermath irrigation, standard deviation was determined not to be high.

Poplar: Poplar trees are grown on small smooth slope areas near river beds. Poplar trees begin to grow leaves from April onwards and the intensive leafed period begins after June. Leaves begin to turn yellow as of September and begin falling slowly in October forwards. For this reason, July and August should be seen as the best physiologic period in order to image process poplar tree cover in satellite images or through near ultra red sensing.

Maize: Maize crop can be produced twice during the summer months. Soil coverage ratio of maize which is planted after wheat harvest reaches to the level of being notices in satellite images 2,5 months after being planted. It has been observed that maize has a different feature of reflection in satellite images in that it has got very different shape and stance of leave compared with other plants and that it forms a dark colored tip especially during the period of blooming.

Table 1. Means of arithmetic reflection values in Landsat 7 ETM images on bands 3, 4, and 5 of plant coverage that widely take place in Torbalı

WHEAT	**Band_3**	**Band_4**	**Band_5**	**MAIZE**	**Band_3**	**Band_4**	**Band_5**
Count	209	209	209	Count	816	816	816
Mean	73.76	90.7	84.11	Mean	58.2475	108.22	86.79
Standard Deviation	7.88	8.45	7.36	Standard Deviation	9.9769	10.94	8.77
Variance	62.02	71.34	54.10	Variance	99.5386	119.59	76.94
Minimum	57	72	69	Minimum	40.00	84	65
Maximum	95	108	99	Maximum	125.00	130	131
VINEYARD	**Band_3**	**Band_4**	**Band_5**	**COTTON**	**Band_3**	**Band_4**	**Band_5**
Count	77	77	77	Count	3882	3882	3882
Mean	90.96	89.78	109.84	Mean	50.58	145.27	93.03
Standard Deviation	18.24	9.51	19.69	Standard Deviation	3.93	9.78	5.49
Variance	332.59	90.36	387.53	Variance	15.41	95.56	30.14
Minimum	61	73	81	Minimum	40	106	78
Maximum	121	108	147	Maximum	97	188	129
TOMATO	**Band_3**	**Band_4**	**Band_5**	**OLIVE_TREE**	**Band_3**	**Band_4**	**Band_5**
Count	350	350	350	Count	117	117	117
Mean	65.02	108.87	88.14	Mean	103.37	82.71	108.29
Standard Deviation	8.85	8.84	8.35	Standard Deviation	14.23	8.58	13.78
Variance	78.36	78.21	69.74	Variance	202.39	73.66	189.81
Minimum	45	86	71	Minimum	65	62	79
Maximum	97	130	114	Maximum	135	108	141
POPLAR	**Band_3**	**Band_4**	**Band_5**	**CLOVER**	**Band_3**	**Band_4**	**Band_5**
Count	45	45	45	Count	44	44	44
Mean	46.6889	97.5556	61.4889	Mean	61.14	114.41	102.73
Standard Deviation	4.3788	3.9171	5.3070	Standard Deviation	11.39	11.80	18.63
Variance	19.1737	15.3434	28.1646	Variance	129.79	139.32	346.99
Minimum	40.00	89.00	55.00	Minimum	47	91	73
Maximum	58.00	105.00	73.00	Maximum	97	138	149

Cotton: Cotton is generally planted in April and completes its germination in May. It is possible to differentiate cotton in satellite images depending on the increasing ratio of soil coverage. At the end of July and beginning of August, the ratio of soil coverage in well grown cotton planted areas exceeds 95 %. For this reason, plant coverage of cotton can be easily detected trough near ultra red sensing area through digital reflection values. Another factor affecting reflection is the irrigation of cotton plant. Although the coverage ratio is high in cotton planted areas, the irrigated state of cotton planted areas decreases the reflection degree in near infrared (NIR) between 10-15 % and as a result, it makes it possible to differentiate between the borders of irrigated and not irrigated fields. It has been found out that soil features between the rows in moisture or wet conditions are very effective together with the ratios of coverage. Depending on this fact, it has been determined that the intervals of least and most reflection are big.

Olive: Olive which is the endemic plant of the region and which has a long span of life is an evergreen plant. The fact that its leaves are not intensive and have a low ratio of soil coverage nakes it difficult to be seen in satellite images with low degree of resolution. For this reason, it has been found out that accuracy rates of determining olive areas by using low degree resolutions of Landsat images is low.

Clover : Clover stays green for most part of the year. For this reason, clover planted areas depending on the high degree of soil coverage during winter and summer months are observed with high reflection values in near infrared band (band 4).

All reflection values obtained were statistically analyzed. A database formed by taking into consideration the arithmetic means of reflections of crop patterns and maximum and minimum values is rather easy. It is possible to reach a crop pattern by using numerical values of peaks in the satellite images; it is also possible to determine digital reflection values of satellite images from crop patterns.

Plants were put into record using database 3, 4 and 5 band data and relations between them were established making use of data in the ID column in the Plant table and ID columns in the Band table using "inner join" method. In doing so, the aim was to record data appearing in more than one column about a single plant. In the questioning process, values of 3, 4 and 5 bands, which were given as parameter, were reached by questioning minimum maximum data. By doing plant description according to database design, reflection values of a particular plant can be imaged as a result of forming relationship between these descriptions (Fig. 7, 8 and 9).

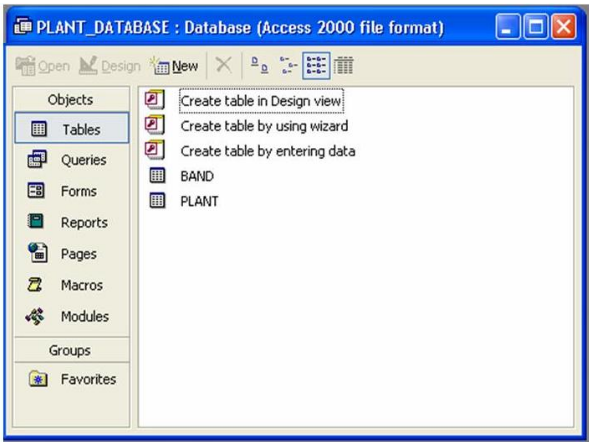


Figure 7. Flow chart for database

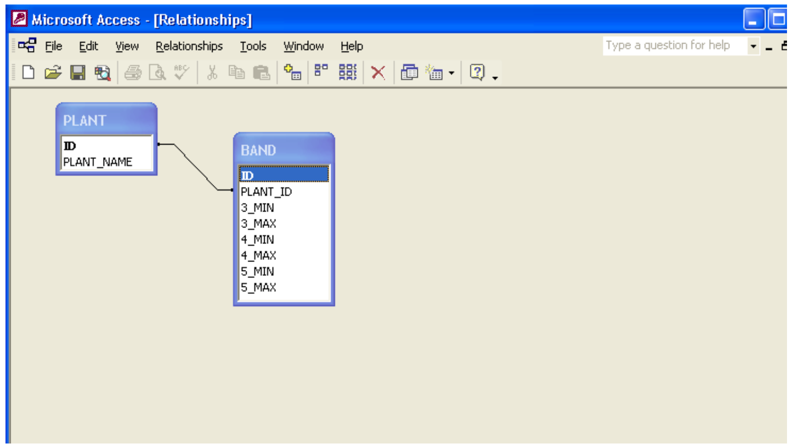
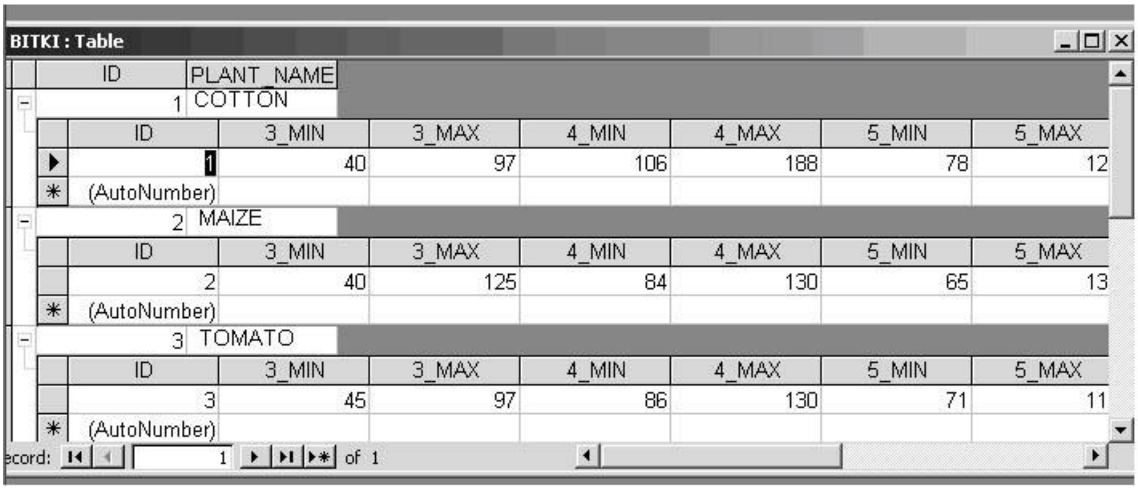


Figure 8. Logic of establishing relation in a questioning of which the initial stage is the name of the plant


BITKI : Table

ID	PLANT_NAME						
1	COTTON						
ID	3_MIN	3_MAX	4_MIN	4_MAX	5_MIN	5_MAX	
1	40	97	106	188	78	12	
(AutoNumber)							
2	MAIZE						
ID	3_MIN	3_MAX	4_MIN	4_MAX	5_MIN	5_MAX	
2	40	125	84	130	65	13	
(AutoNumber)							
3	TOMATO						
ID	3_MIN	3_MAX	4_MIN	4_MAX	5_MIN	5_MAX	
3	45	97	86	130	71	11	
(AutoNumber)							

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Figure 9. Having stated the name of the plant, imaging of maximum and minimum reflection values

Conclusion

Remote sensing approaches for vegetation mapping have been increasingly applied over the last years. These approaches combine detailed ground data fromecological field surveys with remotely sensed data, showing great potential in the field of fine scale vegetationmapping (Alexander & Millington, 2000). In this research project, different plant patterns in township Torbalı were determined by the evaluation of field observations and satellite images together, and a database which involves features of being seen in satellite images was formed. The use of this database which was formed by working on the basis of parcel of 1/5.000 scale is rather high. The plants that are intensely cultivated in the vicinity symbolize the plant species that find ecologic life in the Aegean Region. For this reason, the database for the plant cover on rich soils in the vicinity of Torbalı can be used for other agricultural areas in the Aegean Region. In this context, database which had been formed for the cotton plant by previous projects was brought into a more sensitive state for cotton and enabled to allow use of remote sensing technique for plants like for maize and sunflower. As a result of determining reflection values of different types of plants in the satellite images, it becomes possible to bring about the distribution of cultivated areas and also to determine the harvest yield with the help of field studies. In order to determine agricultural policies of the years ahead and to be able to apply these policies directly, there is a need for data banks that involve reflection values of different crop patterns.

In parallel to the formation of digital database described above, remote sensing technique was introduced to the technical personnel of The Directorate of Torbalı Agricultural Affairs and thus the transfer of this technique to this institution was realized. In the context of this study, digital database was formed in the way that it would allow differentiating crop covers from each other or determining borders clearly in a short time using satellite images. Database was formed for two plant types by using "Access" software in the way that it would cover reflection intervals on the bands 3, 4, and 5 for Landsat 7. In this study which will form an initial step for the use of satellite technology for establishment of agricultural inventory, a coordinated border of a township was formed as digital formatted. The fact that the Directorate of Torbalı Agricultural Affairs took place in this project and participated in the studies helped this technology to be transferred from a university into a practicing institution. As a result, this project showed that satellite technology could be used in application of national agricultural institutions.

References

Adams, M.L, Norvell, W.A., Philpot, W.D., 1999. Yellowness index: an application of spectral second derivatives to estimate chlorosis of leaves in stressed vegetation. *International Journal of Remote Sensing* 20, 3663–3675.

Alexander, R., Millington, A.C., 2000. *Vegetation mapping: From patch to planet*. Chichester John Wiley and Sons Ltd.

Anonymous, 1997. The Population Information Program Center for Communication Programs. The Johns Hopkins School of Public Health, USA.

Aragon, R., Oesterheld, M., 2008. Linking vegetation heterogeneity and functional attributes of temperate grasslands through remote sensing. *Applied Vegetation Science* 11, 117−130.

Arkoç, V., 1996. General Information about Torbalı. Sepici Holding Company, İzmir.

Barbosa, P.M., Casterad, M.A., Herrero, J., 1996. Performance of several Landsat 5 TM image classification methods for crop extent estimates in an irrigation district. *International Journal of Remote Sensing* 17, 3665–3674.

Bastiaanssen, W.G.M., Molden, D.J., Makin, I.W., 2000. Remote sensing for irrigated agriculture: examples from research and possible applications. *Agricultural Water Management* 46, 137–155.

Casasnovas, J.M., Montero, A.M., Casterad, M.A., 2005. Mapping multi-year cropping patterns in small irrigation districts from time-series analysis of Landsat TM images. *European Journal of Agronomy* 23(2), 159-169.

Cerqueira Leite, P.B., Feitosa, R.Q., Formaggio, A.R., Pedro da Costa, G.A.O., Pakzad, K., Del'Arco Sanches, I., 2011. Hidden Markov Models for crop recognition in remote sensing image sequences. *Pattern Recognition Letters* 32, 19-26.

Curran, P.J., Dungan, J.L., Peterson, D.L., 2001. Estimating the foliar biochemical concentration of leaves with reflectance spectrometry: testing the Kokaly and Clark methodologies. *Remote Sensing of Environment* 76, 349–359,

Delli, G., 1998. Estimation of Poplar Grove Areas and its yields. A.G.M-Ankara, I.O.A-Italy.

Dinçer, M., 1993. Geology of Çakırbeyli village-Torbalı. Deparment of Geology Engineering of Dokuz Eylül University, İzmir-Turkey.

Doğan, H.D., 2001. The remote sensing & GIS studies in agricultural areas. 1st Symposium of Global Space Activities & Potential in Turkey. Ankara.

Eastman, J.R., 2002. Idrisi32 Version I32.22 On-line help. Clark Labs, Clark University, Worcester, MA.

Ercan, M., Uluer, K., Selek, F., 2002. Determination poplar grove areas by using remote sensing data in Adapazarı and Düzce Plain. The research center of forest ministry of Turkey. *Technical Bulletin* No:192, İzmit-Turkey.

Friedl, M.A., McIver, D.K., Hodges, J.C.F., Zhang, X.Y., Muchoney, D., Strahles, A.H, Woodcock, C.E., Gopal, S., Schneider, A., Cooper, A., Baccini, A., Gao, F., Schaaf, C., 2002. Global land cover mapping from MODIS: algorithms and early results. *Remote Sensing of Environment* 83, 287– 302.

Geomedia Professional Version 5.00, Copyright (1996-2002), Intergraph Corporation, Huntsville, Alabama 35894-0001

Hansen, M., Dubayah, R., DeFries, R., 1996. Classification trees: an alternative to traditional land cover classifiers. *International Journal of Remote Sensing* 17, 1075– 1081.

Hansen, M. C., DeFries, R.S., Townshend, J.R.G., Sohlberg, R., 2000. Global land cover classification at 1 km spatial resolution using a classification tree approach. *International Journal of Remote Sensing* 21, 1331– 1364.

Hansen, P.M., Schjoerring, J.K., 2003. Reflectance measurement of canopy biomass and nitrogen status in wheat crops using normalized difference vegetation indices and partial least squares regression. *Remote Sensing of Environment* 86, 42–55.

Huang, W., Wang, J., Wang, Z., Zhaochun, J., Liu, L., Wang, J., 2004. Inversion of foliar biochemical parameters at various physiological stages and grain quality indicators of winter wheat with canopy reflectance. *International Journal of Remote Sensing* 25, 2409–2419.

Image Analyst User Guide, 1997. Intergraph Corp., *Manager Mapping Sciences Documentation*, Mail Stop IW17 B2-Dept. 3620, One Madison Industrial Park, Huntsville, AL, USA.

Jakubauskas, M.E., Legates, D.R., Kastens, J.H., 2002. Crop identification using harmonic analysis oftime-series AVHRR NDVI data. *Kansas Applied Remote Sensing (KARS) Program*, 2335 Irving Hill Road, University of Kansas, Lawrence, KS 66045, USA.

Karagüllü, E., Sherill, D., Harrison, J., 1998. Management planning of information technology, the project of development GIS applications and design of database. The Research center of Remote sensing and GIS, Agricultural Ministry of Turkey, Ankara.

Mart´ın-Ord´onez,T., Casterad, M.A., Herrero, J., 2000. Three years of mapping irrigation water in the Flumen irrigation district, Spain. In: Casanova, J.L. (Ed.), Remote Sensing in the 21st Century: *Economic and Environmental Applications*. Balkema, Rotterdam, pp. 191–194.

Meteoroloji Bölge Müdürlüğü, 1990. Meteorological data reports about Torbalı Province. Poligon- İzmir, Turkey.

MicroStation 95 Version 05, 1995. Bentley Systems, Incorporated, 690 Pennsylvania Drive, Exton, PA 19341, USA.

Oldeland, J., Dorigo, W., Lieckfeld, L., Lucieer, A., Jürgens N., 2010. Combining vegetation indices, constrained ordination and fuzzy classification for mapping semi-natural vegetation units from hyperspectral imagery. *Remote Sensing of Environment* 114, 1155–1166

Panigrahy, S., Sharma, S.A., 1997. Mapping of crop rotation using multidate Indian remote sensing satellite digital data. *ISPRS Journal of Photogrammetry and Remote Sensing* 52, 85–91.

Panigrahy, S., Chakraborty, M., 1998. An integrated approach for potato crop intensification using temporal remote sensing data. *ISPRS Journal of Photogrammetry and Remote Sensing* 53, 54–60.

Paoli, H., Volante, J., Fern´andez, D., Noe, Y., 2003. Analisis de la rotaci on de cultivos en la region NOA por sistemas de informaci on geografica: campana agricola 2000–2001. Informe de la campana agricola 2000–2001, Instituto Nacional de Tecnologıa Agropecuaria (INTA)—Estaci on Experimental Agropecuaria de Salta, Salta, Argentina, 7 pp.

Pinter, P.J., Ritchie, J.C., Hatfield, J.L., Hart, G.F., 2003. The agricultural research service's remote sensing program: an example of interagency collaboration*. Photogrammetric Engineering & Remote Sensing* 69, 615–618.

Raupenstrauchk, J.D., Selige, T.M., 1998. Detection of crop rotation using satellite remote sensing for nutrient balance models and risk assessment. In: Gudmandsen (Ed.), Future Trends in Remote Sensing. Balkema, Rotterdam, pp. 139–143.

Ren, J., Chen, Z., Zhou, Q., Tang, H., 2008. Regional yield estimation for winter wheat with MODIS-NDVI data in Shandong, China. *International Journal of Applied Earth Observation and Geoinformation* 10(4), 403–413.

Roy, P.S., Tomar, S., 2001. Landscape cover dynamics pattern in Meghalaya. Indian Institute of Remote Sensing (IIRS), NRSA, Dept. of Space, 4-KalidasRoad, P.B. 135, Dehra Dun, 248001 India.

Schuerger, A.C., Capelle, G.A., Di Benedetto, J.A., Mao, C., Thai, C.M., Evans, M.D., Richards, J.T., Blank, T.A., Stryjewski, E.C., 2003. Comparison of two hyperspectral imaging and two laser-induced fluorescence instruments for the detection of zinc stress and chlorophyll concentration in Bahia grass (Paspalum notatum Flugge). *Remote Sensing of Environment* 84, 572–588.

Şimşek, C. , 1998. Hydrogeology of Torbalı province (MSc. Thesis). Dokuz Eylül University, Institute of Natural and Applied Science, Buca/İzmir.

Tuğaç, M.G., Torunlar, H., Peşkircioğlu, M., 2001. Creating agricultural database and Land use planning by using Geographical information system. Institute of Field Crops, Agriculture Ministry, Ankara-Turkey

Wardlow, B.D., Egbert, S., 2002. Discriminating cropping patterns for the U.S. Central Great Plains region using time-seriesMODIS 250-meter NDVI data – Preliminary results. *Proceedings of the ISPRS Commission I*: "Integrated remote sensing at the global, regional and local scale", vol. XXXIX part I, 12 pp. Denver, CO, USA.

Wiegand, C.L., Richardson, A.J., Kanemasu, E.T., 1979. Leaf area index estimates for wheat from Landsat and their implications for evapotranspiration and crop modeling. *Agronomy Journal* 71, 336–342.

Zak, M.R., Cabido, M., 2002. Spatial patterns of the Chaco vegetation of central Argentina: Integration of remote sensing and phytosociology. *Applied Vegetation Science* 5, 213–226.