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COĞRAFİ BİLGİ SİSTEMİ (CBS) VE UZAKTAN ALGILAMA (UA) İLE TUZLULUĞUN ETKİSİ ALTINDA PAMUKTA VERİM KAYBININ BELİRLENMESİ (GAP BÖLGESİ, AKÇAKALE ÖRNEĞİ) TÜRKİYE[*]

THE DETERMINATION OF THE COTTON PRODUCTIVITY AND LOSSES UNDER THE EFFECT OF SALINITY BY USING GEOGRAPHICAL INFORMATION SYSTEM (GIS) AND REMOTE SENSING (RS) (GAP REGION, AKÇAKALE SAMPLING) TURKEY

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Özet

GAP(Güneydoğu Anadolu Projesi); Türkiye'nin en büyük, entegre, çok sektörlü, sürdürülebilir bölgesel kalkınma projesidir. Proje; kalkınma için pek çok sektörü kapsamakta olup, tarım ve sulamada bunların içindedir. 9 il ve pek çok ilçe GAP kapsamında yer almaktadır. Akçakale ilçesi de bunlardan biri olup, rakımı 385 metre, iklimi yarı kurak, yüzölçümü ise 1248 km^2'dir. Harran ovasında yer alan Akçakale genel olarak kuzeyden güneye doğru açılan düz ve geniş bir ova görümündedir. İlçe yüksek taban suyu ve buharlaşma nedeniyle tuzlulaşma problemi ile karşılaşmaktadır. Harran ovasında ana ürün pamuktur.

[*] **Bu makale Crosscheck sistemi tarafından taranmış ve bu sistem sonuçlarına göre orijinal bir makale olduğu tespit edilmiştir.**

Bazı alanlarda şiddetli seviyelerdeki tuzluluk değerleri bitki verimini önemli oranda etkileyebilmektedir. Yapılan bu çalışmada farklı tuzluluk seviyelerine gelen pamuk tarlalarından (0-20 cm derinlik) alınan bozulmuş toprak örnekleri değerlendirilmiştir. Ayrıca bölgenin Landsat TM uydu görüntüsü alınmıştır. Böylece çalışma alanlarında pamuğun yetişme periyodunda gelişimi, topraktaki tuz değişimi ve verimi takip edilmiştir. Son yıllarda uzaktan algılama teknolojileri kullanılarak seçilen örnek alanlarındaki bilgiler kullanılarak geniş alanlardaki durum tahmin edilebilmektedir. Bu amaçla yapılan çalışmada farklı tuzluluk değerlerine sahip arazi analiz ve verim değerleri uydu verileriyle ilişkilendirilmiştir. Akçakale ilçesindeki pamuk ekili alanlardaki tuzluluk etkisiyle oluşan verim değerleri hesaplanmıştır. Buna göre 2009 yılında, tuzlanma nedeniyle 1 840 625 kg ürün ve 935 711 USD gelir kaybı meydana gelmiştir. Türkiye pamuk ithalatında dünyada Çin'den sonra ikinci sırada yer almakta olup, 2009/2010'da 957 bin ton pamuk ithal etmiştir.

Anahtar Kelimeler: GAP, Tuzluluk, Pamuk Verimi, Uydu Görüntüleri, NDVI (Normalize Edilmiş Vejetasyon İndeksi)

Abstract

GAP (Southeastern Anatolian Project), is the biggest integrated, multi-sectorial, sustainable regional development project of Turkey. It covers many sectors for development including agriculture and irrigation too. GAP covers nine provinces together with many districts. Akcakale district is one of them, located in Harran plain, and confronted with the problem of salinity because of the high base water level and evaporation rate. Severe levels of salinity is significantly affect the efficiency of the plant yields in some areas. Main crop pattern is cotton in Harran plain beacuse of many reasons. Turkey ranks second after China in the world in cotton imports in 2009 with an amount of 957 000 tons. In this study, from the cotton fields of different salinity levels (0-20 cm depth) were evaluated from the disturbed soil samples. And also Landsat TM satellite image of the region were also taken and studied. Thus, growth of cotton during growing period and the yield of cotton were monitored. At the same time exchange of salt in the soil was monitored, too. In recent years by using remote sensing technologies, yields can be estimated using information from the selected sample areas for the large areas. For this purpose, the study analyzed for different salinity levels and yield values of land have been associated with satellite data. And finally yield of cotton cultivated areas in the Akcakale district calculated according to the effect of salinity and found that 1 840 625 kg of yield losses has been occurred due to salinity and the resulting income loss was 935 711 USD in 2009.

Key Words: GAP, Salinity, Cotton Yield, Satellite Data, NDVI

1. Introduction

The region of Southeastern Anatolia extending over wide plains in the basins of the lower Euphrates and the Tigris covers the administrative provinces of Adiyaman, Batman, Diyarbakir, Gaziantep, Kilis, Mardin, Siirt, Sanliurfa and Sirnak. The region is bordered by Syria to the south and Iraq to the southeast. GAP Region is almost 10% of the country in terms of surface area and the population. Turkey has 8.5 million hectares of irrigable land and about 20% of this land is in Southeastern Anatolian Region.

Coined as "Fertile Crescent" or "Upper Mesopotamia", the region is also commonly referred to as "craddle of civilizations." Throughout history, the region served as a bridge connecting Anatolia with Mesopotamia.

The basic objectives of the GAP project include the improvement of living standards and income levels of people so as to eliminate regional development disparities and contributing to such national goals as social stability and economic growth by enhancing productivity and employment opportunities in the rural sector.

The Southeastern Anatolia Project (GAP) is a multi-sectorial and integrated regional development project with an approach of sustainable development. GAP covers the 22 Dams, 19 Hydro-power plants and 1.822 million hectares of irrigation areas by the state institutions more than 378 000 ha of area of which under irrigation with 21% of realization rate so far. The calculated total cost of GAP is 32 Billion USD. And financial realization rate is over 85%. (GAP, 2013)

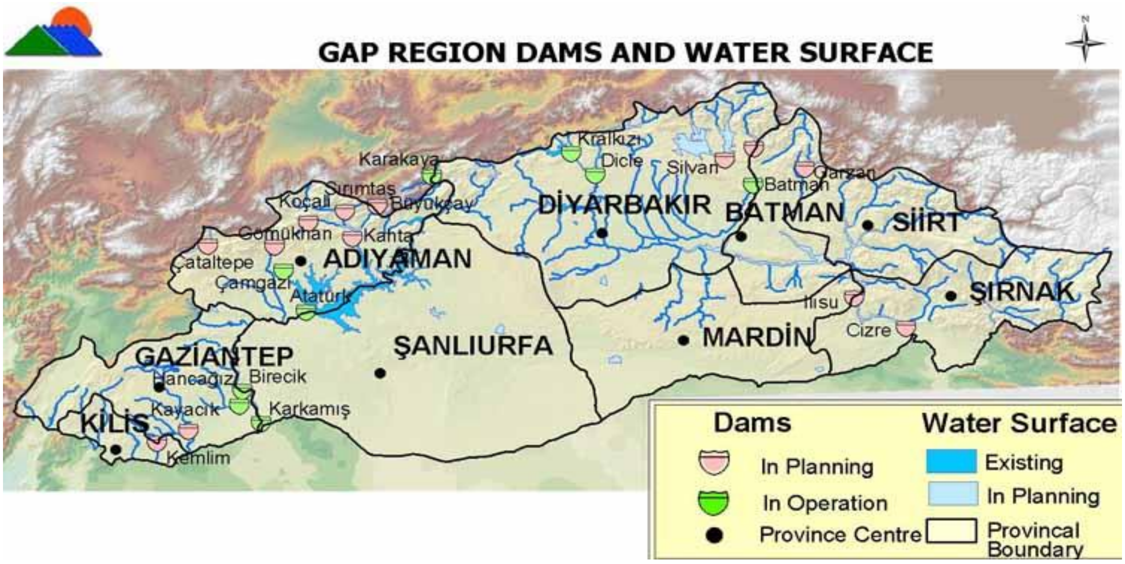


Figure 1. GAP Region Dams and Water Surface (Resource: GAP Administration)

The agricultural and industrial potential of the region boosted through the GAP will raise the income level of the region fivefold and create employment for about 3.8 million people in the region.

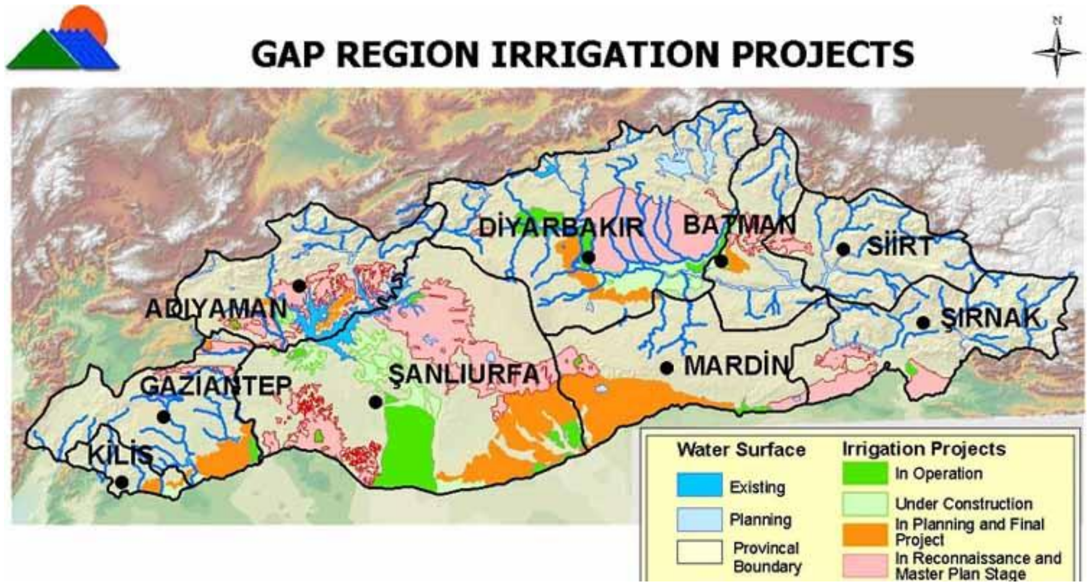


Figure 2. GAP Region Irrigation Projects (Resource: GAP Administration)

According to the GAP Master plan; agriculture is the one of the most important sector for realizing of GAP's achievement. In order to achieve this goal the following things will be realized:

- Improve the efficiency of agricultural extension services by leaving practical work in extension to farmers' organizations as well as to private and voluntary ones,
- To shift the role of the government in extension services to the field of support and quality control,
- To ensure that all farmers can reach relevant and quality information in their local conditions,
- To remove crop patterns, production relations, types of ownership and employment that hinder the process of dynamic development in agriculture,
- To assess optimal sizes of farming enterprises in the region and to eliminate factors that drive enterprises off from this size,

2. Objective

The objective of this study is to determine the effects of salinity on the productivity of cotton in terms of yield losses by using Geographical Information System (GIS) and Remote Sensing (RS) in Akcakale district of Sanliurfa where is located in GAP Area for the year of 2009.

3. Salinity

It should be approached carefully to the problem of salinity is extremely important for the protection of land and water resources. The main causes of salinity are insufficient rainfall, high evaporation and irrigation (Richards, 1954). In this study, the changes of salinity were monitored at every stage of development periods of the cotton. Yield losses were calculated by the integration of cotton yield and satellite data.

3.1. Effective factors of salinity: The main sources of salinity are; oceans, main formation materials of land, topography, channel linkages, irrigation applications, and the climate (Terry, 1997; Ergene, 1982). The most important factor of above mentioned ones is main formation materials of land. Because the flow of surface and ground waters brought to salts to soluble that is available in main formation materials. Mixing of this salty water to surface and groundwater increases salinity.

3.2. Problems of salinity: Salt-affected soils are caused by excess accumulation of salts, typically most pronounced at the soil surface. Salt can be transported to the soil surface by capillary transport from a salt laden water table and then accumulate due to evaporation. It can also be concentrated in soil due to human activity, for example the use of potassium as fertilizer, which can form sylvite, a naturally occurring salt. As soil salinity increases, salt effects can result in degradation of soils and vegetation. In Turkey, the area about 1 513 645 hectares has salinity and alkalinity problem. (Dinç et al., 1993).

4. Material and Method

a) Study area: Akcakale is 52 km. away from the south of Sanliurfa and located in Harran plain. Akcakale is surrounded from east by Ceylanpınar-Viranşehir, west by Suruç, north by Şanlıurfa-Harran, and in the south by the Syria. It has the altitude of 385 meters with a surface area of 1248 km^2, semi-arid climate and high evaporation rate. Harran Plain seems like a broad flat plain from north to south. Average precipitation amount is between 300-365 mms and annual evaporation is 1,848 mms. (DMİ, 2011). Akcakale is surrounded by the other districts and in the south by Syria. Akçakale District is a suitable place for monitoring the salinity by the view of climate and topography.

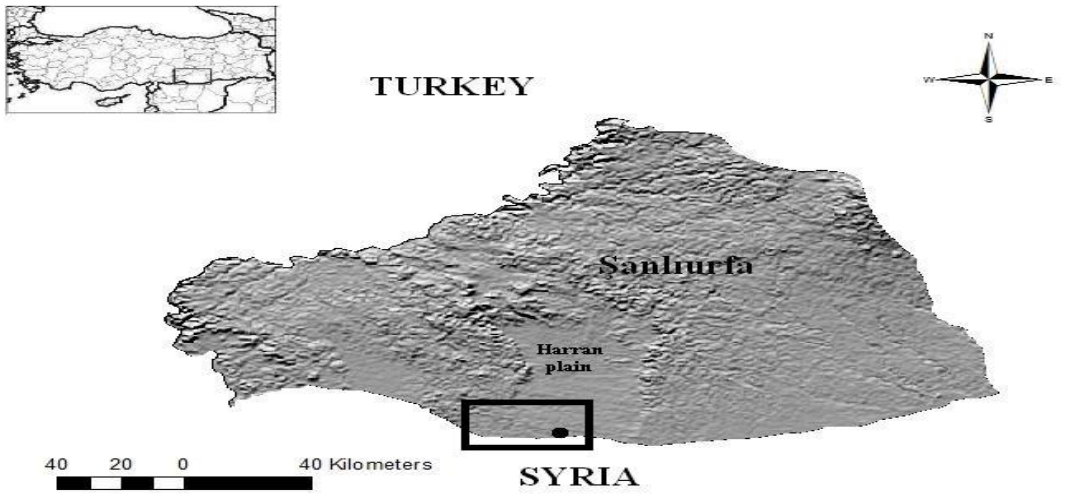


Figure 3. Study area: Akçakale, Şanlıurfa, Turkey

b) Data: Monitored values of salinity, Cotton Fertility, Geographical Information Systems (GIS) outputs, Remote Sensing (RS) technique, Normalized Difference Vegetation Index (NDVI), Landsat TM Image.

b.1 Normalized Difference Vegetation Index (NDVI)

It is possible to express that salinity can be determined only by using of spectral reflections (Csillag et al., 1993). Plants grow in salty soil have higher absorption rate of light. Cotton plant that was grown in salty soils have greater plant chlorophyll absorption of the light. It is reflection rate is less than the cotton plant which is grown in unsalty soils. (Victor et al., 1966; Reeleves et al., 1994).

The satellites in remote sensing measure the spectral radiation, but does not give any direct information about the product yield, salinity etc.. (Bastiaanssen et al., 2000). There have been numbers of models developed for estimation of product yield. Vegetation index (VI) is one of the methods may be possible to predict product yield. VI is created using multi-band data of electromagnetic spectrum from the visible near infrared regions data for product yield management systems (Richard et al., 2001). To know the relationship between the index and the efficiency of plant, may give an idea to the researchers about the yield.

NDVI is the one widely used in remote sensing for vegetation index models. The most common vegetation index derived by using remote sensing data and electromagnetic wave height rates. It is calculated by the proportion of two wavelengths to each other (Turner et al., 1999).

NDVI= (Near Infrared Band - Red Band)/(Near Infrared Band + Red Band)

Landsat satellite image is composed of seven bands. Various modeling can be done by using these bands, and the NDVI is the one of them.

Figure 4. Landsat satellite image and study area

Figure 5. The location of Akcakale

c) Method: Evaluation of total data and discussing the changes of the parameters of the sample area that is Akcakale District-Sanliurfa City, before and after GAP Project irrigation for the year of 2009 by using GIS, RS, NDVI and Landsat TM Image datas.

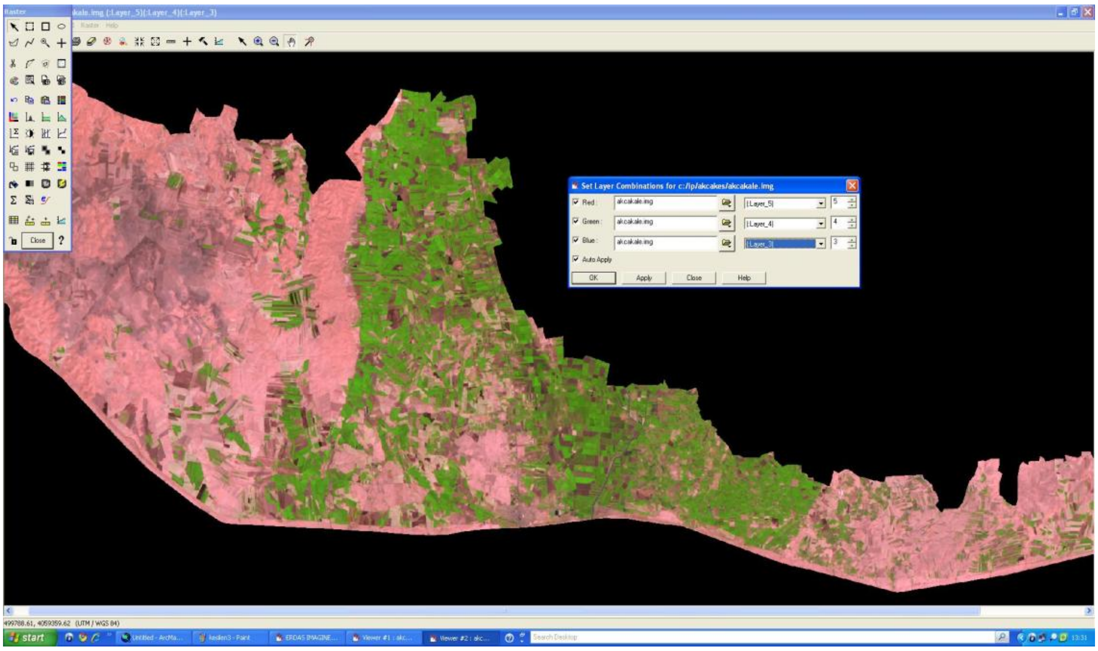


Figure 6. The view of Akcakale from Landsat

Homogenous climate and soil properties in relation to the terrain, location data and satellite data to predict the effects of salinity on yield can be investigated. The total yield can be estimated with the help of satellite images and data from sample plots to be selected as a result of this application in related fields and will be discussed.

Different colors scale of soil in plant root zones reflections will be gotten by satellite images. It can be observed seasonal changes of salinity in root zone according to these reflections. These satellite images will be used to examine and determine the effect of salinity on yields. Outcome of large areas by using satellite images will help to determine the amount of harvesting and yield losses from these areas.

Due to the high salinity of ground water level at Akçakale district that is faced with the salinity and yield losses problems. The ground water level is a severe problem in some areas of this district. It causes salinity because of high temperatures and it reduces the efficiency of the plant. In recent years, remote sensing technologies are used for large areas by using information from the selected sample areas can be estimated by the method of NDVI. In this study, satellite data analysis used for different values of soil salinity. The cotton yield and losses will be estimated in Akcakale Irrigation Area by using these satellite images.

The data from satellite technology associated with GIS techniques can be applicable for estimation of large areas.

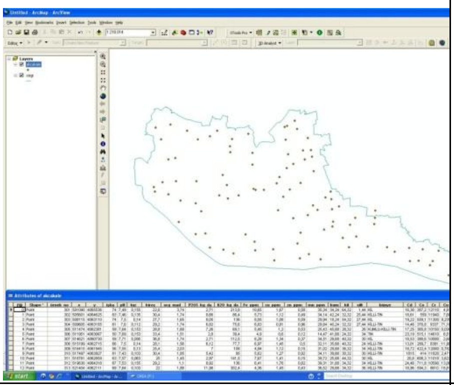
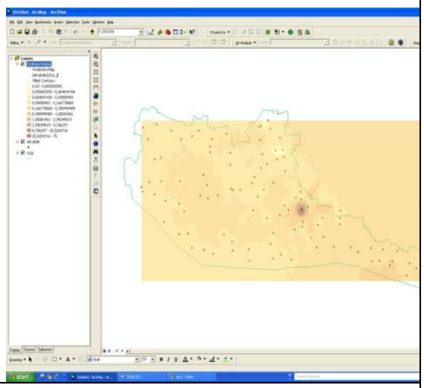
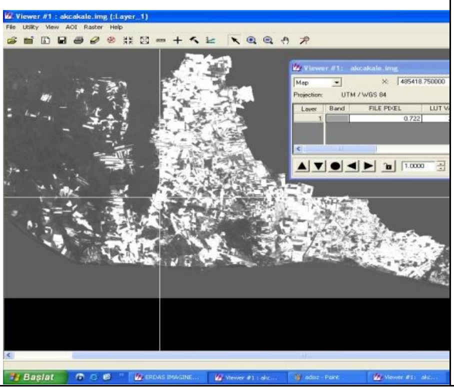
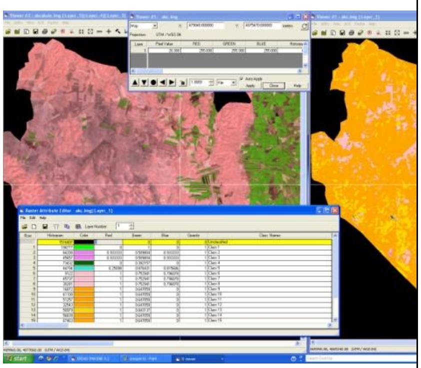
5. Findings

In agricultural fields, irrigation status can be determined by NDVI data which is created by using multi-band satellite images. At the same time, product availability and product dynamics of large areas can be traced.

In this study, Stoneville-468 (Gossypium hirsutum L) type of cotton was selected. Stoneville was developped and registered in The United States in 1988. Its leaves are medium width with frequency and can grow moderately hairy in a pyramid form. Its pods are medium-sized, oval or roundish with slightly beak. The mean number of growing is 120 days. It is widely used in Harran Plain since 2005. (Harem, 2010).

The roots of cotton plants can go up to a depth of 150 cm. and 100 cm. soil depth is ideal for an optimum growth. Cotton may grow in soils with a pH rate of 5-8 (Martin et al.,1976) In saline soils, plant growth is hindered by salt accumulated in the root zone. After level of pH 5-8 salinity, plant growth is limited, even if the plant roots are in water zone (American Society of Civil Engineers, 1990; Karim et al., 1990)

Cotton plants are resistant to salinity up to a certain level, but after that level, the Electrical Conductivity (EC) reduced plant yield. Reduction of Crop yield is subjected to change of salinity that is accumulated in root zone during the year (Mass and Hoffman, 1977; Mass, 1986). Even if salt tolerance limit of cotton is exceeding, cotton plant can be grown in the region. But because of each EC unit exceeding is caused to the yield loss of 5.2% (Maas ve Hoffman, 1977).

	
Salinity GPS coordinates for Akcakale	Salinity in Geostatistical emissions
	

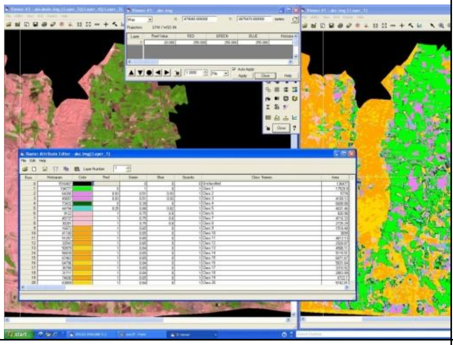
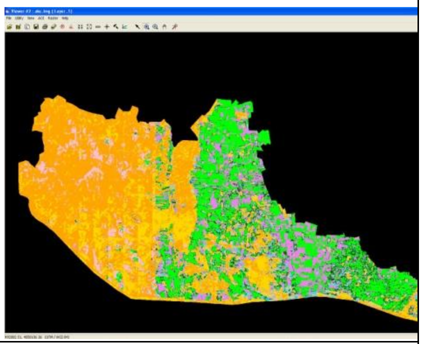
NDVI	Supervised classification using GPS coordinates
	
Classification study	Classified view

Figure 7.Total result maps

The projection of the study is selected as Universal Transfer Marcator (UTM) and WGS84 datum. The Akcakale border is converted to vector data as a raster data by importing to ArcGIS environment. Field work with GPS coordinates together with EC readings from the disturbed soil samples were analyzed in the laboratory. GPS coordinates were measured with the same parcels of cotton yield. GPS coordinates and values of salinity are set in the ArcGIS environment. Spreading the salinity is thematically mapped. Landsat TM satellite image of the month of September of the same year is imported to the UTM-WGS84 projection with ERDAS program.

According to the provincial border Akcakale satellite image has been captured. Supervised classification in accordance with the data of GPS coordinates have been made. The NDVI image analysis was performed. The table below was developed and supervised with the images obtained from NDVI analysis for estimation of yield loss. It was calculated as shown in the table 1.

The color and type of area	EC(dS/m)	NDVI	Yield (kg/da)	Area (da)	Predicted loss (kg/da)	Total Predicted loss (kg)
Green(cotton)	1-4	0.55-0.65	450-500	175290	---	---
Dark Green(Cotton in salty areas)	6-8	0.45-0.55	350-400	66080	15-20	991200-1321600
Cyan(Cotton in salty areas)	8-10	0.35-0.45	250-350	250-350	20-25	608200-760250
Violet (Burned stubble)	---	---	---	98870	---	---
Orange(rock and stone areas)	---	---	---	127580	---	---
Gold(Cereal stubble)	---	---	---	190140	---	---

Table 1. NDVI Analysis for Estimation of Yield Losses

6. Results and Conclusion

During the growth stages, knowing that the salt changes of the root of the cotton plant is important to cause the yield losses. It needs for salt management. Therefore; soil samples taken at certain times and at the different level of lands, may give significant data for determination of salt management and yield loss. According to the findings 1 840 625 kg of yield losses has been occurred due to salinity. The average cost of seed cotton was 0.79 Tl/kg (TUIK, 2010) and 1 USD was 1.554 TL (Isyatırım, 2014) in 2009. Because of the salinity in Akcakale monetary value income loss was $ 935 711 in 2009. If these figures extend for whole GAP Area, even for a national level, it also shows the importance of this subject very well. Generally, 45% of Harran Plain which is around 75 000 hectares of land is used for cotton production. Almost 50% of the factories located in Sanliurfa Organized Industrial District use cotton for productions as row material. Turkey ranks second after China in the world cotton imports depending on the investment and export in textile and apparel sector, and 957 thousand tons of cotton were imported in 2009/2010 (Özüdoğru T.,2011).

Unless adequate measures are taken salinity will continue to increase in intensity in the plains. Plant growth will be affected by increasing in the severity of salt in soil. There will be significant yield losses occur due to the increasing salinity in soil and ground water. Besides the classical methods, the use of remote sensing and geographical information systems provides an important opportunity to estimate quickly product and yield for different purposes. Today these technologies, in both public and private organizations, are used extensively in the world. Productivity prediction is not only important for farmers, but also it is important for decision makers such as state officials and entrepreneurs. Entrepreneurs are using cotton in agro-based industry. It is very important for them to know the amount of cotton production will take place. It will allow them to make proper plan for operations in case of shortages.

Turkey has appropriate geographical and ecological conditions for cotton productions. The cotton producers and users have an important place within the country among the others. Estimation of right areas for cotton planting is an important issue for development of GAP Region. This subject is not only important for agricultural production but also important for the agricultural industry, for the income levels of the GAP Region and for the saving of natural resources. This method will also enable us to foresee the problems and take precautions. It will also let to use this information for agricultural and industrial purposes for modelling of activities.

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