LAND USE CHANGE ANALYSIS OF ERDEMLI – KIZKALESI REGION BY USING GIS METHODOLOGY

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by

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“ ...for my family”

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ABSTRACT

According to scientific authorities in the year of 2025, the majority of the world's population around 5 billion people will be living in urban areas. As human settlements expand, prime agricultural land and habitats such as wetlands, forests, and watersheds are transformed into land for housing, roads and industry. In the developing countries the urban poor, searching an alternative place to live, often establish informal settlements in ecologically fragile areas.

Changes in land-use and land cover have important consequences for natural resources through their impacts on soil and water quality, biodiversity, and global climatic systems. Land use and changes are particularly related to increase of population and intensive agriculture. With the awareness of the importance of land-use changes at coast sides, the study of regional or global land use change has become the focus of much scientific authorities and international organizations.

From past to future remote sensing technology has been recognised as a useful means of supplying up to date information on activities within the urban environment . At the same time, computer – based geographic information systems are being used to improve the management and use of information. The aim of the study is : to determine the land use changes through the years in the coast of Erdemli and Kizkalesi by using the Geographical Information System , ARC- VIEW GIS software and ER MAPPER .

ÖZET

Bilimsel çevrelere göre dünya nüfusunun büyük bir kısmı 2025 yılında şehirlerde yaşayacaktır. İnsan yerleşimleri arttıkça birincil tarim alanlari ,sulak alanlar,ormanlar ve su havzaları gibi yerler yapılaşma ve endüstriyel faaliyetlerde kullanılmak üzere yeni alanlar haline getirilecektir. Şehircilik açısından geri olan gelişmekte olan ülkelerde ise yaşam alanı bulunması için ekolojik olarak verimli alanlarda kaçak yapılanmalar görülmektedir.
Arazi kullanımı ve arazi örtüsündeki değişiklikler toprak ve su kalitesine, biyoçeşitlilik ve global iklim sistemleri ayrıca doğal kaynaklara dolaylı olarak etki edebilmektedir. Arazi kullanımı ve değişikliği populasyonun artması ve intensiv tarimın uygulanması ile ilgilidir.

Kıyı alanlarında ki arazi kullanım değişimi, bölgesel ve global arazi kullanım değişimi gibi çalışmalarının önemi doğrultusunda bilimsel çevrelerin ve uluslararası organizasyonların dikkatleri bu çalışmalara kaymıştır. Geçmişten günümüze uzaktan algilama teknolojisi şehirsel açıdan çevre çalışmalarına güncel bilgilerin sağlanmasında vazgeçilmez olmuştur. Aynı zamanda bilgisayar tabanlı coğrafi bilgi sistemleri de yönetim ve bilginin işlenmesi sürecinde kullanılmıştır.
Bu çalışmanın amacı Erdemli ve Kızkalesi sahilinde yıllara göre arazi değişimini Coğrafi Bilgi Sistemleri yazılımları, Arc View GIS ve ER Mapper kullanarak tespit etmektir.

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1. INTRODUCTION

Geographic Information Systems (GIS) is a methodology that is increasingly used in Environmental Science and Geographical Science together. According to Michael Kostiuk (2000) the increasing use of spatial data and GIS by organisations and researchers is a valuable tool for coastal zone management. The effectiveness of the results obtained by using a GIS is dependent upon the quality of the data that goes into these systems. Those data are known as spatial data, since each geographic feature in the database has its own geographic coordinates such as longitude and latitude. Another important aspect of spatial data is that of scale. As with a map, spatial data contains geographic information that is limited to the scale of the database. For example, a 1:100,000 scale map does not show as much detail as a 1:50,000 scale map because it displays an area that is four times smaller. The reduction of detail on maps is known as map generalisation. Map generalisation not only limits the amount of information that can be shown on a map, but it can also limit the accuracy of a map. The same is true of spatial data. Spatial data is simply map data in a digital format. In the study different types of data will be collected from various sources. The aerial photographs, standard topographical maps ,various landscape topographical maps and several photographs will be used. At the beginning comparing the remote sensing data from a specified year to a year is aimed. Landscape topographical maps such as geology, soil and land use maps will be drawn as vector data by using ARC VIEW.

As mentioned above GIS ARC VIEW SOFTWARE is going to be used to interpret the data and to produce digital maps of the study. The aim of the study is to determine the land use changes through the years in the area of Erdemli and Kizkalesi by using the Geographical Information System , ARC- VIEW GIS software., and ER MAPPER. The study area is located at the Eastern Mediterraean coast of Turkey, nearby the city of İçel.

2.GEOGRAPHIC INFORMATION SYSTEMS

2.1. Definition of GIS

Geographic information systems can be defined as computer based systems that are used to store and manipulate geographic information (Aronoff, 1993). According to Göksel and Türkoğlu (1991) GIS is a decision support system involving the integration of spatially referenced data in a problem – solving environment. It is an institutional entity reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time. They described that GIS is an information technology which stores, analyses and displays both spatial and non-spatial data. One of the main reference source is written by Burrough (1986) who explains that GIS is storage, input, analyses and output of spatial data.

Although , Aronoff (1993) insisted that GIS is designed for the collection, storage, and analysis of objects and phenomena where geographic location is an important characteristic or critical to the analysis, he also gave an example of the location of a fire station or the locations where soil erosion has been most severe, were key considerations in using this information. Turoğlu (2000) pointed that GIS is a way of methodology, which covers many softwares under one topic. Those softwares can be counted as:

ATLAS GIS, IDRISI, GEO MAP, ERDAS, ARC INFO, ERMAPPER, CAT, STAR GIS, MAPS Geosystems

The GIS stores the location of each feature as a pair of geographic coordinates, or as a set of coordinate pairs that define its shape (line or area). When one draws a map , the GIS uses the coordinates to draw the features ,using a specified symbology (Miller ,2000). It is accepted that Geographic Information technologies and Geographic Information Science have improved our ability to process digital geographic data that accurately represents empirical geography. Miller(2000) also postulated that environmental problems, enquity and access the issues and increasingly scarce resources require integrative global-level perspectives and tighter linkages between the human and physical sciences.

Furthermore, Williams (1995) also defined GIS under the terms of “Integrated GIS Model”, shown in Figure 2.1. According to him; A generic model for an Integrated GIS is formed with the following components Geographic data, geoprocessing, geographic information and world model. A simple description of GIS is presented in Figure 2.2

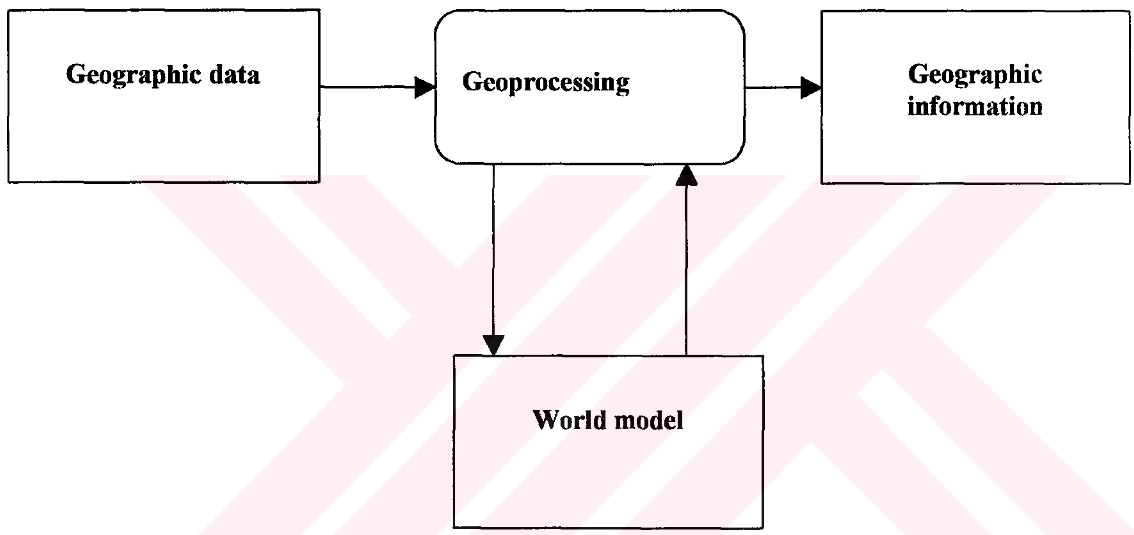

Figure 2.1. An Integrated GIS Model (Williams, 1995)

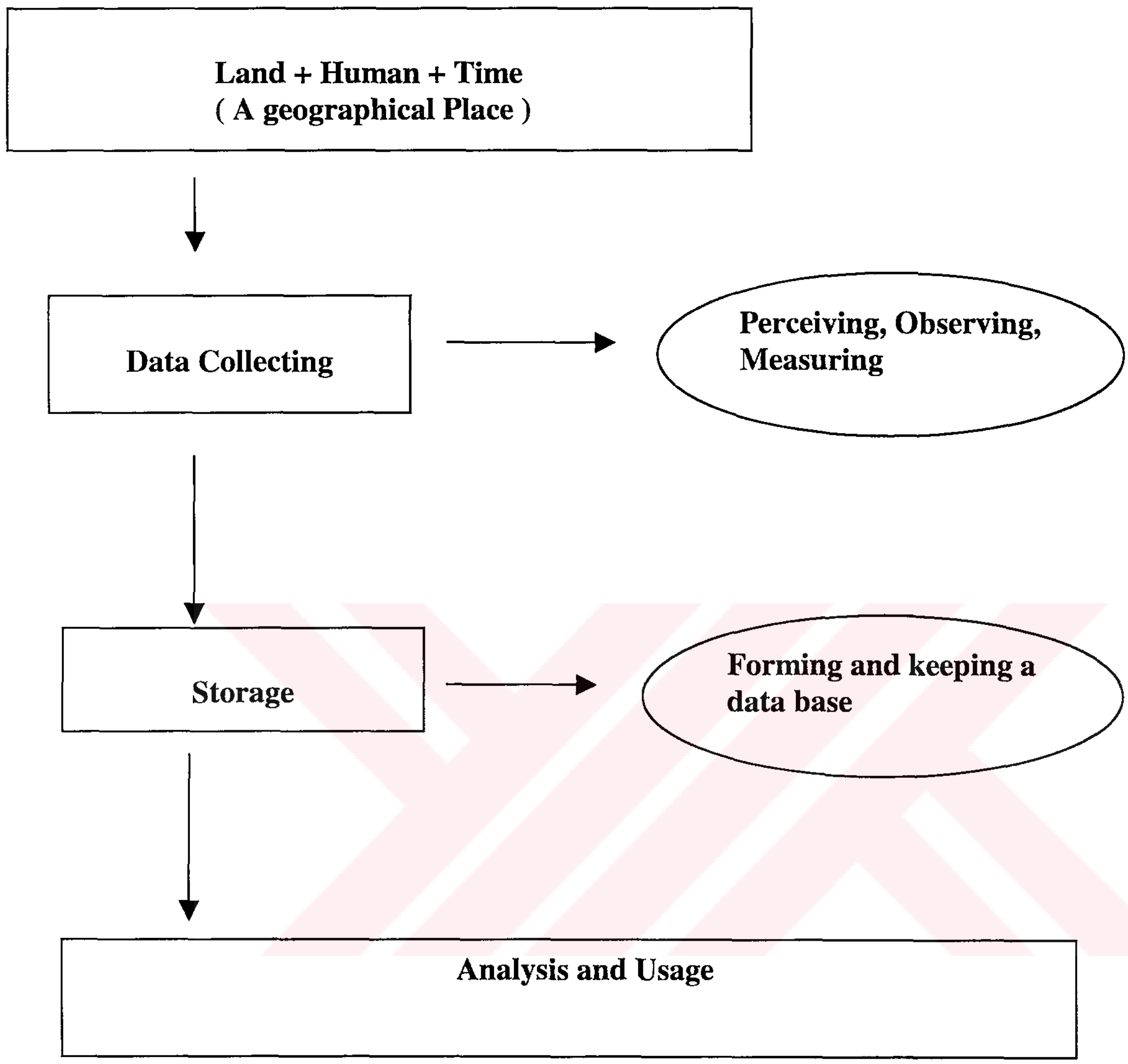

Figure 2.2 What is Geographic Information System (Turoglu, 2000)

2.2. The Components of a GIS

Aronoff (1993) described that the following is a brief description of the basic components a GIS.

a. Data Input
b. Data Management
c. Data Manipulation and Analysis
d. Data Output

a. Data Input: The data input component converts data from their existing form into one that can be used by the GIS. Data input is typically the major bottleneck in the implementation of a GIS (Aronoff, 1993). Typical categories of input data include :

- map sheets
- digital map sheets
- digital elevation models
- satellite and aerial images
- non-spatial or tabulated data,such statistical or demographic information (Williams, 1995)

Map sheets can either be digitised by hand (using a digitising tablet) or by automatic scanning. The resultant digital data will be subjected to some form of validation or quality control, such as interactive editing . Digital Elevation models can either be input in a standart format or generated internally from digitised contours. Satellite and aerial data will either be in digital format or may be digitally scanned if the original data is photographic (Williams, 1995). The components of GIS are shown in Figure 2.3

b. Data Management: The data management component of the GIS includes those functions needed to store and retrieve data from the data base. The methods used to implement these functions affect how efficiently the system performs all operations with the data (Aronoff, 1993)

c. **Data Manipulation And Analysis (Data storage and manipulation):** The data manipulation and analysis functions determine the information that can be generated by the GIS. A list of required capabilities should be defined as part of the system requirements (Aronoff, 1993). At some sources this sub-part is searched as " Data Storage and manipulation". For instance Williams (1995) preferred to name it this way. He also named the functions at this sub - part ;

- create a new object in the database
- retrieve an existing object
- modify a database object
- store the object in the database
- delete a database object

d. **Data Output:** The output of reporting functions of GIS vary more in quality, accuracy, and ease of use than in the capabilites avaliable. Reports may be in the form of maps, tables of values or text in hard copy or soft copy (Aronoff, 1993). According to Williams (1995) two trends are likely to continue at this way ;

- The use of high –performance workstations to allow the user to conveniently view and edit the output, and to interact to control the process of a GIS operation
- The ability to interconnect with an external GIS and other environmental databases in an open system

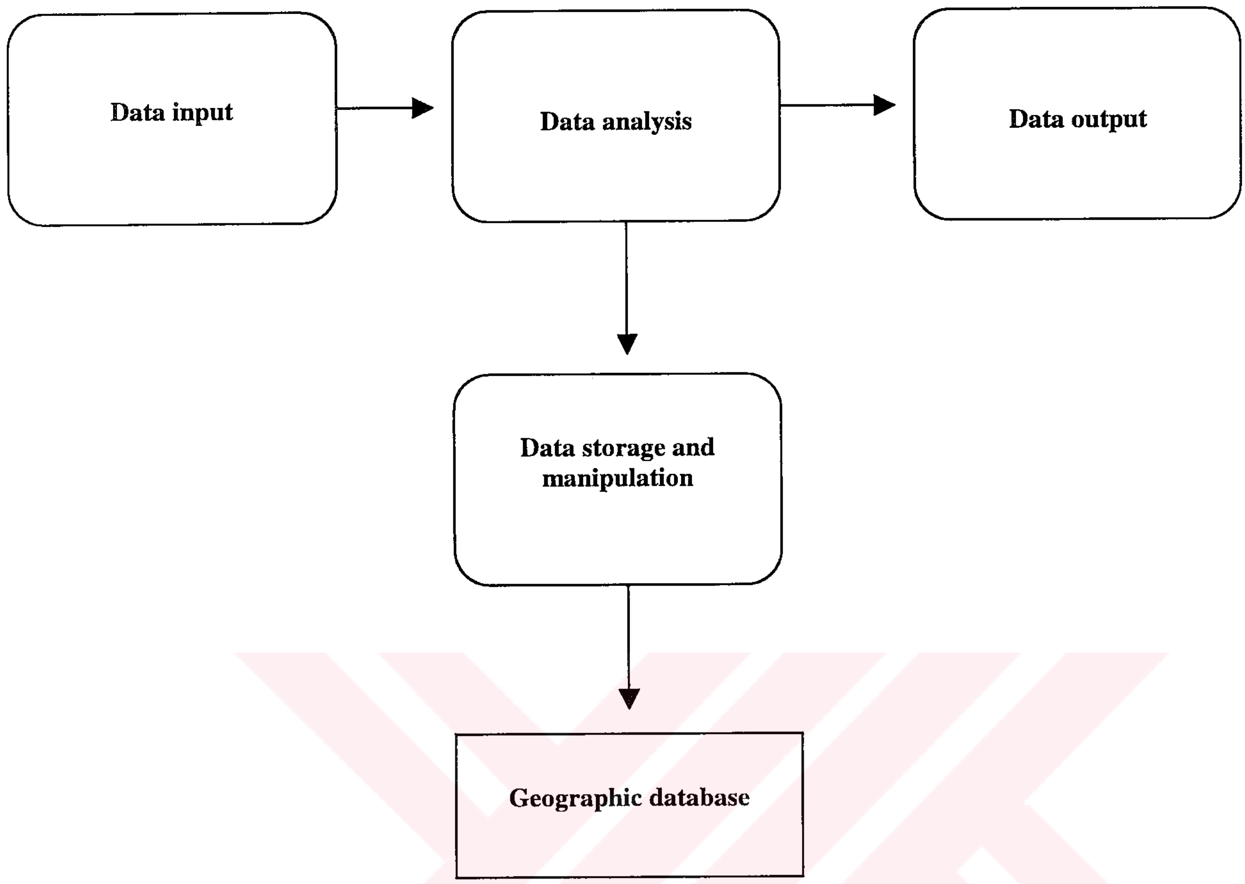

Figure 2.3 Components of a typical GIS (Williams,1995)

GIS can be described as a methodology, (Figure 2.4). This methodology has several steps. Those are ; Data information Collection, Data Structures, Data Entering Methods, Analysing and Result. All steps are linked to each other and acquire the information within a logical algorithm. Below, a scheme of this view can be seen. If we have technical point of view about GIS we can say that GIS, which can use information from many different sources, many different forms, can help with such analyses. The primary requirement for the source data is that the locations for the variables are known. Location may be annotated **x**, **y** and **z** coordinates of longitude, latitude and elevation or by such systems as ZIP codes or highway mile workers (Jones, 1997).

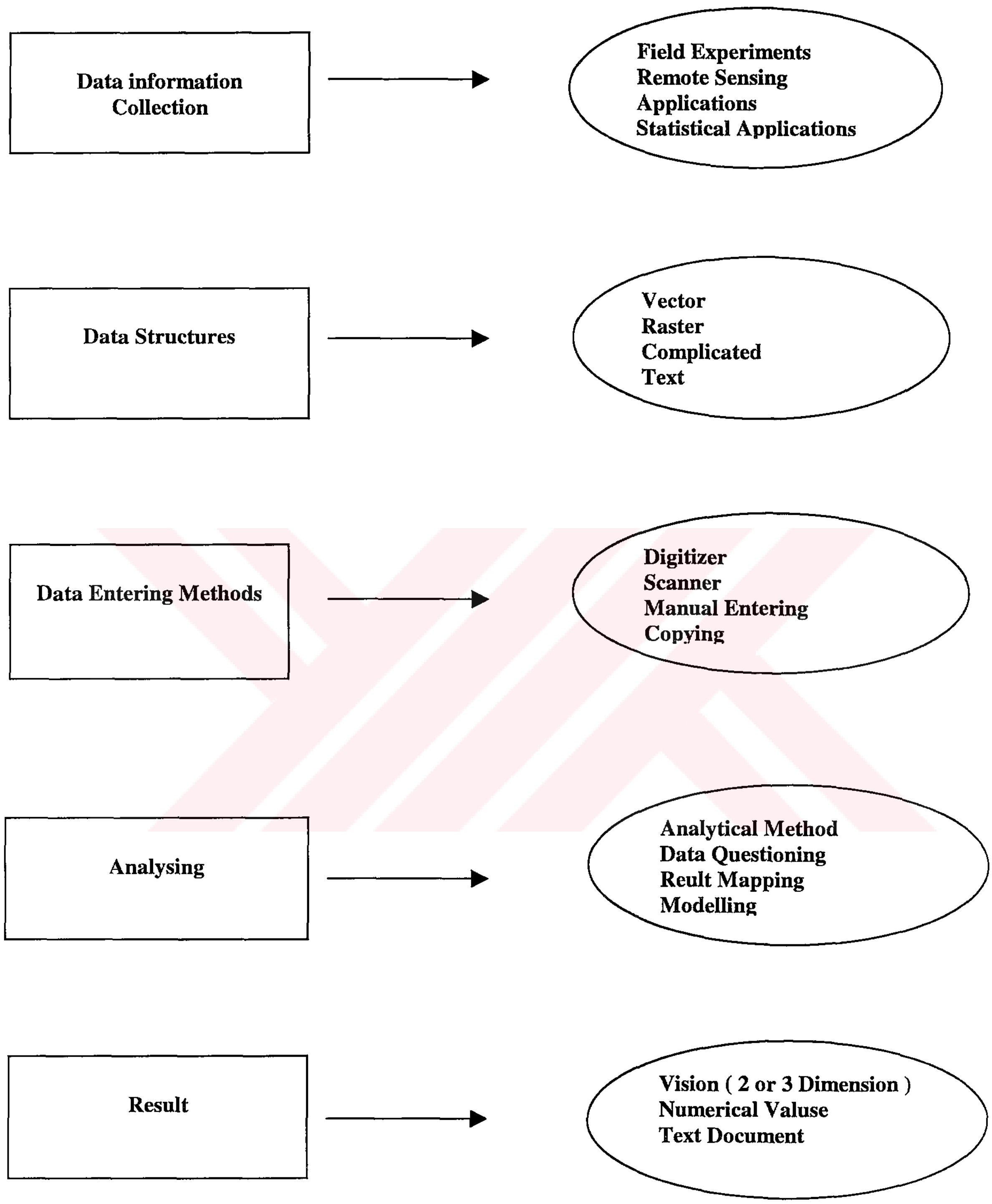

Figure 2.4 Geographic Information System Methodology (Turoğlu, 2000)

2.3. GIS Data Structures

"How one models space is also a fundamental theme in GIS ?". There are two fundamental approaches to the representation of the spatial component of geographic information: the Vector model and the Raster model (Göksel and Türkoğlu,1991).

2.3.1. Raster Model

The raster data model serves to quintize or divide space as a series of packets or units, each of which represents a limited, but defined, amount of the earth's surface. The raster model can define these units in any reasonable geometric shape, as long as the shapes can be interconnected to create a planar surface representing all the space in a single study area.

The raster model divides the earth into rectangular building blocks as grid cells or pixels that are filled with the measured attribute values. Its row and column numbers defines the location of each cell or pixel. Raster data structures do not provide precise locational information therefore it may seem to be rather undesirable (Göksel and Türkoğlu, 1991). One alternative raster format is the quadtree (Williams, 1995), this is constructed by dividing an image into quarters, then these quarters into further quarters, and so on hierarchically until the entire image is divided up. The end of any "branch" on the quadtree is defined when any of the square blocks produced by the splitting process at a particular level contains pixels with all the same value. Thus the quadtree represents the values of the image by a hierarchial tree of homogenous squares of various sizes.

2.3.2.Vector Model

In the vector model, the spatial locations of features are defined on the basis of co-ordinate pairs. These can be discrete, taking the form of points (POINT or NODE data); linked together to form discrete sections of line (ARC or LINE data); linked together to form closed boundaries encompassing an area (AREA or POLYGON data). Attribute data pertaining to the individual spatial features is maintained in an external database. (http://ads.ahds.ac.uk/project/goodguides/gis/sect32.html). On the other hand DeMers (1997) defined the vector model as the data structure which is representative of dimensionally as it would appear on a map. Vector representation makes use of three simple topological objects (Williams,1995) :

1. points (zero-dimensional objects)
2. lines (one-dimensional objects)
3. areas (two-dimensional objects)

2.3.2.1.Geometric Corrections In a Vector Format : According to Burrough (1986), when converting data to a common vector format it is essential to bring all data to a single , exact coordinate system so that the various points, lines and areas are digitized into a vector-overlay-structure (Figure 2.5).

This method requires objects in the RS image to be recognized and classified first, and then the boundaries are captured in vector format. If necessary these boundaries can be brought to a common coordinate system by a registration procedure and placed in the vector-overlay-structure. There are two main methods for detecting objects and their boundaries. One method involves the application of automatic image interpretation keys (“experts”) which assists the extraction of certain objects from the image (Burrough,1986).

This approach is most suitable for high resolution images of artificial objects such as buildings and land parcels. Semi-automatic methods can be used for coarser resolutions and objects that are difficult to distinguish or for extensive databases. Point data can be interpolated to larger regions by the same methods that were given for raster format. Data concerning elevation measurements can be described in vector format as triangulated irregular networks (TIN). These have a polygonal vector structure comparable to normal polygonal structures.

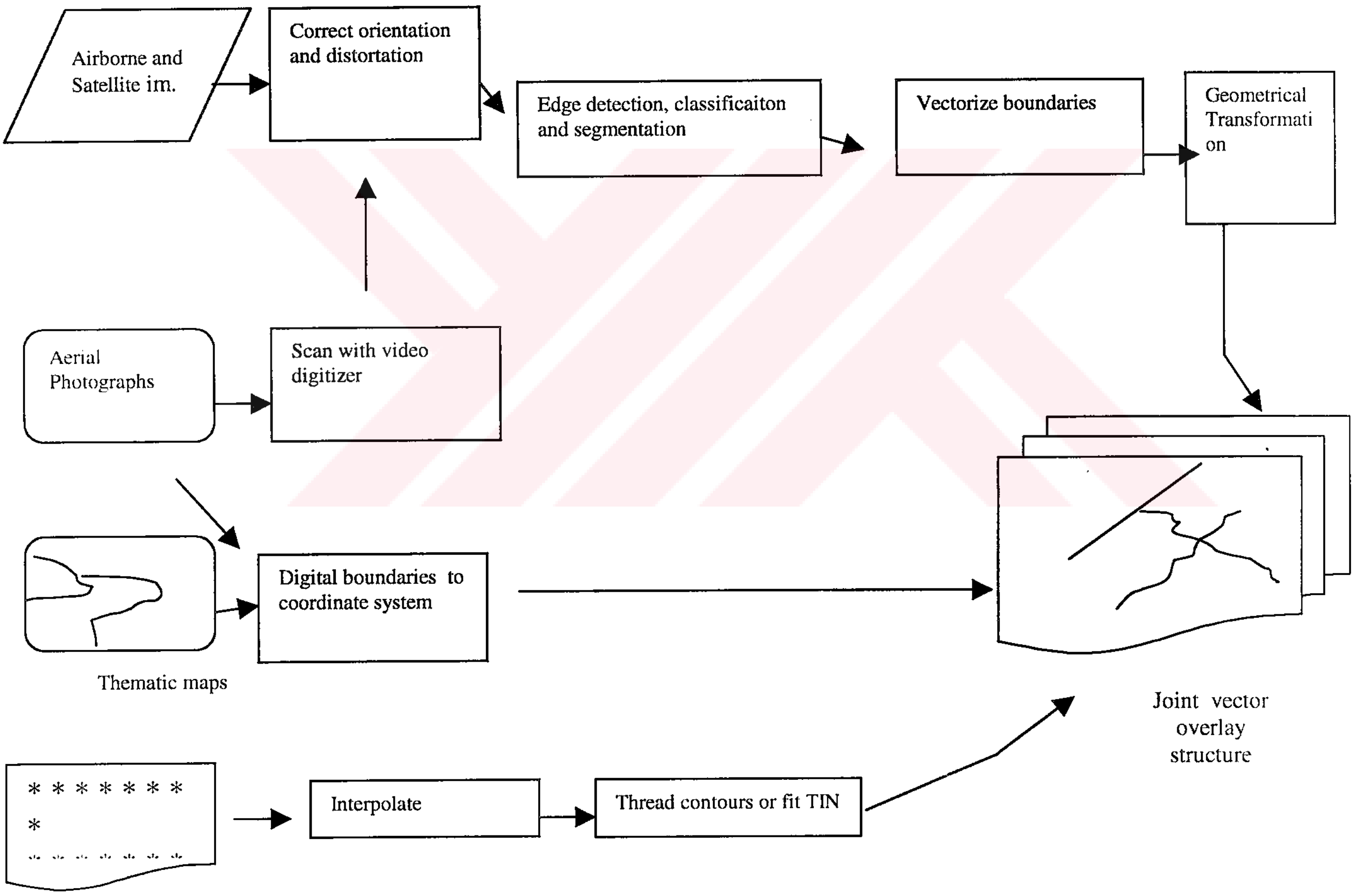

Figure 2.5 The conversion of various kinds of spatial data to a common vector format (Buiten and Clevers ,1993)

2.3.3. The Disadvantages And Advantages Of Vector And Raster Data

One of the advantages of using quad trees method in Raster data, is that they can be used in a top –down manner to provide a representation of the image at various scales, with all finer detail being hidden at lower levels of resolution. The quadtree representation is extremely efficient for performing arithmetic and deriving image statistics, and is relatively easy to implement in software (Williams, 1995).

Table 2.1 Advantages and disadvantages of vector and raster data (Göksel, and Türkoğlu, 1991).

Raster Data	Vector Data
Advantages	**Advantages**
• It is a simple data structure • Overlay operations are easily and efficiently implemented • High spatial variability is efficiently represented in a raster format • The raster model is more or less required for efficient manipulation and enhancement of digital images	• It provides a more compact data structure than the raster model • It provides efficient encoding of topology and as a result more efficient implementation of operations that require topological information, such as network analysis
Disadvantages	**Disadvantages**
• The raster data structure is less compact data compression techniques (an often overcome this problem) • Topological relationships are more difficult to present • The output of graphics is less aesthetically pleasing	• It is a more complex data structure than a simple raster • Overlay operations are more difficult to implement • The representation of high spatial variability is inefficient • Manipulation and enhancement of digital images cannot be done in the vector domain

2.3.4. Evaluation of Vector and Raster Data

Burrough (1986) defined that the linking of RS images and other spatial data in GIS raises problems of geometry and thematic. The application of raster techniques is recommended for objects that are not easily recognizable, and under circumstances where the analysis and modelling of data are paramount. Vector data are preferable in real-estate and cadastral applications where data on clearly recognizable objects must be collected quickly with a high degree of geometric accuracy. Statistical methods of spatial analysis can be helpful in cases where relationships between patterns on the images and spatial differences on the ground are vague, or where the differences vary gradually (Buiten and Clevers , 1993).

2.4. Definiton of Remote Sensing

Remote sensing also called "tele – detection" or earth observation refers in a general sense to the instrumentation, techniques and methods used to observe the surface of the earth usually by the formation of an image in a position stationary or mobile at a distance remote from that surface. After formation this image is analysed (Buiten and Clevers, 1993).

On the other hand, remote sensing also can be described as an art, science and tool of acquiring information about targets of certain phenomenon by a sensor that is not in contact with these targets or phenomenon (Göksel and Türkoğlu, 1991). The process regarded with remote sensing can be seen in Figure 2.6.

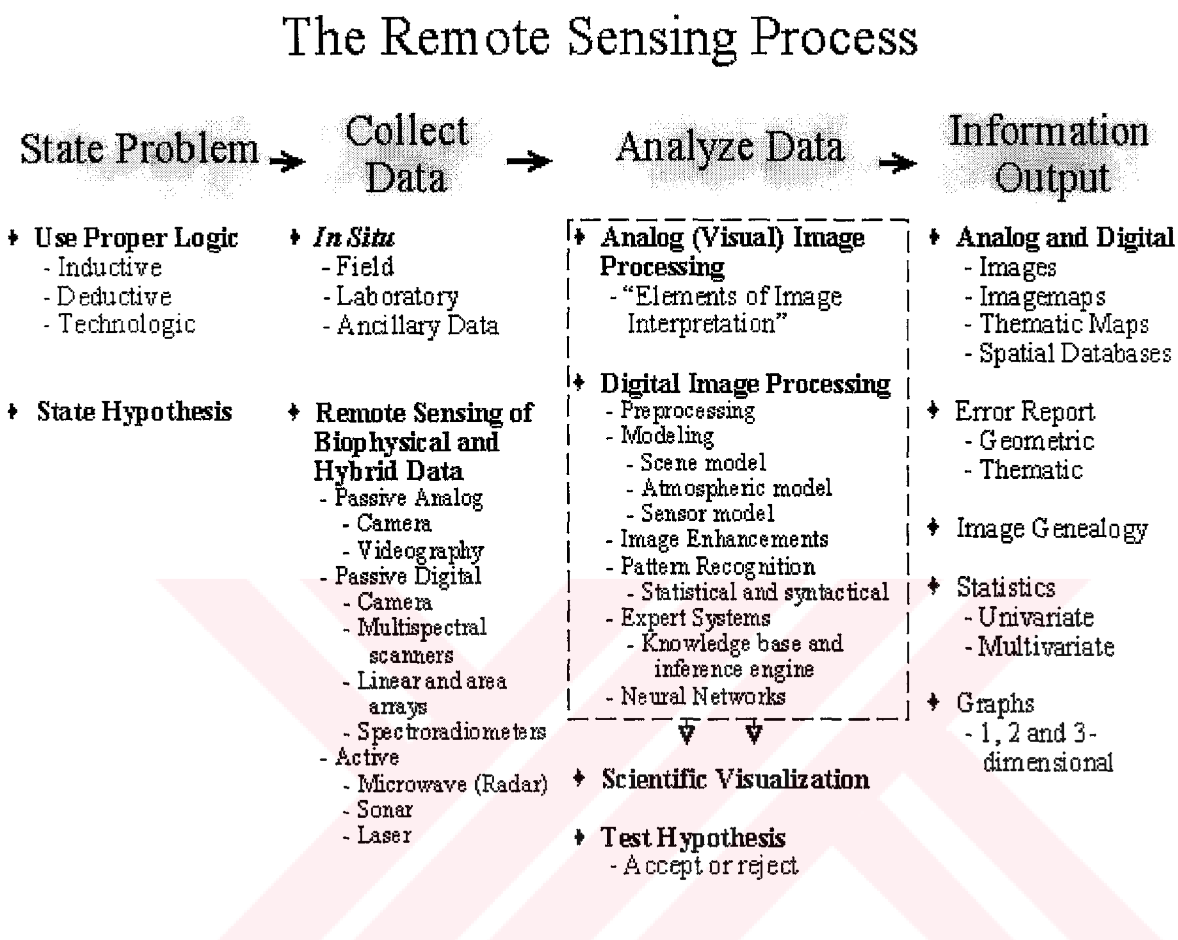

Figure: 2.6. Remote sensing process (www.cla.sc.edu , 2002)

Although , Remote Sensing is a data acquisition technique, the remotely sensed data are an ever increasing input to GIS databases, especially where large areas must be analyzed and repeated coverage is necessary due to rapidly changing conditions.

According to Aronoff (1989) Remote Sensing and GIS technology are both used to collect, analyze, and report information about the earth's resources and the infrastructure that developed to use them. The two technologies provide complementary capabilities.

Remote sensing analyses are improved by the verification data retrieved from a GIS and GIS applications can benefit from the information that remote sensing can generate. The use of digital image data offers the additional advantage of a computer compatible format that can be input directly to a GIS.

2.5. Integration of GIS and Remote Sensing Data

The integrated use of remote sensing and GIS methods and technology can not only improve the quality of geographic information but also enable information previously unavailable to be economically (Aronoff, 1989).

Over the past few years manufacturers have developed more sophisticated technology for integrating remote sensing systems and geographic information systems. Thus, this permits the overlapping of several layers of information with the remotely sensed data, and the application of a virtually unlimited number of forms of data analysis (Göksel, and Türkoğlu, 1991).

Remote sensing data can be produced at any time .The analogue or digital recorded images can be viewed at leisure, they can be processed with instrumental equipment or with digital image processing systems and interpreted and analyzed with the aid of prior knowledge. This broadens the prospects for the combination of RS and Geographic Information Systems (Buiten and et.al., 1993).

4. METHODOLOGY

The working pathway of the study was described at below.

1. Determining the Ground Control Points
2. Georeferencing
3. Registering
4. Intersection and Union

3.1. Characteristics of Database

In this study, raster data wer obtained by scanning maps, and satellite images. Scanned maps usually do not exactly match with the topography of the Earth's surface. To analyze the land use changes between 1982 and 2001, remote sensing data are used . The digitised land use maps and IKONOS Satellite Images are the main sources to interpret the land use changes at coast zone of the region. The attitude of the satellite was 680 km. The characteristics of the satellite images are presented in Table 3.1.

Table 3.1. The characteristics of Ikonos Satellite Image used in the study (Inta Space Systems. Inc, 2001)

Image	**Date**	**Precision**	**Number of Bands**	**File Format**	**Map Projection**
Ikonos	28 August 2001	5 meter RMSE	Multi band	TIFF (LCC, ACEA)	UTM

The high qualified satellite images are used to determine soil and water pollution levels , and natural disasters. For high performance and accuracy, 1 meter pan sharpened and 1:25.000 scaled IKONOS satellite images are preffered to use in the study.

Using raster data with other spatial data often requires that the raster data be aligned or georeferenced to a map coordinate system (Price, 2002). Johnston (1998) postulated that a distinguishing feature of a GIS is that all data are georefenced to a coordinate systems. These reference systems use distances from a specified reference point as the basis of all locations . Such systems of reference are called plane coordinate systems. The Universal Transverse Mercator sytem is the best – known plane coordinate system, and is based on a transverse Mercator projection. In this system, the projection is secant to the Earth's surface, to balance scale variations.

The UTM system divides the Earth's surface into zones that are 6 degrees of longitude wide. Each zone is numbered, and the quadrilaterals 8 degrees of latitude high within a zone are lettered. This scheme of lettering and numbering provides a simple mechanism for locating areas on a coarse grid. Precise locations on the earth are described in terms of north-south and east-west distances, measured in meters from the origin of the appropriate UTM zone (Star and Estes, 1990). Geographic datums and the coordinate reference systems based on them were developed to describe geographic positions for surveying, mapping, and navigation coordinate values resulting from interpreting latitude, longitude, and the height values based on one datum as though they were based on another datum can cause positional errors of up to 1.5 km. (Johnston, 1998). As a result ground control points were thoroughly determined from standard topological maps' (Scale 1:25.000) and plot at the IKONOS satellite images

3.1.1. Ground Control Points

Ground control refers to physical points on the ground positions that are known with respect to some horizontal coordinate system and/or vertical datum. To have a beneficial outcome, ground control points can be used to establish the exact spatial position and orientation of an aerial photograph relative to the ground at the instant of exposure (Lillesand and Kiefer, 1994).

Consequently, ground control points provide the necessary information to convert a dataset into the correct coordinate space. These consist of easily recognizable locations that can be found in both the source data and another data source with known georeferencing information. A combination of one control point on the source raster data and the corresponding control point on the map data is referred to as a link. When enough links have been chosen they can be used to compute a transformation that can assign the correct map coordinates to any raster (ARC GIS Manual Book, 2000) . Furthermore, Ground Control Points are points in aerial photographs, and satellite images for which the output map coordinates (or other output coordinates) are known. GCP's consist of two X,Y pairs of coordinates :

a. **Source Coordinates :** usually data file coordinates in the aerial photographs being rectified

b. **Reference Coordinates:** the coordinates of the map or reference image to which the source image is being registered.

The term "map coordinates" is sometimes used to apply to reference coordinates and rectified coordinates. These coordinates are not limited to map coordinates (Erdas Field Guide, 1997) . Accurate ground points are essential for an accurate rectification. From the ground control points, the rectified coordinates for all other points in the image are explorated. For the study we selected many GCPs throughout the satellite images.

According to Erdas Field Guide, 1997 and ARC GIS Manual Book, 2000 the more dispersed the GCPs are, the more reliable the rectification will be.
GCPs for large-scale imagery might include the intersection of two roads,airport runways, utility corrdidors, towers,or buildings. The GCPs were found randomly at the standart topological map whereas the same scenes with satellite images , and the determined coordinates were entered by using ER MAPPER 6.02 version.

3.1.2. Georeferencing the Images

Georeferencing or known as rectification can be defined as inolving manipulating the raw dataset so that the spatial arrangement of objects in the data corresponds to a specific geocoding (or geodetic coordinate) system (Star and Estes, 1990). They also gave an example of a rough sketch of an undeveloped area, made on-site by a landscape architect which typically does not show objects in their true spatial relationships. They added that : Once the sketch has been brought back into the office, the sketch can be redrafted so it conforms to a useful coordinate system. The procedure of this technique was performed to register satellite images by using ER MAPPER 6.02 Version.

Once the satellite images have been loaded as digital images into ER Mapper, they need to be registered, or geocoded, to real world map coordinates.The images can be combined with each other and other data, such as GIS or CAD based vector information. When Ground Control points have been defined, ER Mapper will create a new registered version of the image, using polynomial or Delauny Triangle rectification (ER Mapper Help Guide, 1997).

By using ER Mapper, ground control points can be picked in a number of ways, including:

1.) Picking points from one or more other digital images which have already been geocoded.
2.) Picking points from vector based digital data, such as from a GIS or CAD vector overlay.
3.) Using a digitizer to pick control points from a paper map, such as a USGS map.
4.) Typing in coordinates for known points, such as survey post coordinates.

The first method was followed at the study . Satellite images belonging to 20th August 2001 and have been geocoded to GIS based vector data. Rectified standard 1:25.000 topological raster map views are used to pick up Ground control points.
More than 10 to 15 points, evenly across the satellite images were chosen for way to the edges and corners of the image.

After this process set up four windows were seen on the work station. The four views were

- an overview of the image to be geocoded
- a zoomed view of the image to be geocoded
- an overview of the raster map views being used as reference data to pick ground control points
- a zoomed view of the raster map views being used as reference data to pick ground control points.

To achieve the best geocoding results, it was prefered to select polynomial sampling of the image to ensure a quality result is achieved.

When the rectified image was created , it used a file name that reflected that this was no longer raw data. The raw data was called "sat1.ers", use "sat1_rec_ers" for the file name for the geocoded imagery. Finally, the satellite images were checked correctly to overlay (intersection and uinon) with raster map views.

3.1.3. Registration

According to Star and Estes (1990) registration is similar to rectification, but not based on an absolute georeferencing scheme. Both sketches from a field team and uncontrolled aerial photography have distorted views of the Earth's surface. Moreover, the registration process involves changing one of the views of surface spatial relationships to agree with the other, without concern about any particular geodetic referencing system.

3.1.4. Intersection and Union (Overlaying)

The crucial part of this study is Intersection and Union process. To determine the land use changes at the study area , satellite images and digitized land use maps that were georeferenced by using ER Mapper and overlayed in Arc view 3.01 version.

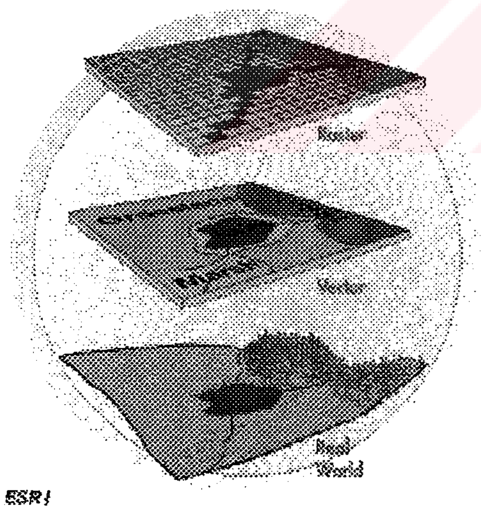

Figure 3.1 Scheme of Intersection and Union Process (http://www.uni-kiel.de:8080/castle/ch5/s4l6p010.htm, 2002)

Union process is used to produce a new theme containing the features and attributes of two polygon themes. To use in union process, digitized satellite images are needed to produce maps. The drainage, population, land use maps belong to 1982 and 2001 are used as the overlay or Union theme. The result was a new theme named "union1.shp" (default name).

4. GIS DATA AND CAHARACTERISTICS OF ERDEMLI – KIZKALESI REGION

4.1. The Location of the study area

The province of İçel is located on the Eastern Mediterraean coast . The capital of İçel is the city of Mersin and the surface area of İçel is 1,585,300 ha , corresponding to 2 % of the Turkey's total surface area . 49.5 % of this usage is covered by the forest. The horticulture covers 17 % of the whole agricultural activities and it represents an area of 66,860 ha and the green-housing agriculture occupies an area of 8,235 ha . The meadow and pasture area covers 0.4 % (6,109 ha) of the city surface area. The non-agricultural area covers 25.3 % (401,740 ha) and the settlements cover 1 % (15,192 ha) of the whole city surface area, (Icel Environment Report, 2001). Erdemli, a town of the province of İçel, consists of 4 villages namely Limonlu, Kocahasanli Narlikuyu and Kızkalesi. The study area is located within Erdemli and the above named 4 villages. The location of the study area is presented in Figure 4.1.

Erdemli is a recent settlement with a population of more than 30000 inhabitants. It is 35 km west of Mersin in the Mediterranean Region. The majority of its inhabitants' are involved in agriculture. The town consists of two distinctive sections in accordance with natural and human geographical features. One is the coast line with its rich agricultural potentiality to suitable land and climatic conditions, the other is the mountainous area with rocky landscape and a harsh climate. The town covers an area of 207800 ha. The neighbourhood settlements around Erdemli are : The province of Konya in the north and east ; the Mediterranean sea in the south, Silifke in the southwest and the province of Karaman in the northwest. The most important water sources of Erdemli are, Alata and Lamas Rivers. The city is located at the western side of the mouth of Alata river (Koca., 1994).

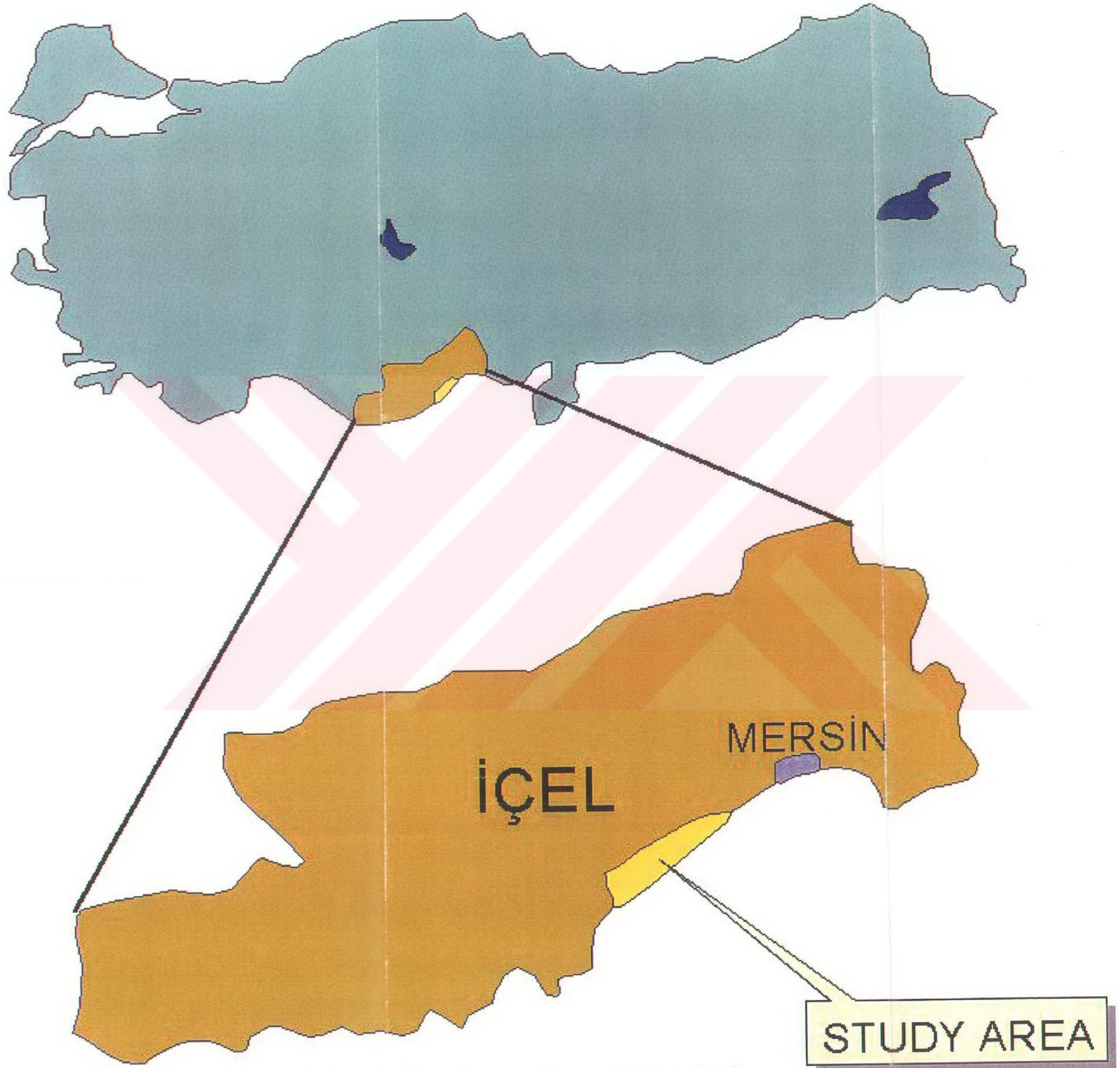

Figure 4.1. Location of the study area.

The ancient village of Limonlu is located partly on the slope of a hill on the right bank of the Lamus (Limonlu) river. Agriculture, especially green housing agriculture is one of the main sources of income . Narlikuyu is located on the highway extending to Mersin. The city center is 20 km away from Silifke Narlikuyu means the "Well with pomegranate" and it was called "Porto Calamie" in the Middle Ages.

Kocahasanli is located at 4 km away from Erdemli. Toros Mountains rise up at the nearby coasts of Kocahasanli. The landscape of the village is rocky. Therefore, the settlements are spread over on the sea side.

Corycus, known as Kizkalesi, is the largest site with ancient monuments and remains in the region. It is located 23 km at the southeast direction of Erdemli and 25 km east of Silifke, on both sides of the coastal highway. Toros Mountains encompass Kizkalesi in the north . The main source of income of the city is agriculture.

4.2 . Land Use in İçel

The land use distribution of the province of İçel is presented in Table 4.1.

Table 4.1 Land use in İçel (İçel Environmental Report, 2001)

Town	Surface	Agriculture Area		Forest		Meadow and Pasture		The non-agriculture Area	
	(Ha)	Amount (Ha)	Rate (%)	Amount (Ha)	Rate (%)	Amount (Ha)	Rate (%)	Amount (Ha)	Rate (%)
MERSİN	177200	45592	25,7 %	94759	53,5 %	761	0,4 %	36088	20,4 %
ANAMUR	138000	21762	15,8 %	81356	59,0 %	0	0,0 %	34882	25,3 %
AYDINCIK	41000	6406	15,6 %	28944	70,6 %	10	0,0 %	5640	13,8 %
BOZYAZI	62500	9729	15,6 %	37749	60,4 %	0	0,0 %	15022	24,0 %
ÇAMLIYAYLA	67500	7388	10,9 %	36445	54,0 %	0	0,0 %	23667	35,1 %
ERDEMLİ	207800	50141	24,1 %	56404	27,1 %	0	0,0 %	101255	48,7 %
GÜLNAR	166900	30433	18,2 %	84809	50,8 %	130	0,1 %	51528	30,9 %
MUT	255400	59949	23,5 %	141213	55,3 %	22	0,0 %	54216	21,2 %
SİLİFKE	266600	55704	20,9 %	160980	60,4 %	1106	0,4 %	48810	18,3 %
TARSUS	202400	104902	51,8 %	62786	31,0 %	4080	2,0 %	30632	15,1 %
TOTAL	**1585300**	**392006**	**24,7 %**	**785445**	**49,5 %**	**6109**	**0,4 %**	**401740**	**25,3 %**

On the other hand, if we compare the land use of the province of İçel and to that of Turkey together, the following results can be presented;

Table 4.2. Use of Land , 1991 (State Statistical Institute , 1991)

	Turkey	**İçel**
Total cultivated area (decar)	**214 .494 824**	**3 056 375**
Irrigated	30 .935.454	730.457
Non-irrigated	183.559.370	2 .325. 918
Area sown	157. 848.470	1 .877. 055
Irriagated	22 .640.322	223.806
Non-irrigated	135 .208.148	1 .653. 249
Vegetable and flower gardens	5.211.652	165.511
Open field vegetable	4 .095.079	155.138
Undercover vegetable	1 .116.573	10.373
Fruit orchards and other permanent crops	19 .400 588	576.452
Citrus	4 .200 .053	351.513
Cereal	15 .200. 535	224.939

4.2.1 Land Use in Erdemli and Kizkalesi Region

Land use in Erdemli and its surroundings has been studied by Koca (1994). Except for the coastal regions, low grade lands form the soil characteristics of the study area. Koca (1994) clarifies the agricultural lands into seven categories in which first and second class lands occupy only a total of 3.7 %. However, the classification here has two many parameters involved so that land use land use distribution by Erdemli Agricultural Office (1992) is more easily comprehendible (Table 4.3).

Table 4.3 Land use at the town of Erdemli and the villages of Limonlu, Narlikuyu, Kocahasanli in the year of 1991 (Erdemli Agriculture Office ,1992)

Way of usage	Surface (ha)	Percentage
Agricultural Land	52.900	25.5
a.) Intensive Agriculture	12.612	
b.) Extensive Agriculture	40.288	
Forestry Land	78.000	37.5
Meadow Land	16.000	7.7
The non-profit Land	60.900	29.3
TOTAL	207800	100.0

4.3.Demographic Characteristics of the study area

According to Koca (1994) , the coastal zone between Erdemli and Kizkalesi is a densely populated area due to the increase in agricultural and touristic activities. Favourable soil and climatic conditions have caused many people to operate green houses along the study area.

The population was 16,669 inhabitants in 1935. Between 1935 – 1990 this value increased five fold. The great increase can be seen mostly in coastal zones. There was no significant change in the population in the mountanious region within the study area between 1965 – 1970. Expansion of the settlements along the coastal zone can be counted as a result of the population increase.

In 1955, some settlements were located at restricted areas along the coastal zone. By 1990 such settlements, also known as "secondary houses", were spread all over the coastal zone. This can be observed in Figure 4.2, where the buffer zones at this map symbolise the area of the secondary houses along the coastal zone in 2001. Moreover , the population increasing from 1982 to 2001 in the study area can also be seen in Figure 4.3.

4.4. Environmental Pollution and Pollutant Sources In The Study Area

Pollutant sources have been classified as point and non point sources. Point source pollutants are discharged into the environment from specific sites. Discharge of industrial effluents and waste and discharge of residential waste are chief sources of water and soil pollution. (Göksel and Türkoğlu,1991).

The well-known main sources of pollution in the province of İçel are industrial plants namely, Koluman Ticaret ve Sanayi A.Ş, Soda Sanayi A.Ş, Akdeniz Gübre Sanayi A.Ş, Koniteks A.Ş, Berdan-2 Textile (İcel Environmental Report, 1998) .

Non-point sources of pollution in the study area are from use of fertilizers and pesticides. Greenhouse and citrus agriculture are spread extensively along the region. The increase in the distrubition of greenhouse and citrus agriculture can be seen in Figure 4.4.

Farmers use pesticides and fertilizers in green houses and agricultural fields, and citrus orchards. The chemical fertilizers that are used in İçel are presented in Table 4.4. It is often very difficult to limit the use of fertilizers and pesticides in farming practices. Farmers prefer to use excessive amounts rather than insufficient amounts.

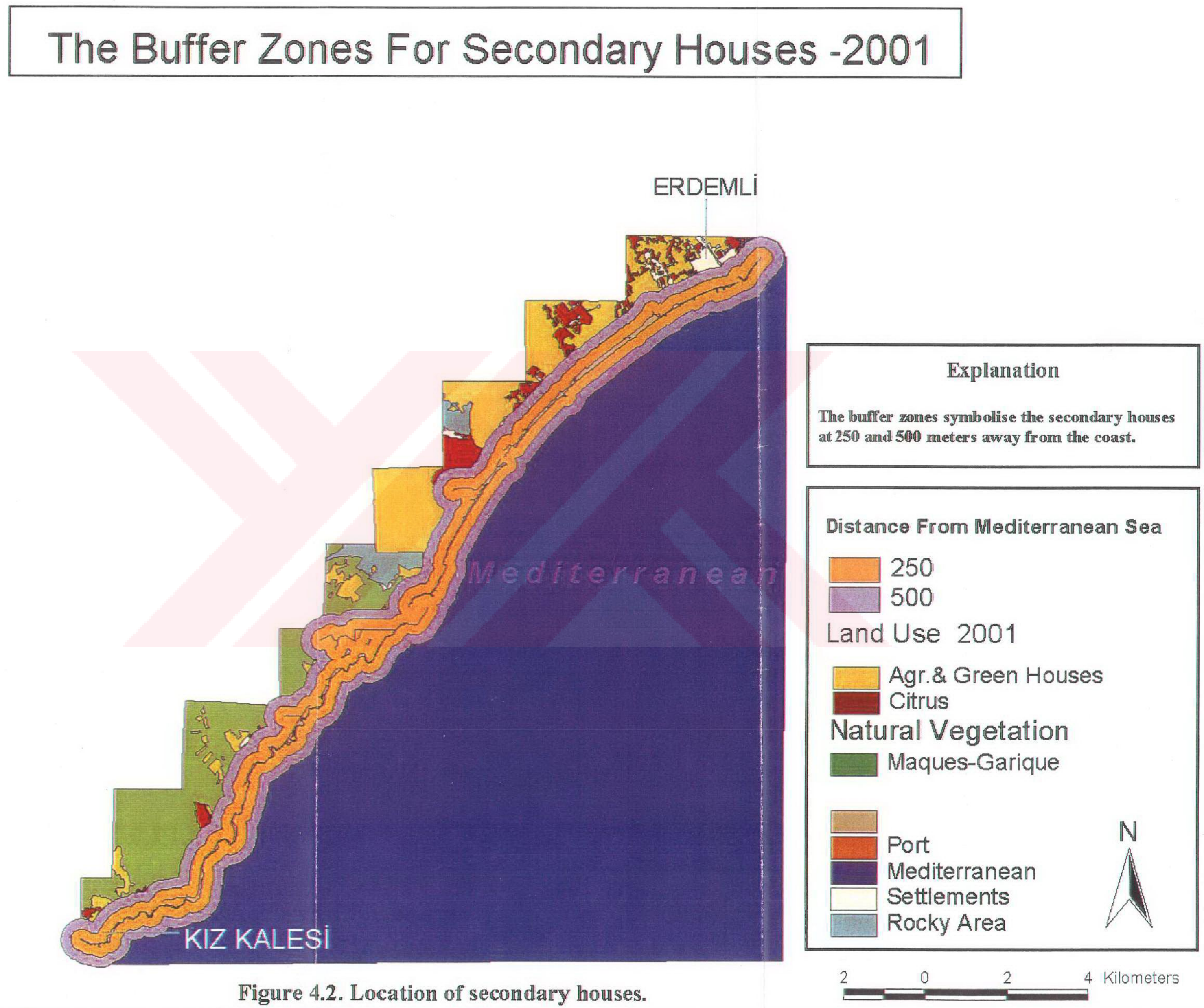

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Figure 4.2. Location of secondary houses.

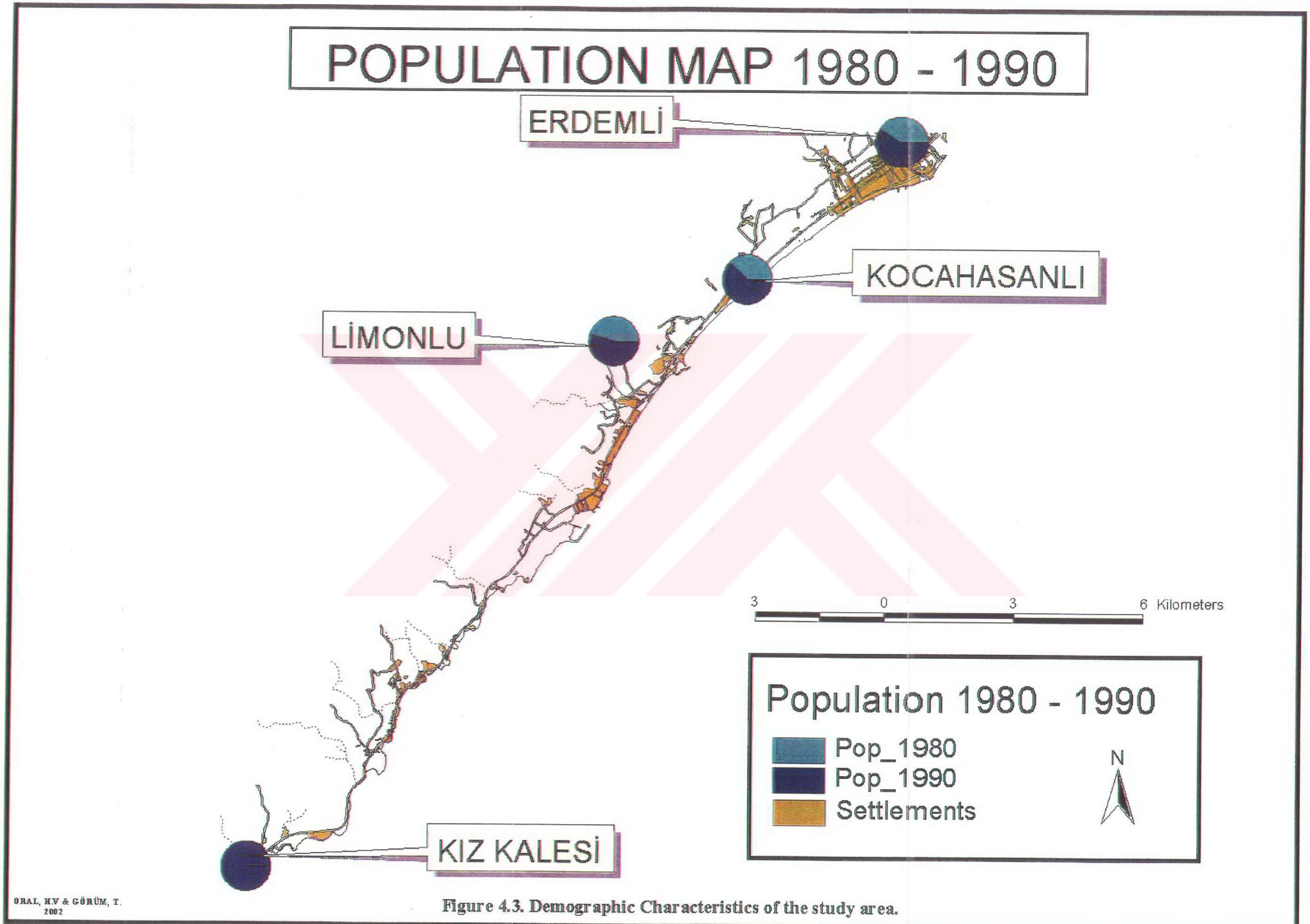

Figure 4.3. Demographic Characteristics of the study area.

This is often good for the agricultural product but creates a burden for the environment as excessive amounts of these chemicals are potentially hazardous for terrestrial and aquatic ecosystems.

Table 4.4 The Fertiliser Consumption in Mersin Region on September 1998 (İçel Environmental Report, 1998)

Chemical Structure	**Consumption**
Ammonium Sulfate	11525,4 Ton
Calcium Ammonium Sulfate	9119 Ton
Ammonium Nitrate	10586 Ton
Urea	24935 Ton
Triple Superphosphate	785 Ton
Diammonium Phosphate	1560 Ton
Potassium Nitrate	487 Ton
Potassium Sulfate	2284 Ton
Calcium Nitrate	21 Ton
Compost	31276 Ton
TOTAL	**92578 Ton**

Unfortunately, there is no clear information about the accumulation rate of the fertilisers and pesticides in soil and their secondary effects to the environment.

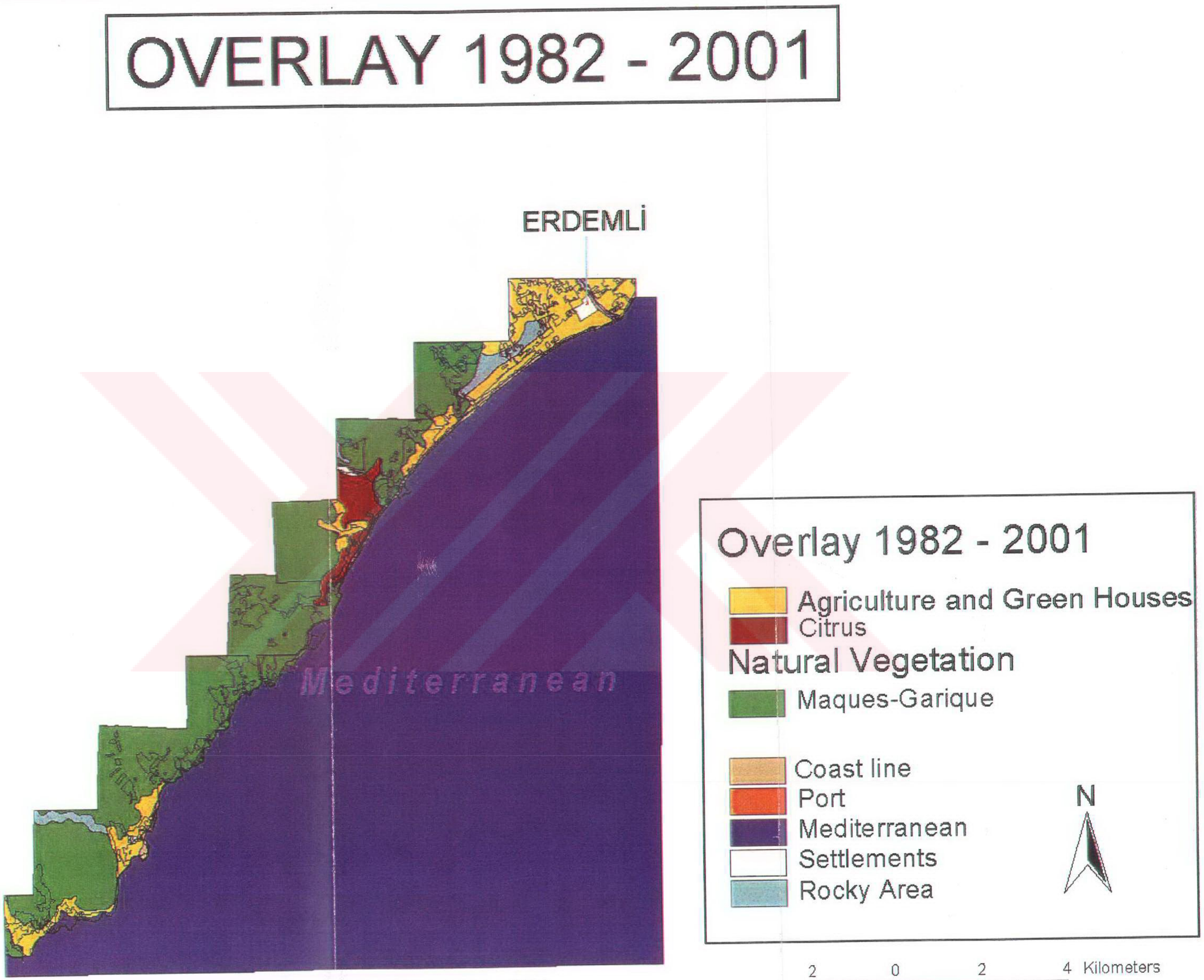

Figure 4.4. Overlay map between 1982 - 2001.

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5. RESULTS AND DISCUSSION

Long term developments in land use in many industrialised countries indicate significant changes . Urban and agricultural land use have grown considerably over time at the expense of wastelands. Urban land use is still on the rise, but due to overproduction and intensification in agriculture (mostly irrigated area and green houses) , the amount of agricultural land is considerably rising. Agricultural activities became an important outcome on the coast because of the suitable soil and adequate conditions.

In the study , the land use change differences between 1982 and 2001 were figured out by using ARC View Software. This can be seen in Table 5.1.

The area of Mediterranean represents the part of the ocean within the study area. This area decreased 0.1 % from 1982 to 2001. Possible reasons are the construction of a port at the Tirtar Region (Figure 5.1) and other coastal expansion activities such as filling in the sea with land.

According to the data sources of this study , this port was not seen on the aerial photographs that belong to 1975 and 1987 and standard topographical 1:25.000 scale maps. However, the port was seen on the IKONOS Satellite Images that belong to 2001 visual processing. Establisment transportation from the port area towards the settlements area, and construction of roads can be counted as first results. As a second result, settlements were built in the nearby region of this port and the population of these settlements tended to rise up at recent times.

This may represent a marginal change but in fact it insignificant as this is a common practice to gain land in coastal regions.

Table 5.1 Land Use Changes Between 1982 and 2001

	Area in 1982(m^2)	Area in2001(m^2)	Area Diff.(m^2)	Area (%) 2001	Area (%) 1982	Area Diff. (%)
Mediterranean	162000143	161790048	-2100095	79,3	79,4	-0,1
Port	15219	94952	79733	0,04	0,007	+ 0,33
Citrus	2015888	5790024	3774136	2,84	0,98	+1,86
Agriculture	8448139	14178000	5729861	6,95	4,14	+2,81
Maqique - Garique	28510537	15114507	-13396030	7,41	13,9	-6,49
Settlements	329975	4142218	3812243	2,03	0,16	+1,87
Rocky Area	1622186	1703015	80829	0,83	0,79	+0,04
Coast Line	900623	1046800	146177	0,51	0,44	+0,07
TOTAL	203842710	203859564		100	100	

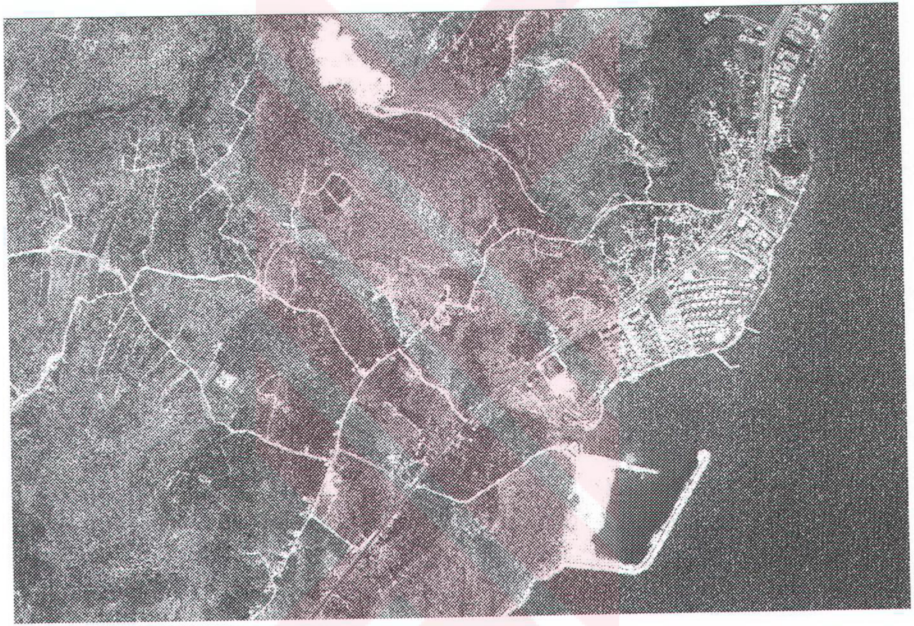


Figure 5.1: The Ikonos Satellite Image of the port constructed at Tirtar Region in 1992

The study incurs a 1.86 % increase in the citrus farming areas. This is a result of a gain from the destruction of maqiue and garique area. In the land use the budget between 1982 and 2001, a 6.49 % decrease in maqiue and garique lands has been qualified. A fraction of this decrease has been gained by citrus farming.

It is evident that the 2.81 % increase in agricultural lands is also due to the decrease in maqiue and garique vegetation. An important part of this is greenhouse farming with vegetable such as tomatoes and peppers and also decorative flowers such as carnations and tulips.

Greenhouse farming and citrus agriculture have been very popular within the study period as those have been source of good income for farmers. In Figure 5.2 changes in land use can be observed with the noticeable increase in greenhouse constructions in Erdemli. A drastic increase in greenhouse farming in the last 2-3 decades has been a source of substantial financial gains by the farmers within the entire Southern Mediterranean coast of Turkey.

The rest of the land gained by the destruction of maqiue and garique vegetation has gone to settlements. The increase over the period 1982-2001 is 1.87%. The settlements mentioned here are permanent and secondary houses.

There are five main settlements in the study area. These are the town of Erdemli and its villages, Limonlu, Kocahasanli, Narlikuyu and Kızkalesi. It is seen that 30 % of the total population at the study area live in town centers , and the rest in rural places.

Expansion of secondary houses on the coast line, and establishment of permanent settlements can be counted as uncontrolled urban land use. This type of land use was detected by 1982 and 2001 land use maps (Figure 5.3). A large population increase in the coastal line is caused by the expansion of the villages located at the study area . It is seen that the population of Kizkalesi with only a few inhabitants in 1980, but in 1990 the population reached to 3091. The main reasons of this increase are expansion of agricultural activities and development of tourism. Development of tourism within the study area over the period 1982-2001 is mainly domestic tourism activities and building of summer houses

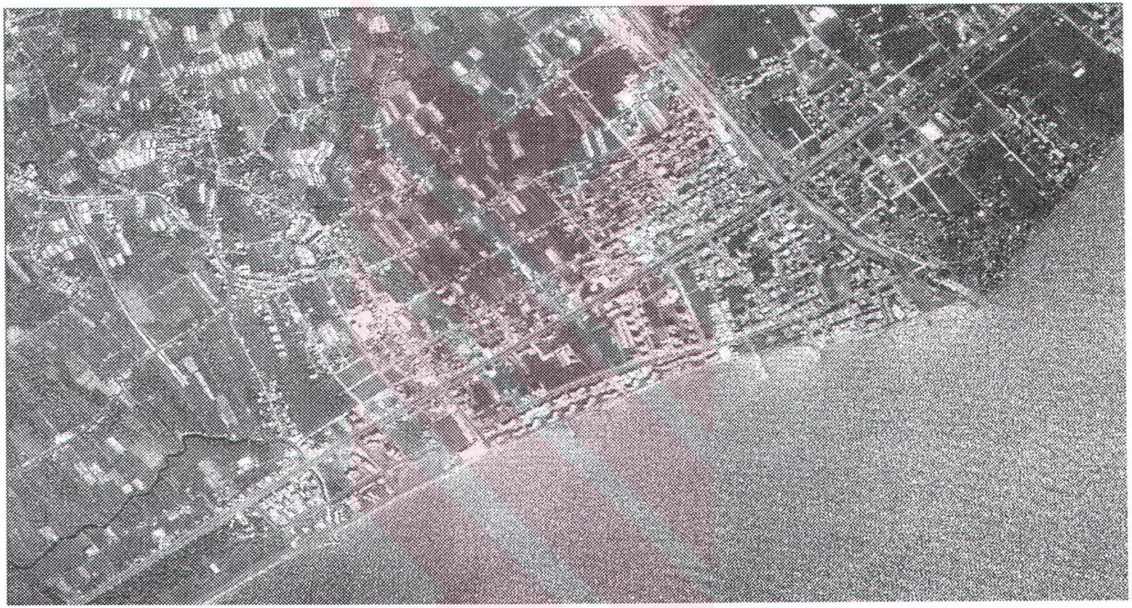
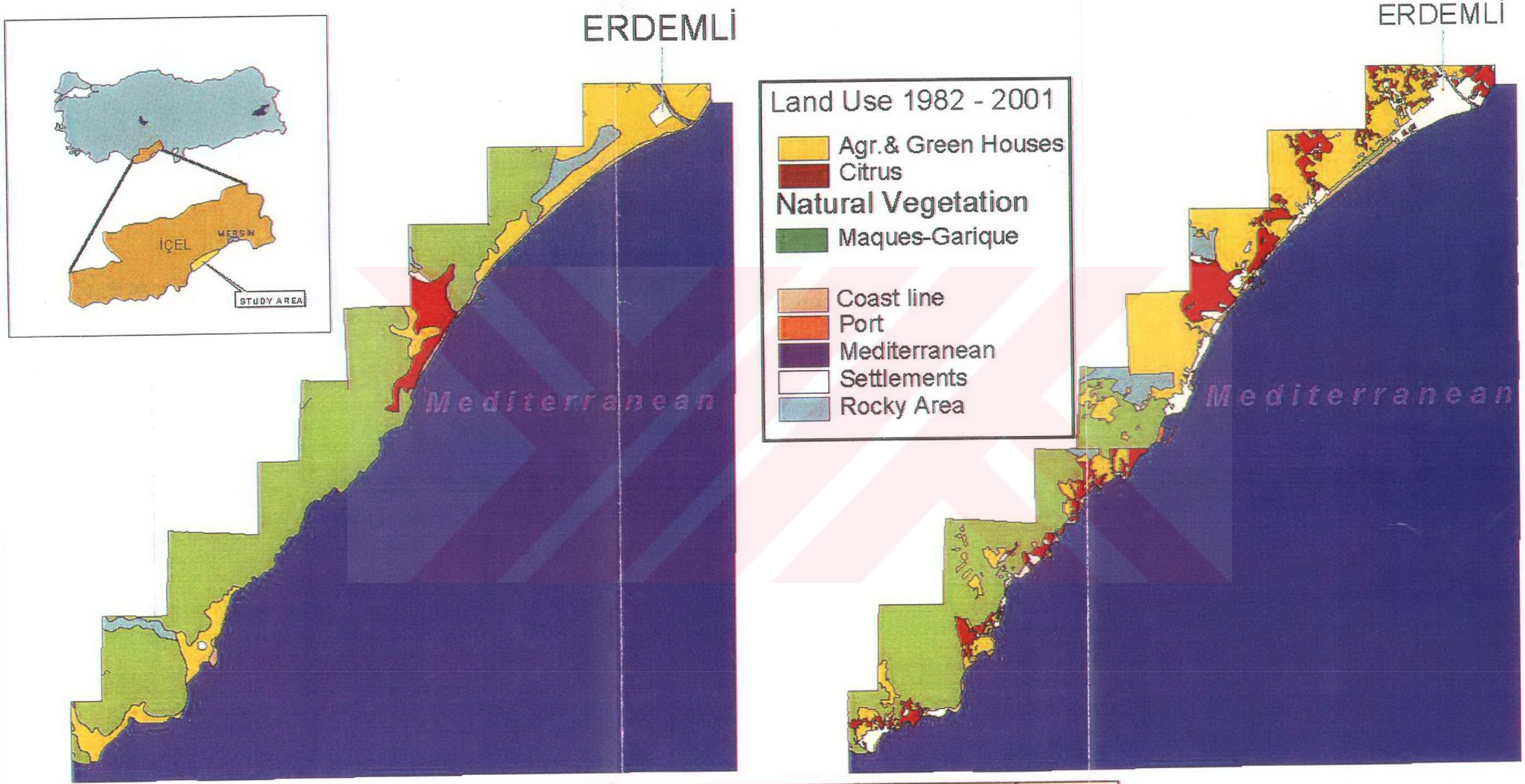
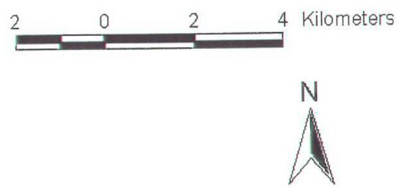


Figure 5.2 : Ikonos Satellite Image of the Greenhouse area in Erdemli

LAND USE 1982 - 2001



Land Use Type	Area in 1982 (square mete	Area in 2001 (square mete	Area 1982 (%)	Area 2001 (%)
Mediterranean	162000143	161790048	79,4	79,3
Port	13219	94552	0,007	0,04
Citrus	2015888	3790024	0,98	2,86
Agriculture	8448139	14178000	4,14	6,95
Maqiue and Garique	28510537	15114507	13,9	7,41
Settlements	329975	4142212	0,16	2,03
Rocky Area	1622186	1703015	0,79	0,83
Coast Line	900623	1046800	0,44	0,51
Total	203842710	203859564	99,81	99,91



ORAL, H.V & GÖRÜM, T. 2002 Figure 5.3. Land Use Between 1982 - 2001 by the people of Adana and Mersin. Unlike the coastline between Antalya and Side, this coastline has not been an international touristic zone and no large touristic complexes were constructed.

Expansion of settlements and population increase in the study area also lead to another problem known as breaking the carrying capacity. Carrying capacity can be defined as the maximum population of a given species that can be supported indefinitely in a defined habitat without permanently impairing the productivity of that habitat. Breaking occurs where the population uncontrollably increases and natural sources are rapidly depleted. There are indicators that the carrying capacity of this region is in the verge of being exceeded.

Uncontrollable population increase push forward the inhabitants to find alternative places for carrying out agricultural activities such as planting citrus orchards. Due to this reason, the natural vegetation (the maqiue and garique area) area was removed. However, removing natural vegetation often leads to soil erosion. The flood disaster of Fall 2001 may partly attributed to the removal of maqiue and garique vegetation which is known to hold soil much better than any type of vegetation. Uncontrolled run off caused by removing natural vegetation in the catchment area of the water sources, overgrazing of upland watersheds and the increased silting of river channels may have caused the disastrous flooding in the province of İçel in November – December 2001.

The outcome of the remote sensing analysis used in this study is two folds. First the classification results of remote sensing data obtained in this project have shown that the IKONOS satellite images and digitized land use maps of the region can be effectively used for measuring the land use change. Secondly, it is seen that remote sensing analysis and GIS methodology can be a tool for the continuous monitoring of land use changes.

6. CONCLUSIONS

The purpose of this study was to determine the land use changes between 1982 and 2001 at Erdemli – Kizkalesi region by using GIS technology. Therefore, Arc View 3.1 made the visual interpretation.

The results are summarized below

1. The area of Mediterranean within the study area decreased 0.1 % from 1982 to 2001.
2. A 1.86 % increase is detected in the citrus areas.
3. The area difference at the agricultural land use is 2.81 %.
4. As for settlements, 1.87 % increase is observed.

The main reasons of the area differences may be

1. Reclamation facilities at the coastal zone.
2. Destroying the maqiue and garique area.
3. Population increase.
4. Expansion of permanent and secondary houses.

On the other hand, there are some secondary effects within the study area that may be linked with main findings. These are ;

1. Breaking the carrying capacity.
2. Soil erosion.
3. Flood Disaster.
4. Increased silting of water sources (Alata and Lamos Rivers).

The visual interpretation was made by ARC View which shows that the increase in the agricultural and citrus lands may in high at the following years. It is predicted that the removal rate of the natural vegetation will be also high.

The classification results of remote sensing data obtained in this project have shown that the IKONOS SATELLITE IMAGES and digitised land use maps of the region can be effectively used for measuring the land use change.

7. RECOMMENDATIONS

The GIS technology and Remote Sensing System were used together to detect the land use changes in the study area between 1982 - 2001. It is highly recommended that this kind of studies should be promoted and supported by local authorities and administrative units to see the land use changes periodically at the study area.

In this study, time period of twenty years was investigated by data pertaining to 1982 and 2001. Yearly data and GIS analysis would reflect the changes more accurately over large periods.

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