DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

INVESTIGATION OF KÜÇÜK MENDERES DELTA'S SHORELINE CHANGES

by

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September, 2016
İZMİR

INVESTIGATION OF KÜÇÜK MENDERES DELTA'S SHORELINE CHANGES

A Thesis Submitted to the
Graduate School of Natural and Applied Sciences of Dokuz Eylül University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Geographical Information Systems Program

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M.Sc THESIS EXAMINATION RESULT FORM

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ACKNOWLEDGEMENTS

I would like to thank my supervisor Assist. Prof. Dr. A. Hüsnü ERONAT for his invaluable support and guidance.

Additionally I acknowledge M.sc. Agricultural Engineer Ahmet TOMAR and Dr. Onur GÜLBAY for continuous support and valuable adviced.

I am also grateful to my dear friend, Research Assistant Şevki DANACIOĞLU, for the help and motivation he provided.

I am also thank my friends Ayşegül BAYRAK, Çağdaş KÖKNAR for their genuine help and patience during my study.

Finally, special thanks to my whole family, especially to my brother Uygar UÇAR, for their, patience, help and support throughout this study.

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INVESTIGATION OF KÜÇÜK MENDERES DELTA’S SHORELINE CHANGES

ABSTRACT

Küçük Menderes Delta’s and its surroundings were separated from other delta areas because of the construction of the world famous city, Ephesus, which has historical, cultural and religious values. This area was selected as the subject in order to update previous studies and reveal the recent changes to the coastline of the delta.

In this study, the changes that occurred are presented to illustrate the interactions between natural and man made features that helped the Küçük Menderes Delta coastline develop its present characteristics. In this study, with the purpose of detecting shoreline the shoreline change of the Küçük Menderes Delta, multispectral Landsat images from the years of 1975, 1987, 1999, 2003, 2010, 2016 based on Landsat images, shoreline belonging to these years is drawn numerically and shoreline change belonging to these years in Küçük Menderes delta is provided with the help of Geographic Information Systems and Remote Sensing method and software. Observations made during the field survey showed factors creating the changes in area that were then examined and the extent of the changes were revealed. When these changes are analyzed, it is determined that there is a progress in the Küçük Menderes Delta.

Keywords: Remote sensing, coastal areas, land use, change detection, time series analysis, Landsat image, Küçük Menderes Deltas

KÜÇÜK MENDERES DELTASINDA MEYDANA GELEN KIYI DEĞİŞİMİNİN BELİRLENMESİ

ÖZ

Küçük Menderes Deltası ve yakın çevresi, Dünyaca bilinen Efes kentini barındırıyor olması, tarihi, kültürel ve dini değerlere sahip olması ile diğer birçok delta alanından ayrılmaktadır. Bilinen çalışmalara güncellik getirmek ve son değişimleri gözler önüne sermek amacıyla saha bu çalışmaya konu edinilmiştir.

Çalışmada Küçük Menderes Deltası kıyılarının günümüz jeomorfolojik görünümünü kazanmasına yardımcı olan ve değişimi tetikleyen doğal ve beşeri özellikler arasındaki etkileşimin, kıyı değişimini ne yönde değiştirdiği ortaya konulmaya çalışılmıştır. Küçük Menderes Deltası'nda kıyı çizgisi değişimini belirlemek amacıyla 1975, 1987, 1999, 2003, 2010, 2016 yıllarına ait çok bantlı Landsat uydu görüntüleri kullanılmıştır. Uydu görüntüleri temel alınarak Coğrafi Bilgi Sistemleri ve Uzaktan Algılama yöntemleri ve yazılımlarıyla kıyı çizgisi sayısal olarak çizilmiş, Küçük Menderes Deltasında bu yıllara ait kıyı çizgisi değişimleri tespit edilmiştir. Arazi çalışmaları ile sahada gözlemler yapılarak, değişimi gerçekleştiren faktörler incelenebilmiş ve değişimin boyutlarına ulaşılmıştır. Bu değişimler incelendiğinde Küçük Menderes Deltasında ilerleme olduğu ortaya çıkarılmıştır.

Anahtar Kelimeler: Uzaktan algılama, kıyı alanları, kara kullanımı, değişim tespiti, zaman serileri analizi, Landsat görüntüleri, Küçük Menderes Deltası

CONTENTS

LIST OF FIGURE

Pages

LIST OF TABLES

CHAPTER ONE
INTRODUCTION

Coastal shorelines are places with rich natural resources where air, land and sea come together, thus coastal shorelines are places where people preferred to colonize. Unlike other coastal areas, delta coastlines are important geographical areas because of their fluvial deposition and very rich coastal ecosystems in point of land, air, freshwater and saltwater coming together.

Coastal areas have witnessed many different uses from the first settlements to present, thus the present geomorphological appearance has evolved with the aid of natural causes combined with human factors. Initially, natural processes were key factors since they determined the geomorphological appearance and uncover change fields of the Landsat Images. However, gradually, increasing population and human- centered pressures brought by increasing population, changed the intensity and mechanism direction of natural processes. Anthropogenic impacts have become the main active shaper of the coast and its surroundings subsequently, reducing the activities of natural processes to a minimum in some areas.

Deltas are very rich habitats in that (land and sea were left out) fresh water and salt water ecosystems meet. For this reason, they were subjected to intensive use during geomorphological evolution. Natural processes and human impact have triggered the changes in deltas. Sustainable development is required for existing ecosystems to be maintained and transferred to future generations.

Sustainable development can be defined as development which provides for the needs of the current generation without endangering the needs of the future generations. Today, development is a current topic. There is a need for planning in all areas from micro to macro level. Sustainability is also an important issue in the wetlands of the coastal systems.

In the formation and evolution of landforms in the coastal areas, fundamentally, roles of abrasion, transportation and deposition operations of waves are seen (Hoşgören, 2003). However, because the priority in delta areas is shaped by rivers, major effects are both waves and river effect.

Wave abrasion occurs when a body hit the shore bringing elements like sand, gravel, and blocks to the shore. This is called hydraulic effect. Streams, winds, sea ice, terrestrial factors and human beings are examples of other factors that affect the formation and evolution of landforms in coastal areas (Hoşgören, 2003).

Wetlands are areas defined as natural or artificial, continuous or temporary and having stagnant or flowing, fresh, brackish or salt water, all water, marshes, peat bogs or marshes that do not exceed 6m in the withdrawal of water when the ebb and flow of sea occurs (Üçüncüoğlu et al., 2002). The word "wetland" in English became widespread in the mid 20th century and has been translated into two different words in Turkish. Despite the term "islak alan" being used by early publication, the term "sulak alan" has become more widespread and has been a generally accepted term for subsequent studies (Tırıl, 2006).

Coastal erosion, caused by natural or human-induced factors, is considered as the permanent loss of land occurring along the coastal line. While wind and storms, longshore currents, sea level elevation and the slope of the land are among the most important natural factors that cause coastal erosion, coastal engineering structures, dam and reservoir construction, dredging, mineral extraction and water supply factors can mainly be listed as the human-induced factors causing the coastal erosion (Coastal Engineering Manual, 2002; Kuleli, 2010).

Naturally, there have been some changes in the coast other than anthropogenic influences (Gibeaut, 2001). Changes occurring in the coastal line are divided into 3 parts as long term variations, short term variations and episodic variations. In this context, long-term changes are changes that occur in the 10 to 100-year time frame; short term changes are changes that occur in 5 to 10 years and episodic changes are defined as sudden changes that occur as a result of natural phenomena like storms (Tağıl and Cürebal, 2005).

Coasts are natural resources that cannot be recovered. Negative ecological effects have been realized as a result of irresponsible and exponential usage throughout the world and in Turkey, works have begun in order to take measures for conservation at present (Varol, 1998). The truth is that; neither before nor after the Republican Period, was a clear policy concerning coastal structures established. For a better understanding of these issues and for a better decision about what to do in the future looking back to the past is needed to know current practices.

Today, expansion of the area of increased human activity and search for a solution to the environmental problems has brought about an increase in the need for information systems. The most important factor in the management of coastal areas is the creation and development of an information system intended for management and presentation of collected data. Data in the information systems should be developed with features of geographical location and thematically, information should be stored in the way for rapid communication, the results obtained should be shown and presented in different ways, such as results, reports, maps (Üçüncüoğlu et al., 2002). Geography and geographical information systems, succeed to encircle the power of computational age for the development, information, data analysis that is needed in modern technology and presentation of these with an incredible diversity (Convis, 2001).

Identification of geographical features is a key to obtain an interpretation and knowledge. These elements are actually a part of everyday life whether realized or not (Yomralıoğlu, 2005).

Thanks to thriving information technology today, elements like shoreline change and land use can be evaluated using geographic information system and remote sensing methods by handling long term data. Since, these methods use the exact same satellite picture of the land, air photograph of the land or maps of the land, it increases the reliability of the study.

Küçük Menderes Delta, with its wetland, is one of the most important ecosystems of the Aegean Sea, consequently, Turkey. The delta formed as a result of fill with flood delta sediments of Küçük Menderes River in the distinct cups collapse over the west side of Menderes massive. Due to the presence of the ancient city of Ephesus in the south of delta plain, interests of geomorphologists, archaeologists and historians are especially interested in the region (Sütgibi, 2009).

The method of study consists of 4 steps.

1- Image improve,

2- Classification with the method of unsupervised classification (CORINE legend land cover) and change detection,

3- Creating coastline maps,

4- Constructing thematical maps in the medium of Geography Information System. This study and analysis that will be done in this study will contribute to studies conducted in this area in the future.

1.1 Purpose and Scope

Wetlands are generally located between deep water ecosystems and upper continental regions and affected by both ecosystems. This feature of being in the transition area is not because wetlands are unique ecosystems, but they are the extension of continental or water ecosystems.

At the same time, many wetland scientists agree on the originality of the wetlands. Some of the living species, plants, animals and microorganisms in a wetland can live in both wet and dry environment and limits the presences of these species an indicator for a wetland. Wetlands show differences in scale to hundreds of square kilometers to extending a few acres as a small pond. Wetlands are distributed from continental areas and rural areas to urban areas. While ecosystems such as forest ecosystem show similar features in the structure and function wetland types show very different features from each other.

Human intervention in wetland changes from area to area and from wetland to wetland. Many wetlands have been converted by humans. Identification of wetlands that may be easily affected and may be damaged by anthropogenic effects is hard.

Küçük Menderes Delta, which is favorite of the world due to historical values it has and which hosted many civilizations, should be actualized for the protection of the natural and cultural interaction without regarding the advantages in which unity of delta has provided and will provide. Only in this way, negative effects of the ecological balance can be reduced.

The ancient city of Ephesus which is in the list of Unesco protection list is located inside the Küçük Menderes Delta that has swamps and lakes that contain the wetland protection zone. This area is the subject because such an important city existed in history that was affected by coastal change and is still being affected by this change.

This region where an ancient port was constructed at the mouth of the channel has an important potential of tourism. Another factor that increases the tourism potential is the wins of Artemis Temple and House of the Virgin Mary in Selçuk. Examining the coastal development of last the 42 years in this city, which was a coastal city thousands of years ago today provided to interpret the different situations including the tourism phenomenon.

In this study, remote sensing and Geographic Information Systems, programs and softwares were used. The use of Remote Sensing and Geographic Information Systems, which have become an important tool in managing and planning of coastal and sea areas in recent years, especially for delta areas, has resulted in faster and more accurate classification of various ecosystems easily from land, air, fresh and salt water interactions.

Recently, Remote Sensing and Geographic Information Systems are commonly used for the purpose of coastline and coast area management or monitoring coastal changes (Olgun, 2012).

An efficient policy should be developed for the Küçük Menderes River Delta wetlands in Selçuk in order to prevent the repetition of wetland loss and protect the existing areas. This study will be helpful in determining how the coastal changes may occur in the future in the same coastal area. The aim of this study was to form a basis for future research concerning coastal changes in the study area.

Spatial coverage of images used in the examination of study area contains Küçük Menderes Delta and its surroundings. Moreover, the part where the main river shapes as determining the coastline was considered. The areas with hillside masses outside the alluvial lands were not included to study field. Why inner delta behind coast was included to study is to handle the factors causing delta coast change. Ephesus ancient city was included in the study boundaries. The reason is the old port of Ephesus has been the most affected region in history in coastal change.

The scope of the study related to data consists of Landsat images. The reasons of Landsat images to be preferred is because they are the easiest images to obtain. Even though they do not offer high resolution, this study based on Landsat images may be used to compare the results with other studies. All bands were used in Landsat images in Corine classification and infrared bands were used in coast drawing. Seasonally close images and having no cloud images were considered to be chosen in order to decrease the atmospheric effects. Landsat images were obtained from USGS data. Thus, images obtained were used in basic image enhancement applications after making required arrangements.

Temporal scope of the study has been the periodic images preferred between 1975 and 2016. The 12 years between 1975 and 1987, 12 years period between 1987 and 1999, 11 years of period between 1999 and 2010, optimal image, 2003 image among the images before 2010 (in order to draw coastline) and images of 6 year period from 2010 to 2016 were used for coastline change and Corine classification.

1.2 Previous Studies

Examining the change in coastal areas has been the subject of many academic studies due to the improvement over the last 40 years of earth imaging systems and to the computer technologies in which pictures are taken and processed by these systems.

Basin of Küçük Menderes River and its surroundings has been studied by many researchers in varied disciplines. Hydrogeological studies were carried out by Government Water Works (DSİ) in 1957 of the Kiraz-Tire-Ödemiş-Bayındır-Torbalı- Selçuk plains and in 1959 Cumaovası and Pancar plains. The first detailed hydrogeological Basin Studies report was completed by DSİ general directorate in 1973 (Devlet Su İşleri, 1973).

Gözenç (1978), studied the Küçük Menderes River with a comprehensive data which is one of the oldest studies about this area.

Kayan (1996), mentioned about coastline changes for the study. They did soundings for the study. It has been the basis for the most of the studies.

Gökçen et al., (1990) studied the Küçük Menderes River Delta complex and the effects of active tectonism on its development, they emphasized that deltas that have different layers and the situation is extreme for deltas. The study also showed the last geological events for the delta occurrence.

Sıkı (1992), studied birds with the periodical observation of changes in the reeds which provide food, shelter and incubation to birds. Besides, the observations the birds were tagged for the migratory species. In Gebekirse Lake, 86 different bird species were found. This was the first scientific study to be conducted on birds in the area and it suggests that the area where the reeds have been destroyed need to be replenished to support the local ecosystem. It suggests recovery for both fields in which reeds have been destroyed.

Güney and Hepcan (1999), studied the necessity for protection of some sections of Pamucak sand dunes and necessity of a new planning and repair work were mentioned. A necessity of structuring after "To stop the tourism-aimed configuration" taking into account the payload field, a necessity of structuring was mentioned after the separation of areas where facility customers and day-visitors can benefit. It was expressed that the situation is more urgent in the Sazoba-Beyoba internal dune than Pamucak.

In 2000, a study by the Middle Eastern Technical Universty (METU) geological engineering department on update-and management of groundwater of the Küçük Menderes River basin within revised hydrogeological studies was conducted (Su Yönetimi, 2016).

In 2002, Land Use and Environmental Resource Analysis of Tahtali Dam Environment and Küçük Menderes Basin Side was done by The Scientific and Technological Research Council of Turkey (TÜBİTAK) Land, Marine and atmospheric Science Research Group (Su Yönetimi, 2016).

Güler (2002), also examined this area for a Ph.D. thesis. Geographic Information Systems used as a mean in this study and WIMS (A Wetlands Information Management System for Facilitating Wetlands Evaluations) method was used. This method consists of 4 wetland evaluations. As a result of this study, an evaluation was made in terms of opportunities catchment area that gives to Selçuk Pamucak wetland to fulfills its functions. It was divided into regions according to activities to actualize its wetland functions. In terms of conservation priorities Gebekirse, Akgöl and Eleman Swamps were determined as absolute priority protection zone, with the second priority zone being the region where the flora is in the bush form located in the reeds and saline soils, and the third zone was determined as ecologically affected zone where implementation of agricultural activities occur.

Bolca et al., (2005) conducted remote sensing studies on Küçük Menderes Delta using aerial photos of 1965, 1972, 1993 and 2001 and Landsat satellite pictures. They determined that the areas of the lake had become smaller between these years and they showed with analysis that rate of change of the shoreline slowed down.

Aleshekh et al., (2007) prepared a study on the subject of examining coastal change using remote sensing. Changes between August 1989 - August 2001 in Urmia Lake (Iranian) identified as one of the major live reserve areas by UNESCO was examined with sensors of Landsat TM-ETM. As a result, minor changes from 1989 to 1998 and greater changes after 1998 were observed.

In the Europen accession process, The European Union Water Framework Directive (MATRA) is related to water management. The MATRA project Strengthening the Capacity of Sustainable Groundwater Management on Kücük Menderes Basis Groundwater was conducted with regard to the study done by METU in 2008. In the study, which DSİ conducted in partnership with the Netherland Goverment, in accordance with EU instructions for the groundwater, the Küçük Menderes Basin was studied as a pilot project in order to determine the pollution, protection and monitoring of groundwater (Su Yönetimi, 2016).

Bengil et al., (2010) the importance of wetland areas on breeding grounds for birds and protection of birds was discussed. According to the the study, during the study period, breeding evidence for a total of 54 bird species was gathered at the Küçük Menderes Delta. They supposed that due to extensive human activities and illegal bird hunting these species are currently unable to nest in the area. According to their research, irregularly fluctuating water levels and extensive human disturbances through agricultural activities, tourism and hunting are the main reasons for the low number of breeding waterbirds in the delta.

Dronova et al., (2011) made classification using reference objects. The short period between 2007 and 2008. They revealed the changes in wetlands (Poyang Lake, China) with the help of object-oriented analysis.

Delile et al., (2015) showed that in order to understand the hydraulic dynamics of Demise Harbor, they first needed to estimate its water capacity. They assume that most of the sedimentary layers were deposited during short seasonal flood events of the Cayster River, whereas water running into the harbor came from different potential sources: seawater, runoff, karstic springs, and aqueducts.

Stock et al., (2013) since the eighth century BC, especially since the Hellenistic period, a high sedimentation rate indicates fast alluviation and delta progradation of the Küçük Menderes. Deforestation, agriculture and grazing were the main reasons for the erosion of the river catchment area. One consequence was a significant siltation of the Hellenistic/Roman harbor basin. From the middle to the end of the first millennium AD, the influence of Ephesus declined, which resulted in a decrease of human impact.

1.3 Limitations

Even though Geographic Information Systems were developed in the 1960’s the advancements in computer technology made this a very important tool for many scientific disciplines. However, data collection operation in Geographic Information Systems is still very expensive and time-consuming. The need of obtaining satellite pictures about study area belonging to previous years, topographic maps or aerial photographs made data collection hard because the Geographic Information System is a new application for our country.

The selection of images frequency and depending on the area to be researched. Since the subject of this study is coastal change, a period of 6-12 years seemed appropriate. The coastal change develops over a long time period, except for extreme natural events (like tsunamis). The results obtained will represent little time geomorphologically in the last century, even though the only images available are aerial photographs and satellite images.

Another restriction results from Corine classification is being used in the classifying land. There are some situations in which Corine classification is inefficient. Errors may occur for areas less than 25 hectares. Generally, classification is done by Landsat images since they are more available. However, this area was studied considering the general class of Corine 5 since there may be problems to reflect sub-classes of Corine on Landsat images due to the size of the study area. For a more detailed classification, QuickBird and Ikonos are advisable. Resolution of these images is higher.

CHAPTER TWO
USE COASTLINE AND COASTAL AREAS

The area between the shoreline and shoreline side is known as the coast. The definition of shore in geomorphology is the line between the basis of cliffs and the boundary when the the lake or sea water are at the lowest point. This is also called coastline. The coastline is the boundary where land and sea is separated except for flood situation or at any time that varies according to meteorological situations. The shoreline is not stationary and divided into two along the coastline. One is the zone between the usual shoreline and the line where sea moves most ashore which is called high tide and the zone is called foreshore where usual shoreline and the lowest line where sea withdraws is low tide. Coastline is, according to Turkish coastal laws, the natural border in which water move along the coastline forming dunes, sand, rock, stone, reeds, wetland and similar areas. This boundary cannot be changed by landfill. According to Turkish Coastline Law, coast edge line is the natural border determined by the inward motion of water from the coastline, including the land with sand, pebbles, boulders, rocks, reedy and marshland. The present shoreline is a border drawn between the land and sea was much closer in geological past. It is possible there may be old coast forms farther inland than the present day coastline, it is also possible old land shapes may be found up to a certain depth in the fields covered by sea (Erinç, 2001).

According to Hoşgören (2003), the coast is between cliffs and is a place where the water decreases and the line between cliffs. This is divided into two areas as the front coast, which is the part between the coastline where the low tidal fluctuations are observed and the back coast where the high tidal fluctuations are observed. The back coastline may also be the area between the shoreline and cliffs. The coastal zone is the area where the width changes from place to place and extend from the facade of cliffs or from the high shoreline into the land (Hoşgören, 2003) (Figure 2.1 and 2.2).

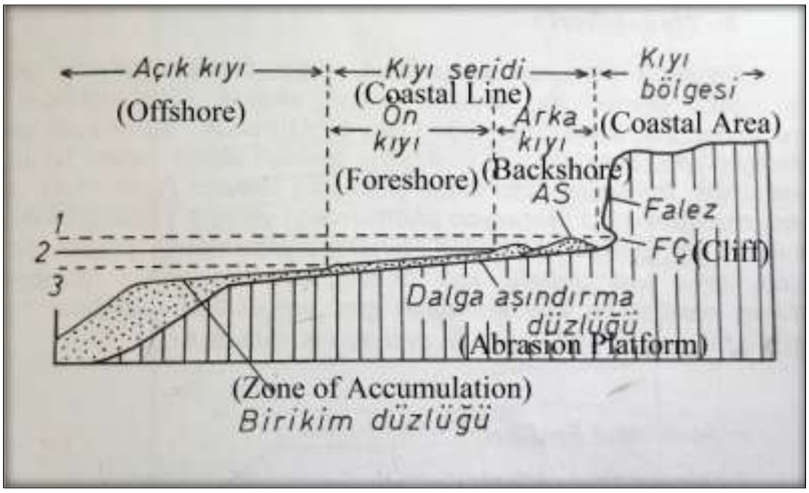

Figure 2.1 Coastal Areas (According to D. W. Johnson, modified by S. Erinç, 1971, (Hoşgören, 2003).

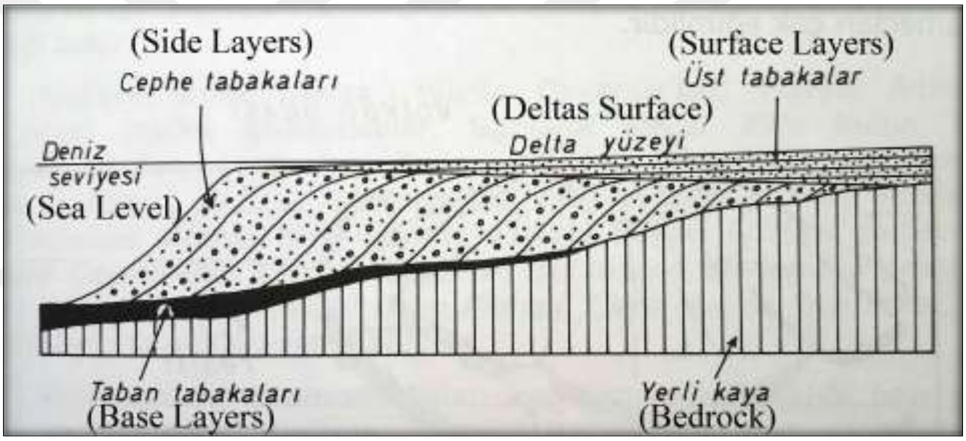

Figure 2.2 Layers that constituent a delta (Hoşgören, 2003).

It is possible to use a wide variety of geomorphological definitions for the specific areas such as beach, front coast set, back coast part, spit, coastal promenade and delta plain. According to Hoşgören (2003), it is deposition patterns consisting of sand or gravel lies along the shoreline. Alluvions constitute the main source of elements like sand, gravel which are found on beaches. Front coast set, is formed by waves hitting the deeping shallow coastline and deposition of eroded materials, While the accumulation of materials under the sea level that create a submarine set or cord, it this accumulation of coast set which intensifies on the surface of the water as a result of repetition of the event. The new shape, called coast cord is the accumulation called spit which intensifies on the surface of the water develop and closes the front of a bay. There is generally a crevice over the coast cords and this crevice provides a link between the sea and the lagoon that formed between sea and coast cord.

According to Hoşgören (2003), it is the shape formed by the deposition of alluvions on river mouth. Waves and coastal streams have roles in the development of a delta.

The coast must have some main features for a delta to develop at the river mouth. First, a shallow coast is a more appropriate environment for the occurrence of a delta. Alluvium that reaches the water surface in shallow coasts occurs quicker. The transportation of a quantity of sediment through a river and the river not being ocean-related coast are two factors that accelerate the occurrence of deltas. Since the ebb and flow of tides triggers water movement in the ocean side, it prevents regular deposition. With the start of deposition, sediments that are dragged under the sea is a drift to the sides and sediments form lake areas and marshland in the situation of appearance on the water. If the water in a lagoon decreases, it turns into land and delta formation may occur.

According to Hoşgören (2003), deltas were from three layers of different groups:

1-The base layers

2- Front layers,

3-Topsheets (Figure 2.1).

The base layer that forms the bottom part of the delta is silt (between 0.002-0.02 mm's) and clay (smaller than 0.002 mm). These very small elements are deposited after being suspended in water at the coastline. Delta coasts are not fundamental coast types, they are second type formed on a coast.

Deltas are built where sediments collected by rivers have filled in the mounths of valleys drowned by Holocene marine submergence to form a depositional feature protruding from the general outline of the coast (Bird, 1984). A delta will only be built if the sediment accumulating at the river mouth exceeds that carried away by waves and currents. Delta progradation above high tide level depends on swash deposition along the delta margins and vertical accretion alongside river channels of sediment delivered by flood waters. Most deltas also incorporate sediment of marine origin, brought alongshore or from the sea floor. Small rivers may build deltas on the sheltered shores of lake or tideless seas, but on coasts dominated by strong wave action and tidal scour, protruding deltas are built only by large rivers draining catchments that yield an abundance of sediment. The classic example of a delta to which Herodotus (440 BC) referred is that of the Nile, built into the Mediterranean Sea on a coast where the tide range is less than 1 m. Beaches, spits, and barriers built by marine processes on the shores of a delta often enclose lagoons, swamps, and are sometimes themselves incorporated as the delta grows larger. Deltas built up on sea coasts during and since the Holocene marine submergence are more complicated than this and may not include foreset beds. Their sedimentary structures, inferred from borings, Show intercalations of marine sediment deposited during episodes of marine transgression (Bird, Coastal dunes are formed where sand deposited on the shore dries out and blows to the back of the beach. On some coasts, wind-blown sand has been accumulating during and since Pleistocene times, producing extensive and complicated sequences of dune topography. Coastal dunes are best developed on the coast in the temperate and arid tropical zones: in the humid tropics, they are of limited and local extent, sandy coastal topography consisting of low beach ridges with little transgressive dune development. Beaches are accumulations of sediment deposited by waves and currents in the shore zone. Beach sediments composed of larger particles tend to develop steeper gradients, chiefly because of their greater permeability. Wave swash sweeps sediment forward onto a beach, and backwash tends to carry it back, but the greater permeability of gravel and coarse sand beaches diminishes the effects of backwash, leaving swash-piled sediment at relatively steep gradients. The nature of beach sediment is clearly related to the nature of material supplied by rivers from the adjacent cliffs and foreshore, or brought in from offshore or alongshore sources (Bird,1984).

At various places on the coast, there are stranded beach deposits marine shell beds, and platforms backed by steep cliff-like slopes, all marking former coastlines that now stand above high tide level and beyond the reach of the sea (Bird,1984).

The type of coast having a young geomorphological period of the study area is the cross-shore type. However, east-west trending mountains form a special kind of shore. Since there is a river here another special coastal shape known as a delta has formed. Wetlands define the areas which are formed inside the coastline and delta. Since wetlands have very different ecosystems and all ecosystems, there is no specific definition.

Mitsch and Gosselink (2000), explained the difficulties in defining the elements of wetlands as follows:

Deepness and continuity of water in wetlands change from wetland to wetland and from year to year even though water is continuously found. While some wetlands are continuously under water the water level fluctuates from close to the surface or just covering the bottom. Even in the same type of wetland, water level changes from season to season and from year to year. This is why the border of a wetland cannot always be drawn according to the presence of water.

To reverse the negative effects of environmental changes, the changes must be classified. Dugan and Jones (1993), developed a classification for changes in the water regime as physical and biological changes (Gencer, 2002).

The study area is located in the Mediterranean wetland areas. There are 24 reasons for the loss of Mediterranean wetland areas (Gencer, 2002).

The definition of wetland adopted in Turkey is the definition included in the Ramsar Convention. The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (The Report of Evaluation of Ramsar Areas in Turkey, 2008).

The International Conventions related to wetlands where Turkey is a party. Convention on Wetlands of International Importance Especially as Waterfowl Habitat (RAMSAR)

- Biological diversity convention
- International convention for the protection of birds
- Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES)
- European Landscape Convention
- Convention on conservation of European wildlife and natural habitats (Bern)
- Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention)
- Instruction of the protection of wild birds (2009/409/EEC) (Instruction of bird, 1979)
- Instruction of securing the continuity of natural and semi-natural habitats and species of flora and fauna (92/43/EEC) (Instruction of habitat, 1992)
- Combat desertification convention

(Türkiye Sulak Alanları, 2016).

CHAPTER THREE
GEOGRAPHIC INFORMATION SYSTEM, REMOTE SENSING, LANDSAT IMAGES AND USAGE OF THESE FOR COASTAL AREA

3.1 Definition and History of Geographic Information System, Remote Sensing and Landsat Images

The history of Geographical Information Systems can be traced back to the 1960's when computer-based GIS use began and manual procedures date back about 100 years earlier. The initial developments originated in North America with organizations such as the US Bureau of the Census, The US Geological Survey (USGS) and The Harvard Laboratory for computer graphics and Environmental Systems Research Institute (commercial). Canadian Geographic Information Systems (CGIS) in Canada, the Natural Experimental Research Center (NREC), Department of Environment (DOE) and other notable organizations in the U.K. were involved in early developments. Laboratory for Computer Graphics and Spatial Analysis Harvard Graduate School of Design and the State University of New York at Buffalo (SUNY-Buffalo) have achieved worldwide recognition. Commercial agencies started to develop and offer GIS software in the early 1970's as a sound and stable data structure to store and analyze map data. Another significant breakthrough occurred with the introduction and spread of personal computers in 1980's. The 1990's can be characterized as a period of the breakthrough of object-orientation in system and database design, recognition of Geoinformatics as a professional activity, and spatial information theory as the theoretical basis for GIS. The potentiality of GIS has been realized in recent years and now it has become popular among many users for a variety of applications. The basic elements of GIS are hardware, software, data, and liveware. Conversion of real world geographical variation into discrete objects is done through data models. Data models are of two types: Raster and Vector. In a raster type of representation of the geographical data, a set of cells located by coordinate is used; each cell is independently addressed to the value of an attribute. The vector data model uses line segments or points represented by their explicit x, y coordinates to identify locations. Connecting set of line segments form area objects.

Geographic Information System (GIS) is used by multi-disciplines as tools for spatial data handling in a geographic environment. At present GIS is considered one of the most important tools for decision making in a problem-solving environment dealing with Geo-information (Raju, 2003).

The term “remote sensing” was first used in the United States in the 1950s by Ms. Evelyn Pruitt of the U.S. Office of Naval Research. Remote Sensing (RS) is now commonly used to describe the science and art of obtaining information about an object, area, or phenomenon under investigation by a device that records the spectral properties of surface materials on the earth from a distance (Singh 1989a, Rogan and Chen, 2004, Al-doski et al, 2013). Basically, there are two types of remote sensing instruments; passive and active. Passive instruments detect the natural energy that is reflected or emitted from the observed scene, whereas active instruments provide their own energy (electromagnetic radiation) to illuminate the object or scene they observe (Al-doski et al., 2013) (Figure 3.1).

Remote sensing from airborne and space home platforms provide a huge amount of valuable data about the surface, including aerial photographs, satellite images, spatial data user and other data (Paradzayi et al, 2008, Al-doski., 2013).

The increased availability of mid-to fine-resolution satellite images since the early 1990s offers repetitive data variance among themselves in terms of spatial, radiometric, spectral, temporal resolution and its synoptic view (Stoney, 2006, Al-doski et al, 2013), also the digital format makes them suitable for many computer image processing softwares (Al-doski et al., 2013).

The benefit of data collection from a far area has been known from ancient times. Remote sensing is the most efficient remote method for obtaining information. Remote sensing method provides data needed by the GIS. The development of remote sensing began with aerial photogrammetry. First photographs were successfully taken in 1860 by balloons. The first use of aerial photogrammetry for military purposes was the American Civil War. Wilbur Wright was the first person to take an aerial photograph from a plane (Yomralıoğlu, 2005).

The first satellite put into orbit for civilian purposes was ERTS-1 (the Earth Resources Technology Satellite) in 1972 by the USA. This series of satellites continued from Landsat-1 to Landsat 8 today. Landsat-1 was placed into orbit in 1972. Similarly, Landsat-2 was launched in 1975. Landsat 3,4 and 5 were placed into orbit in 1978, 1982 and 1984 respectively. Landsat-6 was damaged during launch. Landsat 7 satellite was launched in 1999 (Yomralıoğlu, 2005). Satellite of Landsat-8 placed into the orbit of Landsat-7 in 2013 and has been activated.

Aerial photographs are cornerstones of remote sensing. Today, Remote sensing data is provided by planes equipped with sensors, unmanned aerial vehicles and satellites. Cameras and sensors create images measuring the energy that is reflected and distributed in ultraviolet, visible and infrared regions called "spectrum image region" in the electromagnetic spectrum that is seen in the shape. The energy that moves toward a surface or an object from source (sun) is passed, absorbed, scattered and/or reflected. The relationship between object and energy forms the basis of remote sensing (Şekertekin, 2013).

In remote sensing images, elements or objects, according to the structure of the object are perceived differently. In other words, any object on the earth's surface has a different relationship with electromagnetic energy. It is called the signature of subjects or special behavior in remote sensing (Çölkesen, 2009).

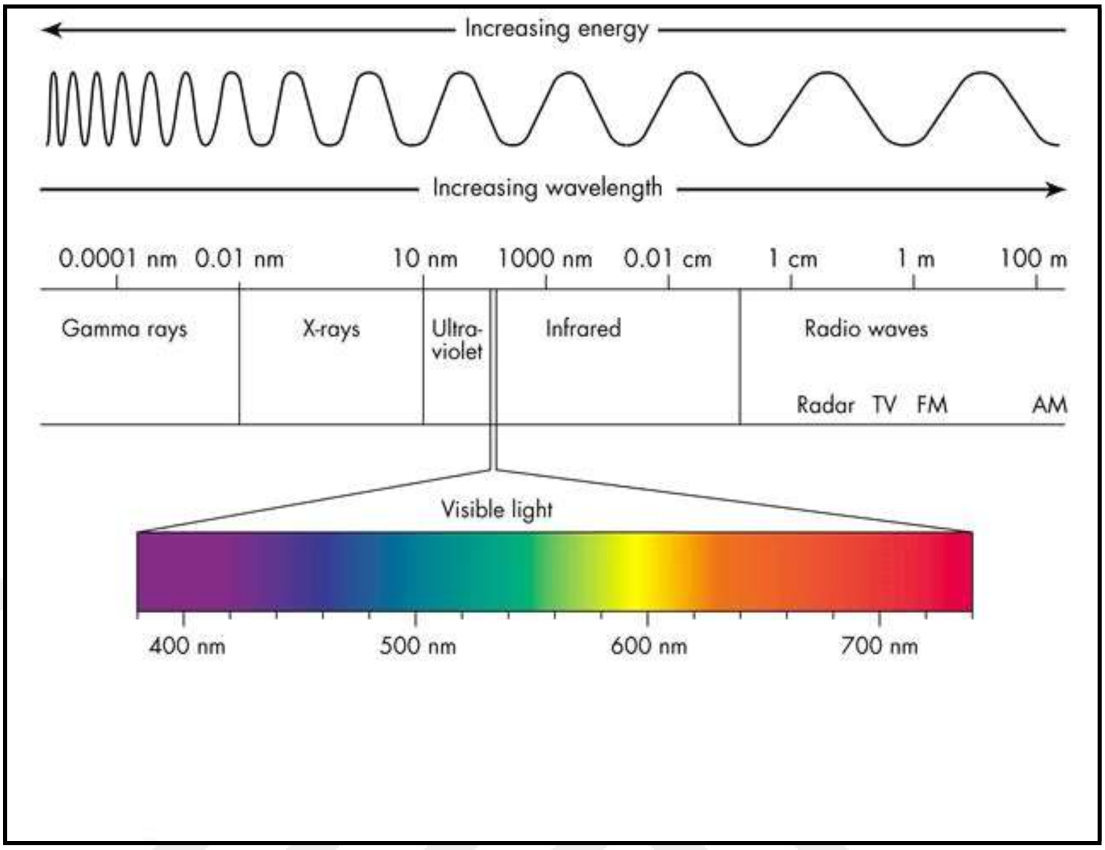

Figure 3.1 Electromagnetic spectrum (Radioact, 2016).

The main event that forms the basis of remote sensing is detection. Sensors are classified according to types. Satellites are divided into two as active detection and passive detection, according to energy resources they use in sensing methods. Passive detection captures the natural energy reflected or scattered from activity area or observed object. Reflected sunlight is the most familiar energy resource detected by passive sensors. Since passive sensors need a resource of energy, images are taken at night and in bad weather are not useful (Su Dünyası, 2012, Şekertekin, 2013). Radar can be counted as an active sensing example. Active sensors send microwave signals on the earth surface and detect surface features saving a backscatter signal. Active sensors produce their own energies. Thus, they are not affected by darkness or weather conditions (Campbell and Wynne, 2011).

Remote sensing operations contain 7 elements depending on the interaction between target and incident light give shape and expressions are listed in Figure 3.2.

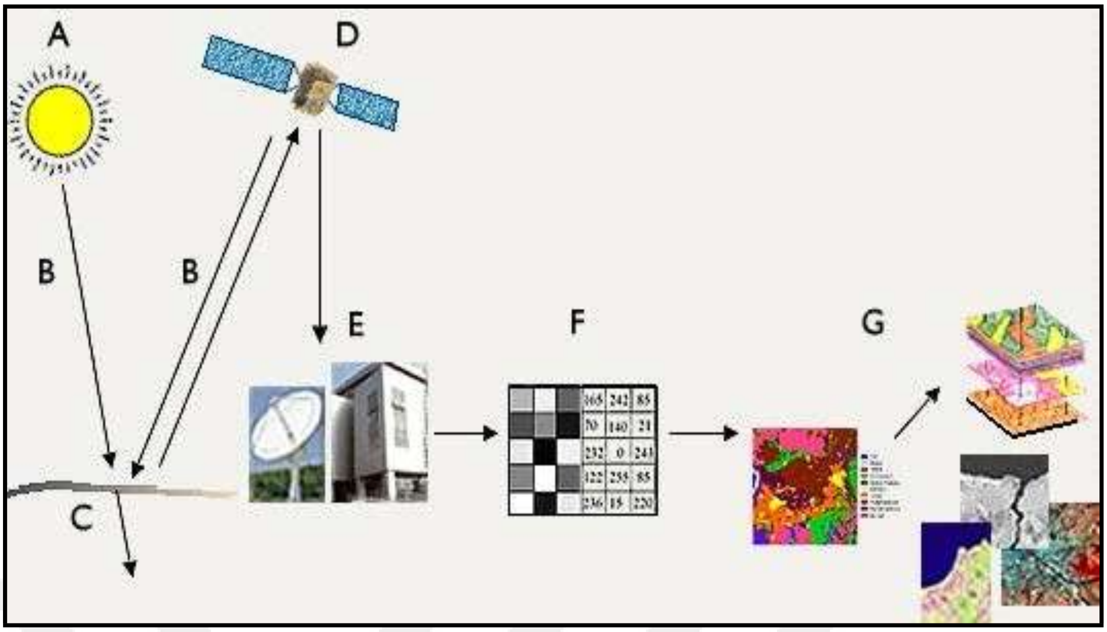

Figure 3.2 Operations for obtaining images at Remote Sensing (Erolkodak, 2016).

A. Energy Resources and lighting: The first requirement of remote sensing is electromagnetic energy that is suitable for the target's feature, or an energy source for lighting like the sun.

B. Extension and Atmosphere: Energy encounters to the prevention of atmosphere as it is extended from source to target. This prevention occurs the second time when it moves from target to the sensor.

C. Blocking of the earth's surface: Energy from the earth's surface is prevented, according to the scattering feature of the surface.

D. Energy Band of Sensor: Sensor collects electromagnetic energy and saves it after spreading the energy in the atmosphere and reflection of energy from the target.

E. Sending, taking, processing: Energy data which the sensor saves is mostly sent electronically to the station for processing the image.

F. Exploitation and Analysis: The data on the target is evaluated either visualles digitally or electronically.

G. Application: It includes the operations, the use of obtained data in various areas or using it to help develop a solution of special problems (Şekertekin, 2013).

Detailed characteristics of Landsat images are explained in the material section. Sensors designed for remote sensing methods are placed on stable platforms to record reflected energy. These platforms are generally satellites. Sensors have been designed for this specific purpose. Spectral bands are important in the design of optical sensors. Every application responds to its specific requirement in terms of spectral resolution, spatial resolution, radiometric resolution and temporal resolution. The spectral resolution specifies the specific wavelength and the number it can save in the electromagnetic spectrum of a sensor. Spatial resolution is defined as the measure of the area on the earth's surface that is represented by every pixel of an image or the measure of the smallest subject that can be distinguished by the sensor. Large and small-scale image terms generally represent spatial resolution. Radiometric resolution is the sensitivity of the detected image of the electromagnetic intensity. The higher radiometric resolution of a sensor, the more sense it has to detect minor differences in reflected and radiated energy Maximum value of brightness in an image depends on the number of "bit" which defines the lost energy. Thus, if a sensor saves data as 8 bits, it will have $2^8=256$ digital value. The temporal resolution identifies in which time-frequency a sensor obtains an image of an area (Olgun, 2012).

3.2 Remote Sensing and Use of Landsat Images in Land Cover and Coastal Change Detection

The latest remote sensing and spatial analysis technology available to researchers is a powerful instrument used to map and identify land use/land cover changes, especially in crop rotation agriculture (Macleod and Congalton 1998; Al-doski et al., 2013), in the deforestation assessment (Al-doski et al., 2013), in yield assessment, and yield estimation (Rao and Venkataratnam 2002; Al-doski et al., 2013); in coastral zone changes (Hongquan Xie, Yanyan Zhang and Xia Lu., 2011; Kesgin and Nurlu, 2009; Al-doski et al., 2013), in land degradation detection, vegetation mapping, in wetland landscape changes, in urban change detection and other applications. RS presents a useful tool for understanding and managing earth resources Land Use Land Cover (LULC) change detection (Al-doski et al., 2013).

The most important reason is the ability of objects on the earth's surface being distinguished by remote sensing method, as described in a previous title, is due to the different spectral features of these objects. For this reason, knowing the spectral features of vegetation, soil, water and other earth surface features, is important for a suitable analysis and interpretation of remote sensing data (Maktav and Sunar, 1991; Çölkesen, 2009). The features of vegetation, soil and water were discussed below:

Spectral reflection of green vegetation is different from others and changes according to wavelength. Chlorophyll which exists intensively in the structure of green vegetation is important, especially for visible wavelength (0.4–0.7 µm). Reflection in near infrared region increases significantly since a green leaf absorbs very little energy in this region. Water absorbs energy in the specific wavelengths in the middle infrared region and green leaves contain a lot of humidity. These bands of water-absorption are dominant in this region. Absorption of chlorophyll in vegetation occurs in blue and red bands. Reflection of chlorophyll is blue and red between 0.5–0.6 µm. However, the most reflected value is near infrared region. In visible wavelengths, most of the energy that comes into the green leaf is absorbed and just a few passes into a green leaf. This low absorption at green wavelengths enables us to see healthy green leaves. Carotene, xanthophylls and anthocyanin pigments are observed in the structure of vegetation. The amount of chlorophyll decreases as it gets older and carotene and xanthophylls in the structure of vegetation become dominant. This is the main reason why the leaves of trees are yellow in autumn. The reason why leaves of some trees are light red is again due to the reduction in the substance of chlorophyll and dominance of anthocyanin pigment being (Maktav and Sunar, 1991; Çölkesen, 2009).

Spectral features of soil materials are not as complicated as vegetation. Spectral features of soil depend basically on the chemical structure (mineral and organic substances), optical geometric scattering (particle size and roughness) and humidity of the surface. Air and water accumulate in the spaces between large particles and this decreases the reflection value. Small particles give a better reflection and less reflection if it is humid. As organic matter content increases, reflectance value decreases and soil appears darker. The amount of iron oxide reduces the reflectance. Thermal tape is very important in identifying the humidity of soil. In humid places, evaporation occurs and the area colder than the environment. A soil that is very dark at reflection region and very bright at the thermal region is poor in organic content (Maktav and Sunar, 1991; Çölkesen, 2009).

The spectral sensitivity of water changes according to its wavelength. The interactions between water and energy are the result of the current structure of water and are affected by various situations. The best method for the distinction of water from other types of cover is by using reflective infrared (near infrared, mid-infrared) wavelengths. Positioning water masses by remote sensing and classification most effective using near infrared wavelengths. On the other hand, some aspects of the status of the water are best detected by using the data obtained in the visible wavelengths. Even though the water may be very shallow in a natural environment, water masses absorb all the available energy, in near infrared and 11 mid-infrared wavelengths. There is very little energy for reflection in these wavelengths due to very effective energy absorption of water in near and infrared wavelengths. Water is advantageous in terms of remote sensing because it has a low reflection. Such significant differences in infrared reflections provide identification and mapping of water masses (Maktav and Sunar, 1991; Çölkesen, 2009).

As described above, considering the diversity on Earth, the spectral features of objects on the earth's surface are not the same everywhere. It can be said that spectral features belonging to an object vary according to geographic location and time. Thus, variability in time or the seasonal variation of biological diversity on the earth's surface should be considered in determining the most appropriate time in remote sensing (Kavzoğlu, 2008; Çölkesen, 2009).

After identification of these lands, the most common method is change detection method for detection of long or short term changes in images. Detecting and analyzing LULC over large geographic areas, as well as, over regional areas has been highlighted both in a manner of discrete long-time span and in sequential time series with high temporal resolution remote sensing satellites through a process commonly called “change detection” (Coppin and Bauer, 1996; Al-doski et al., 2013). Change detection has been defined as a process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989b; Al-doski et al., 2013).

The two categories of change detection methods: are pre-classification and post-classification change detection techniques (Al-doski et al., 2013). The pre-classification techniques, also known as binary change or non-change information detecting techniques, include various techniques that directly use multiple dates of satellite imagery to generate “change” vs. “no-change” maps. The post-classification comparison has been proven to be the most popular approach in change detection analysis (Foody, 2002b; Al-doski et al., 2013). This approach is based on rectification of more than one classified image; where it involves the classification of each of the images independently, then the thematic maps are generated, followed by a comparison of the corresponding labels or themes to identify areas where change has occurred (Al-doski et al., 2013). In this study post-classification was used.

CHAPTER FOUR
MATERIAL AND METHOD

4.1 Material

Different types of GIS and Remote Sensing softwares were used in order to uncover the change in delta and delta coast. These are Erdas Imagine 2014, ArcGIS 2010, TerrSet Geospatial Monitoring and Modeling Software (IDRISI).

Landsat satellite images were used in order to detect the change over the land. Attention was paid to images in order for them not to be affected by cloudiness factors, to have different seasonal features and to be clean in which time periods are close.

Landsat Multispectral Scanner (MSS) images consist of four spectral bands with 60-meter spatial resolution. Approximate scene size is 170 km north-south by 185 km east-west (106 mi by 115 mi). Specific band designations differ from Landsat 1-3 to Landsat 4-5 (Landsat, 2015) (Table 4.1).

Table 4.1 LANDSAT MSS (Landsat, 2015).

Multispectral Scanner (MSS)	**Landsat 1-3**	**Landsat 4-5**	**Wavelength (micrometers)**	**Resolution (meters)**
	Band 4	Band 1	0.5-0.6	60*
	Band 5	Band 2	0.6-0.7	60*
	Band 6	Band 3	0.7-0.8	60*
	Band 7	Band 4	0.8-1.1	60*

* Original MSS pixel size was 79 x 57 meters; production systems now resample the data to 60 meters.

Landsat Thematic Mapper (TM) images consist of seven spectral bands with a spatial resolution of 30 meters for Bands 1 to 5 and 7. Spatial resolution for Band 6 (thermal infrared) is 120 meters but is resampled to 30-meter pixels. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi) (Landsat, 2015).

Table 4.2 LANDSAT TM (Landsat, 2015).

Thematic Mapper (TM)	**Landsat 4-5**	**Wavelength (micrometers)**	**Resolution (meters)**
	Band 1	0.45-0.52	30
	Band 2	0.52-0.60	30
	Band 3	0.63-0.69	30
	Band 4	0.76-0.90	30
	Band 5	1.55-1.75	30
	Band 6	10.40-12.50	120* (30)
	Band 7	2.08-2.35	30

* TM Band 6 was acquired at 120-meter resolution, but products are resampled to 30-meter pixels.

Landsat Enhanced Thematic Mapper Plus (ETM+) images consist of eight spectral bands with a spatial resolution of 30 meters for Bands 1 to 7. The resolution for Band 8 (panchromatic) is 15 meters. All bands can collect one of two gain settings (high or low) for increased radiometric sensitivity and dynamic range, while Band 6 collects both high and low gain for all scenes. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi) (Landsat, 2015).

Table 4.3 LANDSAT ETM (Landsat, 2015)

Enhanced Thematic Mapper Plus (ETM+)	**Landsat 7**	**Wavelength (micrometers)**	**Resolution (meters)**
	Band 1	0.45-0.52	30
	Band 2	0.52-0.60	30
	Band 3	0.63-0.69	30
	Band 4	0.77-0.90	30
	Band 5	1.55-1.75	30
	Band 6	10.40-12.50	60 * (30)
	Band 7	2.09-2.35	30
	Band 8	.52-.90	15

* ETM+ Band 6 is acquired at 60-meter resolution, but products are resampled to 30-meter pixels.

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. New band 1 (ultra-blue) is useful for coastal and aerosol studies. New band 9 is useful for cirrus cloud detection. The resolution for Band 8 (panchromatic) is 15 meters. Thermal bands 10 and 11 are useful in providing more accurate surface temperatures and are collected at 100 meters. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi) (Landsat, 2015).

Table 4.4 LANDSAT OLI & TIRS (Landsat, 2015)

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	Bands	Wavelength (micrometers)	Resolution (meters)
	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 – Blue	0.45 - 0.51	30
	Band 3 – Green	0.53 - 0.59	30
	Band 4 – Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 – Panchromatic	0.50 - 0.68	15
	Band 9 – Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)

* TIRS bands are acquired at 100-meter resolution but are resampled to 30 meters in delivered data product. (Landsat, 2015)

Selected Landsat images are 31 May 1975 MMSS1-5 Landsat 2 image, 8 August 1987 Landsat 1-5MSS image, 4 October 1999 Landsat 7 image, 16 January 2003 Landsat 7 image, 23 August 2010 Landsat 4-5TM image, 10 May 2016 Landsat 8 image. These images were used in the detection of shoreline, mapping of the riverbed in the study field and Corine classification. The image of 2003 was used in shoreline digitization in order for Beydağ Dam to display the effect in which it creates onshore. It was not used in land classification. Seasonally close dates were selected in images, however, because the number of clean images is few, images of different seasons were included in the study. Occurring factors due to different seasons were taken into account in the interpretation.

The image of the study area of 17 October 2011, the Aster Global image was obtained from the USGS and it has been made in 3D with the help of Esri ArcScene. For easier the interpretation of the land and the environment.

The information about studies of coastal changes and coastal use were collected. As a result of field studies, it has been observed that human impact, especially in summer seasons with tourism brings the intensive use.

4.2 Method

Prior work is to provide required corrections on the images during studies. Satellite images were subject to the radiometric and geometric corrections at preprocessing stage. This is also called image restoration or rectification. The purpose is to eliminate radiometric and geometric deteriorations sensor and platform origin. Doing this operation before image enhancement and image classification makes the image more useful.

Image enhancement makes the image more understandable. It is the implementation of operations such as clearness and filtering. However, because the Landsat images were obtained by the USGS, the geometric correction was not needed. While data are supplied here, necessary corrections are made available to the user. Thus, image enhancement is enough. It has been made available by the help of Erdas Imagine 2014 program using Adjust radiometry tool and enhancing the image. General contrast, brightness contrast, photography enhancements, piecewise contrast and breakpoints tools were used with this tool.

Landsat images dated 1975, 1987, 1999, 2003, 2010 and 2016 were composed of the program of ArcGIS using the raster composite tool. For Landsat 8, bands of 1, 2, 3, 4, 5, 6, 7; for Landsat 7 bands of 1, 2, 3, 4, 5 and 7; for other Landsat Images all bands were composited. To increase the usefulness of the image is the reason for band selection.

After the process steps, the boundaries of the study area were cut by the help of Erdas 2014 program. Resolution of images was equalized by resampling tool and bits of images were equalized by rescaling tool with Erdas 2014 program because resolutions of the images were different from each other. After taking reference of the 1987 image and pixel values was arranged in the resolution of 60 to 60 meter, image bits were equalized to 16 bit which is the average value. The reason of taking reference of 1987 Landsat image is because it is the maximum value that we can reach in resolution. Resolutions can be arranged reducing to its maximum values. The reason why the two arrangements were done is because we can encounter pixel values errors during change detection.

In this study, before the change analysis was conducted the ISODATA method was used and unsupervised classification was made on Landsat images. The unsupervised classification method is based on automatic clustering or grouping using some specific algorithms of pixels on images without any intervention of the user. Unsupervised classification is the method used when the data in the image cannot be defined. This classification method is used when there is not enough information about study area and if there is a need of previous information in the studies about the general structure of the area. In this method, the type of land cover is not needed all the number of classes on the image are determined. Pixels that have features in common or similar pixels are assigned to the tags of class, symbol or value and are unified to common types of classes when it is required (Su Yönetimi, 2016; Çölkesen, 2009). The spectral classes obtained is not known, however, natural features of classes can be identified by comparison of existing helpful data. Such as aerial photographs or topographic maps belonging to that area (Çölkesen, 2009).

Minimum distance rule is used as in unsupervised classification. Pixels are analyzed line by line, starting on the upper left corner from left to right. Spectral distance is calculated between each pixel and average of every class and assigned to the closest class. Spectral distances between pixels are calculated by using formulas like Euclid distance and Mahalanobis in unsupervised classification which is a totally automatic classification method. First of all, an average of clusters formed for the required number is calculated and after iteration, after calculating the new average for every cluster, these averages are used for the identification of next clusters. In unsupervised classification, classes that pixels will be included are identified after centers of clusters are calculated temporary and this operation keeps continue until no change occurs in the location of cluster centers (Çölkesen, 2009).

ISODATA classification used in the study was unsupervised classification. The ISODATA classification method is an unsupervised classification method that uses an iterative approach that incorporates a number of heuristic (trial and error) procedures to compute classes. The ISODATA classification method is similar to the K Means method but incorporates procedures for splitting, combining and discarding trial classes to obtain an optimal set of output classes. The ISODATA algorithm analyzes a sample of the input to determine a specified number of initial class centers. Cells are assigned to classes by determining the closest class center (minimum Euclidean distance). After each classification step, the process calculates a new center for each class by finding the mean vector for each class. At the beginning of each iteration, the process evaluates the set of classes produced by the previous steps. Large classes may be split on the basis of a combination of factors, including the maximum standard deviation for the class, the average distance of class samples from the class center, and a number of sample cells in the class. If the distance between the centers of a pair of classes falls below a user-defined threshold, the classes are combined. If the number of cells in a class falls below a user-defined threshold, the class is discarded, and its cells are reassigned to other classes. Iterations continue until there is little change in the location of class centers in successive iterations, or until the maximum allowed number of iterations is reached. The process can create an optional distance raster (Isodata, 2016).

The unsupervised classification which is inside Erdas Imagine 2014 program was applied on the images of Landsat after the arrangements. The classification combined after divided into 5 base classes in accordance with the principles of the Corine classification system mentioned above with the interpretation of terrain textures considering the differences and similarities. Every image was divided into 255 color spectrum and the land was interpreted in accordance with similarities and differences and then 255 color spectrum were reduced to 5 basic classes according to Corine (Coordination of Information on the Environment) classification system and lastly, these classes were unified. Maps were prepared which shows 5 basic classes. Classification is defined as the determination of the specificity of each pixel value in an image and assigned to the property groups of pixels which has similar spectral features. The basis is in general based on the objects having different spectral reflections. Detailed information about classification methods is located on different scientific studies (Şekertekin, 2013). Corine classification was used as a mean in determining the shoreline change by years due to the expressions of factors on land, their use and change triggering pressure. Raster maps created in Corine classification were converted to Polygon in order to calculate area by the Raster to Polygon feature situated at ArcMap program ArcToolbox Conversion tool. The purpose of land classification and detection of a change in the classified land is to determine the dominant factors in the field and interpret the factors that change the shoreline. For this reason, the emphasis was given to the determination of the overall situation rather than a detailed mapping. It has been enough to determine the field use in general terms for detection of shoreline change direction.

Corine Classifications:

Artificial Surfaces

- Urban fabric
  - Continuous urban fabric
  - Discontinuous urban fabric
- Industrial, commercial and transport units
  - Industrial or commercial units
  - Road and rail networks and associated land
  - Port areas
  - Airports
- Mine, dump and construction sites
  - Mineral extraction sites
  - Dump sites
  - Construction sites
- Artificial, non-agricultural vegetated areas
  - Green urban areas
  - Sport and leisure facilities

Agricultural areas

- Arable land
  - Non-irrigated arable land
  - Permanently arable land
  - Rice fields
- Permanent crops
  - Vineyards
  - Fruit trees and berry plantations
  - Olive groves
- Pastures
  - Pastures
- Heterogeneous agricultural areas
  - Annual crops associated with permanent crops

Complex cultivation patterns

Land principally occupied by agriculture, with significant areas of natural vegetation

Agro-forest areas

Forest and seminatural areas

Forests

Broad-leaved forest

Coniferous forest

Mixed forest

Scrub and/or herbaceous vegetation associations

Natural grasslands

Moors and heathland

Sclerophyllous vegetation

Transitional woodland-shrub

Open spaces with little or no vegetation

Beaches, dunes, sands

Bare rocks

Burnt areas

Glaciers and perpetual snow

Wetlands

Inland wetlands

Inland marshes

Peat bogs

Maritime wetlands

Salt marshes

Salines

Intertial flats

Water bodies

Inland waters

Water courses

Water bodies

Marine waters

Coastal lagoons

Estuaries

Sea and ocean (Europen topic centre on urban, land and soil system, 2012)

Change detection was applied and change areas were revealed in order to compare the images and obtain digital data which belongs to images. The image Diff tool program was used for this which is under Change/Time series, which is under the Idrisi GIS Analysis tool which is under Terrset program. Change areas of the longest period in the studied year 1975-2016 were revealed using differences image and standardized class image features. Thus change directions of pressure factors in the field with the specific range of years were revealed.

Shoreline should be determined first in order to determine shoreline change. Original resolutions of the data were used for determining the shoreline. Infrared bands of Landsat images were used because the distinction between water and land was seen better in this way. Boundaries of water and land were detected using the ArcGIS program, were digitized as a polyline and these digitized images were compared and interpreted. Thirty different critical points were determined along the coastline in order to interpret. Change distances and directions were detected by comparing year on year with sections taken from these points. The coastal band opens with ArcMAP area for a show in coastal band modification. It measures that sections from back most coastal band to furthermost coastal band, It was established in the beginning and ending. It shows which dates belong to that. It was calculated with hectare, which between the two years coastal band changes and total coastal band length. In that way, It was calculated how many land changes for the next year. There exist studies on the coasts referencing some specific points. Some of these studies are Aydın and Uysal (2013) monitoring of shoreline change by the help of satellite images: Sakarya-Karasu and Özpolat and Demir (2014) determination of shoreline change by the remote sensing methods and Geographic Information Systems: Seyhan Delta.

Understanding makes coastal change interpretation easier. Using ArcGIS, river valleys were also digitated in order to interpret the images for the study area. Thus, 6 different river valleys were mapped belonging to 6 different Landsat images.

CHAPTER FIVE
GEOGRAPHICAL FEATURES EFFECTIVELY IN THE STUDY AREA OF COASTAL CHANGE

5.1 Geographical Characteristics of Study Area

5.1.1 Location and General Characteristics

Research area covers Küçük Menderes Delta, which is southwest of İzmir, Turkey and is part of the coastal region of the Aegean Sea (Figure 5.1 & Figure 5.2).

The coordinates are between 37° 24´08´´- 38° 41´ 05´´ north latitude and between 26° 11 ´48´´- 28° 24´ 36´ east longitude. The study area located east of the Kuşadası Bay on the Aegean Sea is inside the border of the Selçuk district in İzmir province. The cities of Torbalı and Menderes are situated at the north, cities of Özdere-Gümüldür are situated at the northwest, and the cities of Kuşadası and Söke are situated at the south, Kuşadası Bay is situated at the west, and the cities of Germencik and Tire are situated at the east of the region.

The Küçük Menderes Delta is surrounded on the north and south with low altitude mountains (Boncuk Mountain 750 m., Karaca Mountain 770 m and Maden Mountain 640 m). The Delta is an alluvial filled area which is 11 km long and 5km wide (Erinç, 1955, Sütgibi, 2009). The slope of the valley is slight and the altitude is 5 meters until the “Belevi Straight” (Sütgibi, 2009) (Figure 5.3).

Küçük Menderes Basin covers 110 km in east- west direction. The basin is quite narrow and has an average width of 30km with extreme, ranging from between 15 and 50 km Basin is surrounded by mountains with altitudes ranging from 400 meters and 2200 meters (Silay and Tomar, 2013) (Figure 5.3).

Figure 5.1 Location map of Küçük Menderes Delta (Google Earth, 2016).

1. Turkey general view, 2. Küçük Menderes Delta and its surroundings,

3. Küçük Menderes Delta's coastline and view of the immediate surroundings. Red lines contain the borders of the next view.

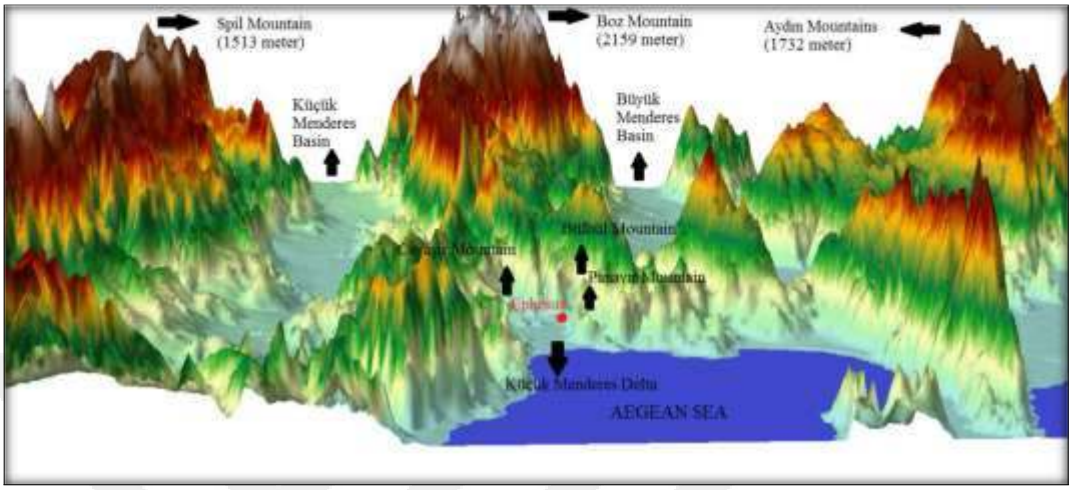

Figure 5.2 Küçük Menderes Basin and it surroundings from west to east

Figure 5.3 Belevi Straight.

Carl Von Scherzer (1873), mentioned that the old name of Küçük Menderes River was Kaystros and that the irrigation he did in 1873 that plain which Küçük Menderes was very efficient despite the small size and a high number of residences.

Küçük Menderes River consists of Bozdağ Creek and the extensions of Bozdağ; Çatak, Sulu, Ulu, Sırımlı and Kadın Creeks. Kadın Creek is the main branch of the river. From the south, Bademiye and Gökçen Creeks join the Küçük Menderes while Üzümlü, Aktaş Creeks join from the north. Falaka and Ergenli Creeks merge from the west. At this point, the Küçük Menderes River spits into two branches. One branch goes north and moves to the west. Near Sağlık village Fetrek Stream merges from the Dağkızılca village and Çarlık creek from the Ahmetli village direction and these 2 branches combine at the north of Belevi village. South branch flows towards southwest and the Küçük Menderes River enters the Selçuk gorge and the river keeps flowing in an artificial channel. The river splits into two again 2 km north of the town of Selçuk. North branch is in a present day channel that is 500 m. East and combines with the Aegean Sea (Gözenç, 1978). This is also the the only example of prehistoric/antique/medieval port city which was not destroyed or built on by other civilizations.

Port landscape is unique in the ancient world and stands out by consisting of an artificial harbor basin, a lighthouse, some outport, an adjacent necropolis, and an inlet channel. There are a few locations for additional port basins through Kaystros (Küçük Menderes) River near Ephesus and the Channel. These buildings were external ports, quay walls and other facilities (Unesco Beyan, 2016).

5.1.2 History

In the works of medieval Islamic geographer, the name of Ephesus was also known as Efesis, Ufsus recorded later as Altougo, Altologo, Haultologe, Astolloch and Latologo. Tournefort (2013) expresses that these names come from the Bible, the Greeks used the name Ayios Skologos instead of Ayios Theologos (theologian saint) and from that name Ayasuluk was derived. The name Ayasuluğ was used until 1914 and after Selçuk (Telci, 1999).

Throughout history, many travelers have visited these places, like İbn i Batuta and Evliya Çelebi (Türkoğlu, 1999).

Selçuk and its near surrounding where the study area is located, can trace its history back to 8000 years ago. Çukuriçi and Arvalya mounds represent the first Neolitic and Chalcolithic settlements around Selçuk in Western Anatolia. A settlement belonging to Bronze Age was discovered on Ayasuluk hill dating back to 2000 B.C. Apasa, is the capital city of Luwian Kingdom is located in Ayasuluk hill.The kingdom dominated Anatolia for the greater part 16th to 13th centuries B.C. In 11th century B.C, migration began to Anatolia from the north and west during the Iron Age. The mytical founder of the city was a prince of Athens named Androklos, who founder of Ephesus took the city from Carian, Leleges and Lydians during this period. Findings around the ruins of the Temple of Artemis belong to early Bronze Age. A revival was seen in the region in the 8th century B.C with the findings of this period that reached in the north to Panayır Mountain. Lydian domination was short-lived and Ephesus came under control by Persian king's Kyros in 546 B.C. The Persians ruled this area 334 B.C, when Alexander the Great conquered the area. Ephesus was moved to its present location between Bülbül and Panayır Mountains by Alexander the Great. The name of the city was changed to Arsinoeia. The reason for the move to this location was the infill of the port by Küçük Menderes River. Ephesus was developed in the new location. The most glorious periods were Traian (98-117 A.D.) and Hadrian (117-138 A.D.) periods. Ephesus became the capital city of the Asian States of the Roman Empire (Selçuk Belediye, 2016).

In the middle of the 4th century A.D. because of many earthquakes, the economy collapsed and there was extensive retoration. After the Battle of Malazgirt (1071), the first Turkish settlement was begun in Ephesus (Selçuk Belediye, 2016).

In the second half in when İstanbul began to rise again in world trade, because the harbors of Ephesus (Ayasuluk) and Milet (Balat) were filled with silt. The trade, which previously went to Ephesus, later headed to (Kuşadası) which had been inside the border of Ephesus since the 2nd Century A.D. (Telci, 1999).

The first excavations of the ancient city of Ephesus started of 5 May Ayasuluk was revived again by the construction of the Aydın-İzmir in 1867. In 1913, the name was changed from of Ayasuluk to Selçuk. It was a part of the city of Kuşadası until 1943 and became a district of İzmir in 1957 (Selçuk Belediye, 2016) (Figure 5.4, Figure 5.5, Figure 5.6 and Figure 5.7).

Figure 5.4 A schematic illustration of the Ephesus (Türkoğlu, 1999).

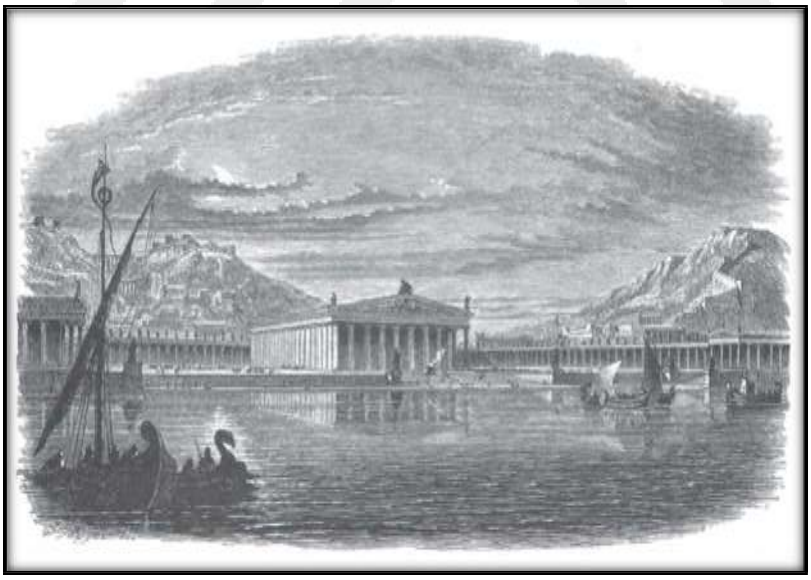

Figure 5.5 A schematic illustration of the Temple of Artemis in a coastal harbor setting (Kraft et al., 2007).

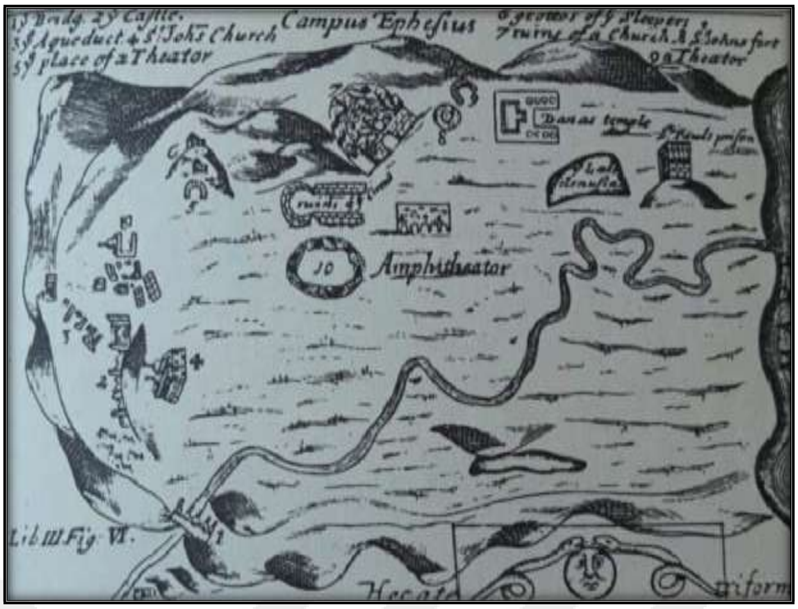

Figure 5.6 G. Wheelear illustration of the study area (Türkoğlu, 1999).

Figure 5.7 J.P. Tournefort illustration of the study area (Türkoğlu, 1999).

5.1.3 Natural Structure

5.1.3.1 Climate

The climate is the average air conditions that do not change for many years inside a large area. There are many factors that affect climate; temperature, humidity, air pressure and how these change daily and yearly (Dönmez, 1984; Report of Ministry of Forestry and Water Management, 2012).

Climate maps are used with methods like climate classification and like Köppen, Trewartha, Aydeniz, Erinç, Thornthwaite, De Martonne, Emberger, Gaussen, Aubreville, Peguy, Akman (Report of Ministry of Forestry and Water Management, 2012).

In terms of macroclima climate types, the study area is a Mediterranean climate type. The main feature is drought and heat in the summer. Winter season is rainy with moderate temperature (Gözenç, 1978) (Table 5.1).

A climate evaluation of the study area was conducted according to data collected from Kuşadası and Selçuk meteorological station.

Table 5.1 Climate type determined by different methods for the study area (Şensoy, 2007, Report of the Ministry of Foresty and Water Management, 2012).

Method	Climate
Mediterranean Climate Type	Semiarid
Erinç Climate Type	Sub-humid
De Martonne Climate Type	Step-Sub-humid
Trewartha Climate Type	Winter is cool, Summer is hot
Thornwaite Climate Classification	Seb-humid Semiarid

The average temperature at the Selçuk Meteorological Station for 42 years from 1970-2011 was 16.6^0 C. The coldest month was January with an average temperature of 8.1^0 C, the hottest month was July with 26.7^0 C. For the entire region the average temperatures ranged from 8.7^0C in the winter to 25.6^0 C in the summer.

The average evaporation rate was 1.173.36 mm according to measurements for 27 years between 1985-2011 at the Selçuk Meteorological Station (Report of Ministry of Forestry and Water Management, 2012).

In the winter, when the amount of sunlight decreases and the rate of cloudiness increases, the energy that reaches the earth is always greater than lost energy (Sütgibi, 2009).

In this region, the relative humidity is higher in the winter, lower in summer seasons. Relative humidity is less than 60% in July whereas in the winter it is over 60%. In December it is about 73% over half of the annual rainfall occurs in the winter since the Küçük Menderes River and environs exhibit features of a mediterranean climate (Sütgibi, 2009).

The average rainfall amounts at the Selçuk Meterological Station for 42 years from 1970-2011 was 665.64 mm. The rainfall average was below average for the years 1985-1993 and 2006-2008. The highest rainfall was seen in 1981 with 1,060.10 mm. When analyzed montly the highest rainfall was seen in winter months, December (129.81 mm), January (110.73 mm) and February (107.46 mm). The lowest rainfall was seen in the summer months of June (6.02 mm), July (1.73 mm) and August (0.75 mm). The annual seasonal distribution of rainfall by season was 22.59% in spring, 1.26% in summer, 24.30% in autumn, and 51.85% in the winter (Report of Ministry of Forestry and Water Management, 2012).

In winter, Northwest of Atlas Ocean and polar (Cp ve Mp), coming over Middle and East Europe create pressure; In summer Atlantic maximum and tropical (mT ve Ct) air masses developing in North Africa create pressure (Koçman, 1989; Sütgibi, 2009). Terrestrial rate of Selçuk according to Sezer's formula is calculated as 17.44% (Sütgibi, 2009)

There are two dominant wind directions in Selçuk. The frequency of winds blowing in January is high and we see the second dominant direction as northwest. The direction is shifting to the southwest in April (Zaimoğlu, 2003).

5.1.3.2 Geological and Lithological Features

The Pliocene was an erosional and depositional period under semi-arid conditions. In this period mountainous areas, which had risen during the Miocene broke-up, were eroded, and tectonic depressions were filled with detrital material, mostly with colluvial or mud-flow characteristics. During the Pliocene, and especially at the end of the Pliocene, some tectonic movements occurred as in the Miocene but were less effective (Kayan, 1988)

The Quaternary was the most important period of geomorphic formation fort the region. A new drainage system formed on the Pliocene topography and easily incised the detrital Pliocene deposits. A rough relief formed, bordering the area of the depressions by this process. Also in this period, rise of the Anatolian land, sinking of the Aegean basin and advancement of the sea toward northwards, caused by climatical-eustatic sea-level fluctuations, affected the valley formation, particularly along the coastral part of the region (Erol, 1976; Kayan, 1988).

The Holocene was a period of general sea-level rise. The level rose rapidly in the beginning of this period. Therefore, valleys of the coastral area, mostly grabens, became wide ria-like gulfs in this period. However, in the Late Holocene, sea-level rise slowed, and alluvial-colluvial accumulation in the valleys and along the coastral area pushed the coastline toward the sea (Darkot, 1938; Erinç, 1955; Eisma, 1962; Bilgin, 1969; Erol, 1976; 1983; Kraft et al., 1980, 1983, 1985; Kayan, 1988) (Figure 5.9 and 5.10).

In the geological structure of Western Anatolia, basically, a very old core mass (massive) that is formed by crystal stones (gneiss, mica schist, marble) exists.

Geological structure/lithospheric stacking with the land studies made in Selçuk and its surroundings was determined.

Menderes Massive Rocks: These rocks form the basis in the region. According to their mineral content, many types of schists, cover large areas in the east, south and southwest of the study area. Marbles are seen at all altitudes north of Selçuk, at Selçuk Castle, Maden Mountain, Panayır Mountain and Bülbül Mountain.

Izmir-Ankara Zone Rocks: These rocks are characterized with sandstone, shale and limestone in Selçuk and its surroundings. Flysch formations are seen in the north of the study area, and in a small area around Zeytinköy which is located on the study area.

Young Sedimentary Rocks: These consist of sedimentary rocks and volcanic sedimentary rocks. This formation is represented in Selçuk and its surroundings by limestone, marl, mudstone and conglomerate. This visual unit is seen at Arvaly Çanakgöl Hill, Kara Hill, Ara Hill and northwest of the study area (Gümüş, 1997).

Young tectonic movements have had a very important effect on the structure and present geomorphology of Western Anatolia (Figure 5.8) Several dome shaped uplifts have given the outlines of the massifs. During these uplifts, Western Anatolia was broken up by the faults causing mosaic-like structure. Tectonic movements especially starting from the middle of the Miocene formed grabens in the W-E direction, perpendicular to the coastline: such as the Bakırçay, Gediz, Küçük Menderes, Büyük Menderes Rivers (Brinkmann, 1976; Erol, 1981; Kayan, 1988).

In previous studies, different vertical faults were determined in Selçuk and its surroundings. These are north-south, southeast-northwest, northeast-southwest and east-west directions. The fault, called the Ephesus fault, is observed in all of the previous research, has a northeast-southwest directions, that continues to Kuşadası Bay. East-West direction faults are active today and occasionally trigger earthquakes (Gümüş, 1997).

Between 1897-1996, 88% of earthquakes were moderate with 12% categorized as severe earthquakes (Sezer, 1997) (Figure 5.8).

Figure 5.8 Ephesus Fault.

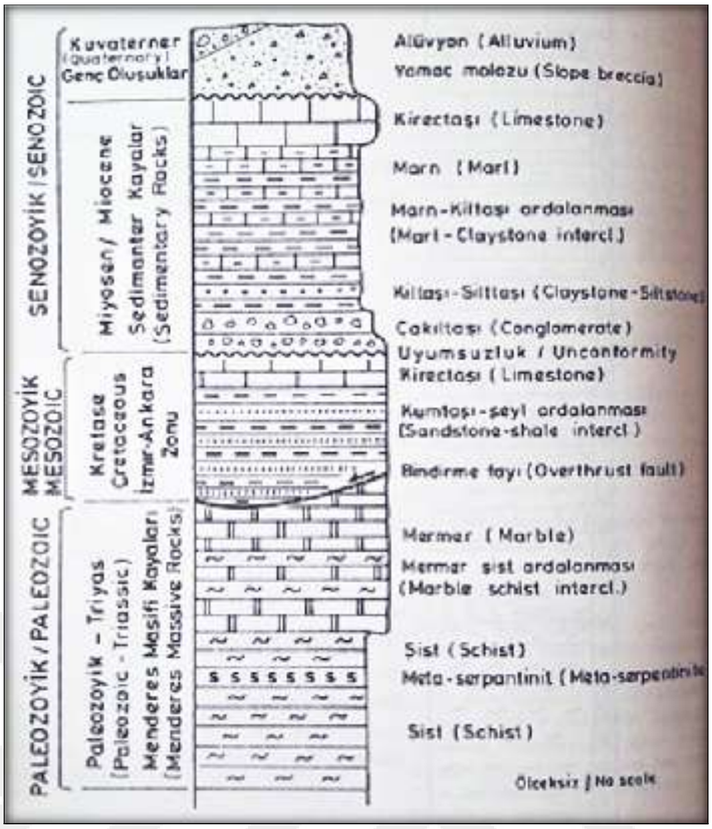

Figure 5.9 Column section Selçuk and its surroundings (Gümüş,1997).

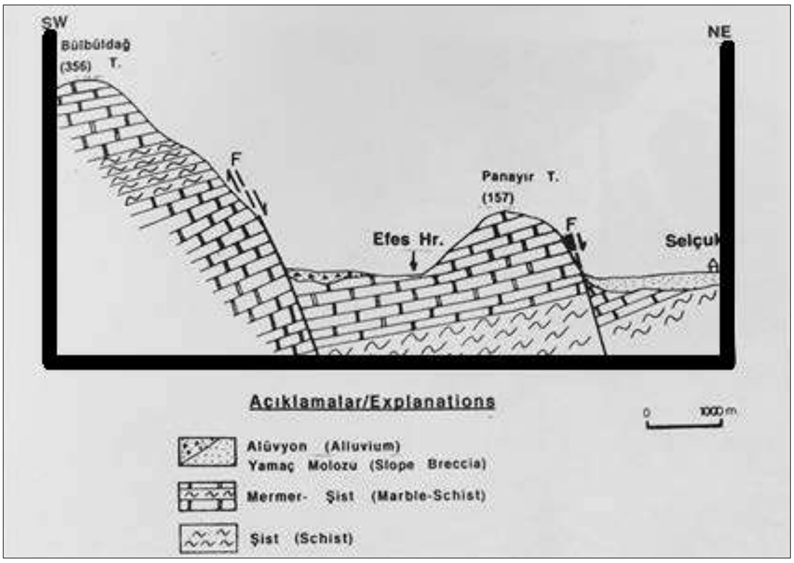

Figure 5.10 Geological 1section (Gümüş, 1997).

5.1.3.3 Geomorphology

Many studies have been made concerning the Küçük Menderes Delta, however, the studies conducted over the past years have contributed more to the interpretation of long-term geomorphological development. Stock et al., (2013) summarized the geomorphological development of Küçük Menderes according to the study conducted on the ancient Ephesus Harbor updated by Brückner (2005) (Figure 5.11 and Figure 5.12).

The Küçük Menderes River, northern part of the basin, is called inner plain sections. The second area, Selçuk plain-delta area is from Belevi straight to the basin where the Küçük Menderes River flows into the Aegean Sea. Belevi straight combines the internal and coastal sections of the Küçük Menderes Valley (Kayan and Kraft, 1997; Sütgibi, 2009).

The Küçük Menderes Delta plain was formed as a result of infilling of flood-delta sediments of the Küçük Menderes inside different cupping collapse on the west side of the Menderes Massive. In other words, alluvial deposition in Selçuk plain took place under the control of marine influence. Thus, in Holocene, it has been revealed by research in the region, that approximately 15,000 years ago, there was a large gulf in the Selçuk plain due to sea rise, and that 6,000 years ago when the sea rise ended the infilling of this gulf started with the alluvions carried by the Küçük Menderes (Kayan, 1999; Sütgibi, 2009).

The alluvial formation in the delta plain was effected by the alluvial coming from the inner plain by way of the Belevi Straight size of the piece combines with litological and morphological effects of the hills surrounding the plain Selçuk (Kayan and Kraft, 1997; Sütgibi, 2009).

As a result, development of the shape of Küçük Menderes Delta plain continued with changes in sea level and deposition of alluvials from the land (Sütgibi, 2009). One of the older research observations (Kraft et al., 1977), denotes that dunes and the coastal promenade / beach ridges existed in a field 1.5 km. farther back from the present coastline.

Beach ridges run parallel to the coastline no more than 1 m in height (Darkot, 1938; Eisma, 1962; Gökçen et al., 1990).

The beach ridges / shore cords are the processed wave products of the old mouth bars (Elliott, 1978; Gökçen et al., 1990). Whereas, there was no coastal promenade in the excavations and cleaning work of the classic cities of Artemis and Ephesus which are located on the edge of the delta (Kraft et al., 1977; Gökçen et al., 1990). In summary, the delta feed rate slowed down over time. River divided into two branches and it carried out very little load, therefore, the occurrence of delta rate slowed (max. 0.5 m/year, average 0.2 m/year).

According to Gökçen et al., (1990) the pace of delta field is 0.2 meter/year.

Gözenç (1978), dealt with the Küçük Menderes basin in 2 parts terms of geomorphological features. First of these is high parts that surrounds plain, second of these is alluvial base the river flows in. There exists large lagoon and increased swamp fields around Selçuk and Kuşadası, near parts close to Aegean Sea of Küçük Menderes Plain (Gözenç, 1978), Eleman Swamp was the Lagoon (Erinç, 1955; Somay and Filiz, 2006).

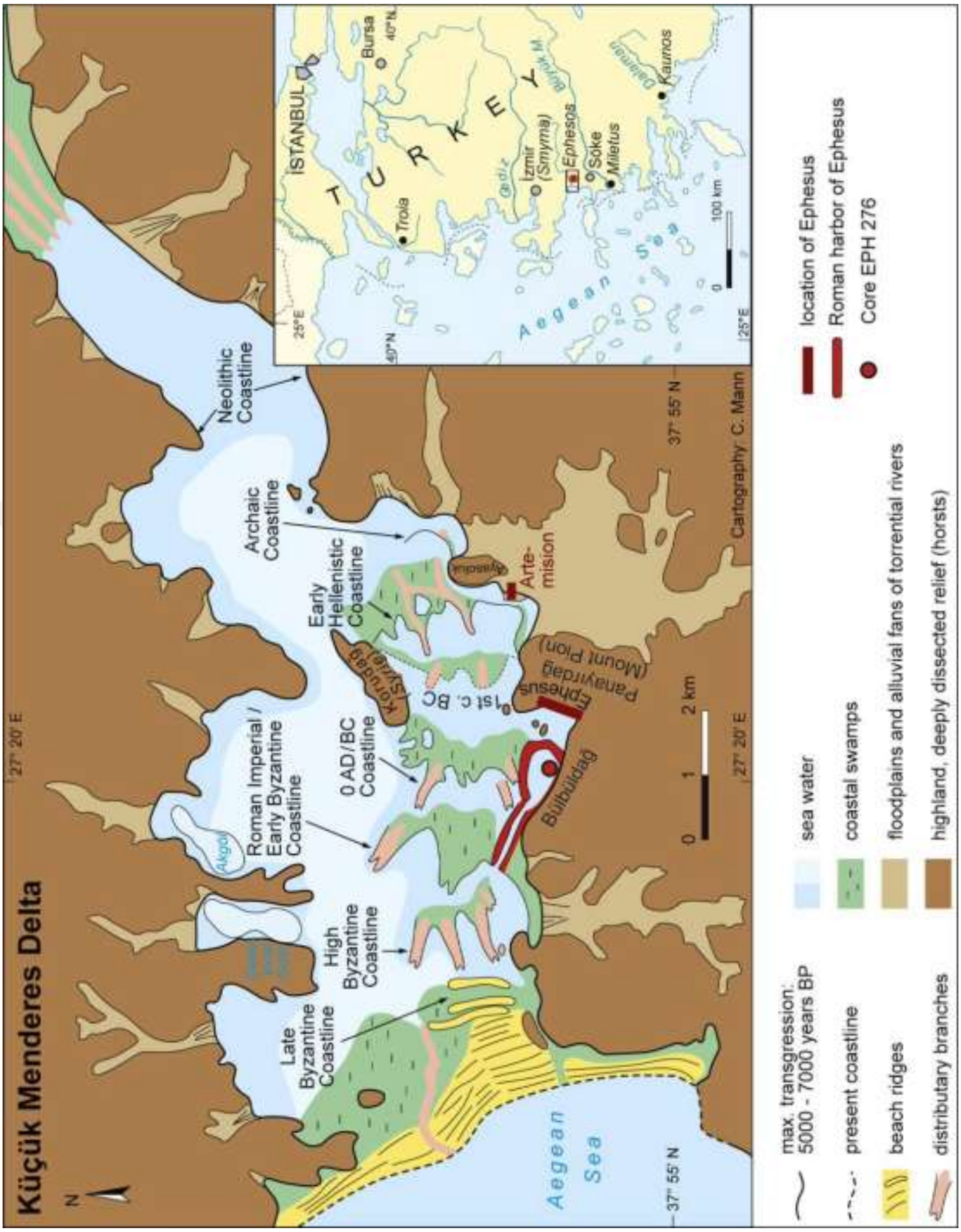

Figure 5.11 Map of the Küçük Menderes Graben located on the Aegean coast of Turkey (inset) with successive positions of the shorelines and site of core EPH 276. (Delile et al, 2015)

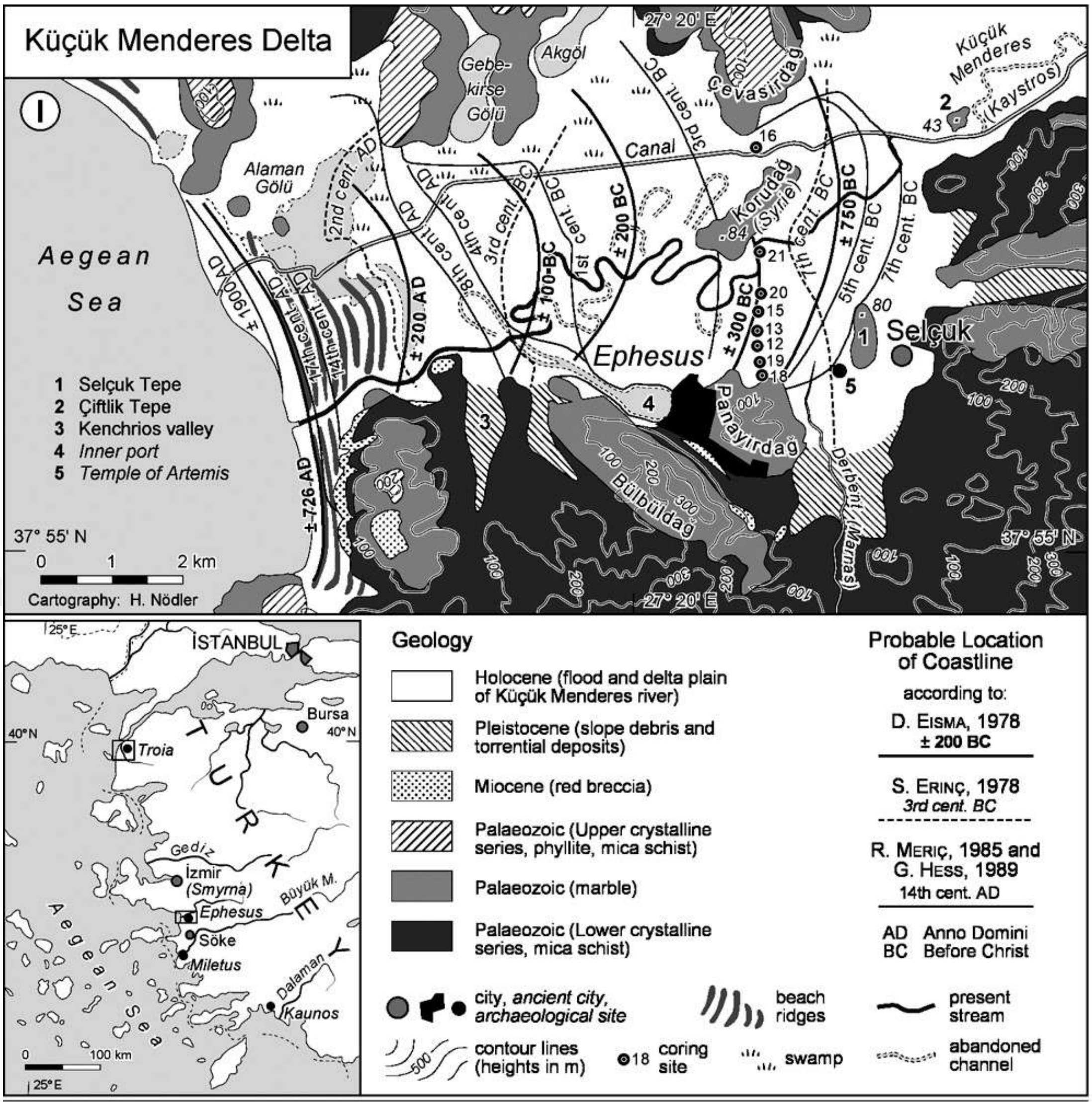

Figure 5.12 These scenarios are based on the interpretation of literary sources (Brückner, 2005).

Kayan (1996), mentioned that the factors causing the change of the coastline for this field are first, the fragmentation of the massifs in the coastline with east- west direction breaks in recent times do not exhibit a natural river valley, but exhibits a property caused by the filling of the Graben formed along a broken line. This is the main factor shaping the land. The second factor is that the presence of the Belevi Strait, limiting Delta area, divides the river basin into the interior and exterior plains. The part separated by Belevi Strait as exterior plain exhibits different lithological features surrounding Menderes Massif. Since the remaining part i s behind Belevi Strait known as the interior plain is in a big and deep depression field of the basin, river alluvium accumulate more here. Thus, more fine-grained and less amounts of alluviums accumulate in the exterior plain of the delta. Besides, because the heights surrounding delta or exterior plain are usually composed of carbonate rocks, limestone and marble, they leak water and the runoff decreases. Apart from that, because the erosion in the rocks around the delta occurs more by dissolving, less alluvium is transported and the accumulation is reduced too. The presence of the marshes and lakes in the delta's north and south edges is due to the fact that enough alluvium does not reach from the slopes. Since the sea and river are the major geomorphological factors in Küçük Menderes exterior plain or in the delta, they were shaped differently compared to the interior plains. By the alluviums shaping with the waves, different coastal environments occurred. Apart from these factors, according to Kayan (1996) sea level changes are among the most important factors shaping the field.

Prof. Dr. J. C. Kraft, Prof. Dr. H. Brückner and İ. Kayan, with samples taken since 1989, have discussed the subject in three different periods to get the present shape of the plain. Kayan (1996), mentioned that this change occurred due to the changes in the sea level happening at Holocene (in the last 15,000 years) and the differences in alluvium accumulation under this control of that. These are:

In the last ice age, the sea, which was 100 m lower than the current level, subsequently sidled to Selçuk-Ephesus depression in the early Holocene by rising rapidly, and by covering the surface, which is 20-30 meters deeper than present plain surface, went ahead to the interior part of Belevi Strait. The alluviums, which Küçük Menderes brought in that time, accumulated as being marine muds at the bottom of the shallow, narrow and long bay, in which the sea waves are not as effective.

In the Middle Holocene, 6000 years ago, the sea level reached the present level and rising ended. In that case, the alluviums, which Küçük Menderes brought, began to fill the gulf more quickly and the delta plain moved rapidly toward the sea. This is a transition period from marine conditions to terrestrial conditions. In the meantime, different environments, in which different sediments accumulated, were formed (such as coastal marshes, ditches, shallow front-shore base shapes).

According to our general knowledge, on the Aegean coast, in this period, lagoons began to form in many places. This shallow water area became easy food-supplier places (especially fish and shellfish, and wetland games as related to them) for the people living here at that time. For that reason, the fields newly becoming land behind or around the lagoons attracted attention as important settlements throughout Neolithic-Bronze ages (Kayan, 1996). In that case, determining the place of old shoreline and geomorphological characteristics along the changing coastal are of great importance in terms of archeology. The settlements almost 6000 years ago, when the sea level was top and the sea sidled the inner parts the most, must be sought on or behind that former coastline. According to that, the oldest settlements in Selçuk-Ephesus plains can be found on the eastern outskirts of the plain (e.g. Northern Selçuk). However, it should be noted that the current surface of the plain is not the same as the surface approximately 6000 years ago. Since that surface is under the alluvium and is probably at a depth closer to the current sea level. It means that it is about 5-10 m below the current surface with an average value. Another point noted is that, according to drilling data, littoral cordon typical for delta shores in the inner part of the current plain and lagoon sediments cannot be found. At the same time, at every transition (alluviums spreading by floods) from marine sediments to terrestrial sediments, a few meters thick sediments belonging to the swamps can be found everywhere. It shows us that the wave energy was low in the old bay. Such a coastal wetland environment, even if there are not typical lagoons, may be considered as the appropriate places to benefit from seafood.

In the Late Holocene, the fields behind the delta coast moving towards the sea by filling with alluviums were covered with river flooding sediments. With this development, because of geomorphological effects mentioned above, the sections showing different features have been shaped in the delta plain. For example, because most of the alluviums accumulated in the middle of the plain and near the riverbed, the marshes and lakes occurred at the edges of the plain away from there. The lakes and marshes even still existing in the northern outskirts (Çatal and Gebekirse Lakes) are examples of that. The natural state of the Ancient Ephesus port also shows such a delayed-filling edge depression feature (Kayan, 1996).

5.1.3.4 Soil

In the investigations, various large soil groups have been identified in study area due to characteristics of climate, topography and bedrock. These are the mainly:

Alluvial Soils (A): These soils are flat, nearly flat (A) C-profile azonal young soils which is on young sediment that is carried by rivers in impact areas or in the bottom of surface waters. Climate, drainage and organic substance amounts according to the user's style shows a broad distribution. Alluvial soils which has 3810 ha distribution in the field is entering a period of 10% in total. The soils are generally suitable for agricultural use.

Alluvial Coastal Marshes (S): These lands appeared at close part of the sea in the area with the effect of wave impact and surface water, and these are the lands that generally continuous or can be remain wet for a long time and these lands are generally in the form of swamp. These lands cover of 602 ha area in the field and are in the period of 1.5% of the total area. Salty swamp lands exist in basis around Selçuk and in the area which lies towards the sea. The white layer formed from salt crystals occur in the dry season (Gözenç, 1978).

Colluvial Soils (K): These are the young A C-layer soils that are carried by slope or accumulated by movement of the creek. Soil characteristics are generally similar to the character of the surrounding upland soil. The area covers 2407 ha of land in this study area.

Red Soil of Black Sea (T): These are typical land areas of the Mediterranean. These are dark red color soils in which profile development is A,B and C layers and are composed of under the 600mm or more rain on limestones. These soils which have a spatial distribution of 4322 ha of the study area are in the period of 10% in all areas.

Red Brown Mediterranean Soils (E): These soils which distributed in space are actually the mixed state of red Mediterranean and brown Mediterranean soils. They are soils which have a profile of ABC These soils are most distributed soils with 21382 ha spatial distribution. Limeless Brown Lands (U): They are A, (B), C profiled soils. Washing is generally available and, the upper soil has more acidic character than lower soil. It takes the third place with 3695-hectare area in study area. It has a distribution of 10% in total area.

Organic Soils (O): Organic soils that were detected in the field are in the northwest of the field. Organic soils of the region called element swamp are AC profile. This soil in study area indicates a distribution of 244 ha.

Bare Rock and Debris (CK): These are fields full of rigid rock and stones that are that have a type of land. The areas cover 969 hectares in the study area. It is in a period of 2.4% in total areas.

Sandy, Gravel, Rubble, River Floodplains (TY) : It covers the field in which rubble, sandy, pebbly materials exists in the floodplain of the river. These fields are generally in the summer seasons where precipitation is little. They are devoid of vegetation. It covers 12-hectare area in the work area (Report of Ministry of Forest and Water Management, 2012).

Agricultural Land Classification of lands in İzmir Küçük Menderes Delta plain are classified as absolute farmland, marginal farmland, planted farmland, Specialty Products Land and Non-Agricultural Areas. Absolute farmland: these are the lands that have national, regional or local importance; that are used in agricultural production and that are suitable. They cover 1350 ha area in study area. Marginal Farmland is divided into two as aqueous marginal and dry marginal farmland. It covers an area of 2896 ha area in the study area. Common planted agricultural areas that are detected in the area were pomegranate, peach, citrus groves. These areas (Standing Farmland) cover 3179 ha field in study area. Specialty Products Land with olive cultivation is the most distributed area with spatial distribution of 4518.5 ha. Finally, another land class that is identified in the area is non-agricultural areas. These lands represent bare rock, beach, dune, stream bed, reeds, swamp lands and residential areas (Report of Ministry of Forest and Water Management, 2012).

5.1.3.5 Hydrography

Küçük Menderes basin, in which Küçük Menderes coast region is located is the smallest basin among 5 basins in Western Anatolia. It has a rank of 25 among 26 river basins in Turkey with 7165 km^2 drainage. In the observation between 1952-1980, it was determined that the river's annual current value was 13553 m^3/sec. During observation, the highest current value was determined as (18.03.1971) 237 m^3/sec. the least current value was determined as dry (21.08.1962) (Zaimoğlu, 2003) (Figure 5.13).

Figure 5.13 Küçük Menderes River

Current values for between 1975 and 2016 were obtained for the study area. The highest current was 1981 with 818.73 hm^3. January, February and March have been three months, which current average is the highest. The reason is that the river is fed by rain. The current increased in rainy periods. June, July, August, September and October are months that have the lowest current average values among the years obtained because dry seasons occur in these months. Current values provided for the expression of impacts on relationship river-current in coast shape (Table 5.2 and Figure 5.13).

Table 5.2 Flow of the Küçük Menderes River (Anonymous, 2016).

Years	Total
1975	293,47
1987	157,57
1999	376,89
2003	417,87

While Küçük Menderes flows southward of Beydağ, it takes Çayağzı, Kiraz ve Sarımlı aqueous streams. It waters Ödemiş, Tire and Torbalı plains. It takes Çaylı, Üzümlü, Aktaş, Falaka, Ilıca, Uladı and Fetrek waters as it passes from these plains. It reaches Aegean sea from Selçuk Plain.

Dams of Beydağ, Aktaş, Burgaz, Ergenli, Uladı, Ödemiş are at the north of the basis. Dam of Bademli is at the south of the basis. Beydağ dam's construction was completed and Aktaş, Bademli and Zeytinova (Burgaz) dams construction was began, Ödemiş Dam is in the investment program, Dams of Ergenli, Uladı are in the stage of project planning (Silay and Tomar, 2013). Height of Beydağ dam is 96m. Volume of lake is 248 million m^3 (Su Dünyası, 2012).

Water is being held from 16 December 2007 in dam Beydağ (Devlet Su İşleri, 2015). A major study was begun in the Küçük Menderes River Basin.

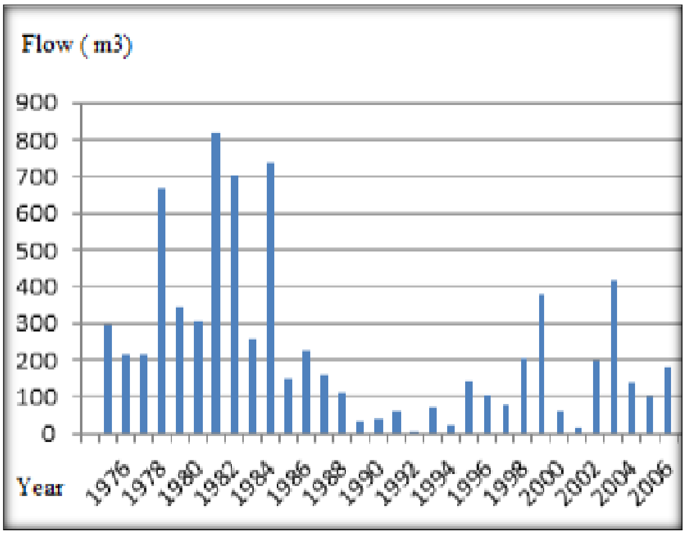

Figure 5.14 Flow Graphic of Küçük Menderes River (Anonymous, 2016).

The route of river is smaller in this study. The 37.500 m long riverbed will be adjusted as 29.500 meters, thus 940 dekares area is aimed to be enabled to agriculture (DSİ Haberler, 2016). The construction of new riverbed does not cover Küçük Menderes Delta.

The first project was prepared in 1919 by Aydın Chief Engineering which is connected to Nafia Umum management for the purpose of improvement by drying large swamp areas in the west of the Küçük Menderes Basin (DSİ, 1972, Silay and Tomar, 2013). But it was not applied. The second study known was Küçük Menderes Basin exploratory report prepared in 1932 and improvement of the Küçük Menderes River was under debate here. On this date, Government of republic attaches great importance of topics of swamps being dried for prevention of malaria and acquisition of lands for agriculture. As a result of this, after the preparation of Law about improvement of Küçük Menderes and its subjects, it was published in official newspaper of the number 2419 and in 5 June 1933, then it was put into action.

With this law;

a) Correcting of Overflowing with Küçük Menderes riverbed, prevention of flood damage by constructing embankments

b) Drying or improvement of all lakes or swamps in the basin including delta area was anticipated.

Malaria affected 38% of population due to areas of lake or swamp that is located on the delta and west side of the Küçük Menderes Basin in the years when this law published, this ratio reached to 90% in some villages. This situation caused the population to run away from rural areas. In the conditions of that time, land amount where agriculture can be done was identified as 2.371.000 decares and agriculturing was done only in 966.000 decares land. In the 1930's, lands of swamp and lands of lake which were dried in the improvement works and in the place of delta of Küçük Menderes River summarized below (DSİ, 1972, Silay and Tomar, 2013).

Apart from these lakes that were dried, flood in the delta area were prevented transfering old riverbed in Küçük Menderes River's Delta area to 11 km long new route that has enough capacity and located more northern (Gencer, 2002).

1-Gümbüldek Lake: This lake, 7 km inside from today's coastline located near Korudağ, has average depth 1.5-2. Surface area is 60 decares.

2-Cevaşir Lake: This lake, at 2 km east of Çatal Lake and located in Kargalıkaya foothills, has average depth 1.5 km. Surface area is 900 decares. It had been getting broader at flood periods and it had been at a situation that was linked with Çatal lake at flood periods.

3-Akgöl: The lake which is located at the north of old Küçük Menderes riverbe has an average depth of 0.4-0.6 m and 450 decares surface land. The Lake which has salty water due to being close to sea and its surroundings are barren.

4-Sıra İnler Lake: The lake which is located at the east of Ephesus ruins has 17 decares surface area.

5-Bodrum Lake: The lake which is a residue of inner harbor has a surface area of 500 decares. The lake connected with one leg to old Küçük Menderes river riverbed 3 km left. Here was used as outer harbor in Ephesus city.

6-Çanak Lake: The lake, located at south beach of the Küçük Menderes river, has average 1.5 m depth and 20 decares surface areas.

Floods in the delta areas have been prevented by transfering old riverbed of the delta area of the Küçük Menderes River to the more northern new path with 11 km long and enough capacity. Among the mentioned 6 lakes which are located in coastal areas, Bodrum Lake was partially and the others were totally dried and the areas turned into agriculture lands. The surface area of 5 lakes that were totally dry were 1447 decares. Lake and wetlands that have an existence in delta of Küçük Menderes are below.

1-Çatal Lake: This lake which has a 5.5 km distance to the sea and next to the northern hillside of delta area has average 740 decares surface area. The lake has 4 m depth (Figure 5.15).

2-Gebekirse Lake: This Lake which has a 4.5 km distance from the left of Çatal lake and next to the north of delta area has average 5 m depth and 750 decares surface area (Figure 5.16).

3-Eleman Swamp: It is the largest watery area in the delta which is located between Küçük Menderes River and northern border of delta area. Areas that were dried after the improvement works that were done around Eleman Swamp are located at east and north-east of the Swamp (Figure 5.17).

Cotton cultivation is generally done today in these lands. The route of state road of Kuşadası-Seferihisar, in which construction was completed in 1988 goes from this watery area and this watery area was divided into two. Eleman Swamp is affected by Küçük Menderes River floods in winter seasons and in this way plenty of water and nutrient reaches the wetland. The water of Gebekirse Lake and Eleman Swamp are partially salty. Çatal Lake is freshwater. Since Gebekirse and Çatal Lakes are fed by hillside springs, they are not sensitive to changes in the Küçük Menderes River. Eleman Swamp area is a wetland that takes water and nutrition by Küçük Menderes floods but partially fed by springs (Silay and Tomar, 2013).

Figure 5.15 Çatal Lake

Figure 5.16 Gebekirse Lake

Figure 5.17 Eleman Swamp

It was emphasized by Sıkı (1992) that Gebekirse Lake and others rise up with a change in riverbed of Küçük Menderes. The occurence of lakes and their ability to protect its assets can be expressed by being under the sea level.

Gebekirse Lake is 7 meters deeper from the sea level of today (Zaimoğlu, 2003). Kocagöl (Bodrum Lake) is located southwest of the Selçuk county seat. When Ephesus city was established, it served as harbor then after the plain was filled by Küçük Menderes river, it turned into lake present. The height of it from the sea is -40 cm. Nutrition of this lake consists of discharged water by Bülbül Mountain fault impact and by discharged water depending on karstification besides precipitation (Ministry of Forestry and Water Management, 2012).

Three wells in the north of Zeytinköy were opened by Ministry of Tourism.

In addition, there are many deep water wells for watering that were opened by local people in plain. There exists karst Akpınar resources in the examination area northwest of the plain around Zeytinköy. All the water of these resources are salty, therefore cannot be consumed. There are water resources other than these. These are fountains of Karaalin, Şirince, Tabakların, and fountains around Söğütçük and Pranga (Zaimoğlu, 2003). Other resources except these resources are Yoncaköy, Karayolu Şantiye resources, Zeytinköy, Tahat bridge, Villa Tepe and Çamaşırlık resources (Gencer, 2002; Zaimoğlu, 2003).

5.1.3.6 Flora and Fauna

Two large ecosystems were determined as aquatic and terrestrial in the bottom basin of wetland of Küçük Menderes's Delta. Aquatic ecosystem is divided into above water, water's side and salty marshes; terrestrial ecosystem is divided into rock ecosystem, lemur ecosystem and dune ecosystem (Report of Ministry of Forestry and Water Management, 2012).

Besides other coastral wetlands in Turkey, which meet BirdLife International's criteria for destination of Important Bird Areas (IBA's), the numbers of two bird species surpass the thershold of the IBA criteria in the Küçük Menderes River: Pygmy Cormorant *Phalacrocorax pygmaeus* (wintering population 35-160 birds) and Spur-winged Plover *Vanellus spinosus* (10-13 breeding pairs) (Kılıç and Eken, 2004, Bengil et al., 2010). According to Eken et al., (2006) the delta further fulfills the criteria as a Key Biodiversity Area (KBA) for both species, criterion 2 of the Ramsar Convention and additionally, harbours a small wintering population of globally threatened Dalmatian Pelicans *Pelecanus crispus* (Bengil et al., 2010).

There are 213 vertebrate belonging to 81 families except the fish in delta of Küçük Menderes. One third of vertebrate species in Turkey lives in here. There are 6 habitats of birds around delta. Reeds around Çatal and Gebekirse Lake are important in terms of habitat of birds. Populations of Cormorant, duck species, stork species, coot and water fowl, water jackets, seagulls, kingfisher, marsh harrier are very great. Another important habitat is dunes. It is important as rest and nutrition area especially for seagulls species. Other important area is agriculture areas and gardens. There exist species like titmouse, crowls, and spider birds here. Barren land is another class. Faunal elements are few because herbaceous plants are not growing much due to salinity. There exists a little number of bird species. Species such as partridge and babbler are seen in forest and rocks. Species like stork, little owl, dove, sparrow and martin are seen in settlements. It was detected that 28 mammalian species distributed belonging to 17 families are distributed in delta and its surrounding. This makes 16% of mammalian species (170 species) distributed in Turkey (Report of Ministry of Forestry and Water Management, 2012).

In a significant number of small cormorants stay in the region during migration. The spurred lapwing, in which the generation is in danger of extinction at the regional level, breed at this area, The dormouse in which the generation is in danger of extinction globally live here. Spotted turtles, tortoise and house snake are reptile species that supply criterias of special nature area. The big brunette, epidemic to our country, are butterfly species that live in the area and have a priority in protection (Türkiye Sulak Alanları, 2004).

In the delta, 206 species and 265 vegetation belonging to the 71 family were named. Six of the plants are endemic. These endemics are cornflowers, bellflowers, wild carnations. mullein and sub-species. Seventy-eight of the plants suitable to Mediterranean plant geography, 10 of the plants suitable to Europe-Siberia plant geography, 5 of the plants suitable to Iran-Turan plant geography are found in the study area (Report of Ministry of Forestry and Water Management, 2012).

Forests divided into certain regions in Küçük Menderes basin. While these are in the north of the basin, from east to west, Gölcük around Kiraz, Keldağ around Ödemiş, Çatmadağ around Bayındır, Ovacık and Bayındır, Marmariç around Torbalı, Oyukdağ and Torbalı regions, these are in the south of the basin, from east to west, Denizalan, Beydağ and Çayırdağ in the south of Kiraz; Eğridere, Kümedağ, Kartaldağ and Tire around Tire; Pranga and Selçuk sections around Selçuk. Pranga sections, represented by red pine forests in the upper parts. Shrub formations are dominant in the lower levels. There exist broken red pine groves inside the valley. Again, broken red pine forests characterize the Selçuk region in the southwest. However, broken groves and shrub areas are dominant in northwest (Gözenç, 1978).

The most characteristic habitat types of the area include agricultural lands, salty mud-flats, maquis, wet grasslands, sand dunes, reedbeds, the open water surface of the river and its tributaries, lagoons, brackish and freshwater lakes as well as human settlements. The prevailing plant species of the seasonally flooded salt mud-flats are *Tamarix* sp. and Common Glasswort *Salicornia europea*, while along the shores of inland lakes and lagoons bulrush Typha sp. and on sand dunes along the coastline sea daffodil *Pancratium maritimum,* a Mediterranean endemic, are found. Recently, mainly cotton and different fruits, like peach, apricot and cherry, have been grown in the delta. Most of the surrounding higher ground is covered with olive groves (Bengil et al, 2010).

5.1.4 Human Structure

5.1.4.1 Population

There were 18 residences in Zeytinköy in 1473-77 year, which is on the coast of delta according to first records concerning the study area. It was recorded as 24 residences in 1512, 38 residences in 1529, 34 residences in 1575. In Ayasuluğ residential; There were 3079 residences in 1473-77 years, 5334 residences in 1512 years, 5563 residences in 1529, 1397 residences in 1575 (Telci, 1999).

Table 5.3 Selçuk population datas (Yerel Net, 2016& Işık, 1997).

Year	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2000**	
Total Selçuk	35.736	35.281	34.979	30.342	30.332	27.880	27.801	27.555	27.284	25.414	
Year	**1990**	**1985**	**1980**	**1975**	**1970**	**1965**	**1960**	**1955**	**1950**	**1945**	**1940**
Total Selçuk	19.412	16.242	12.775	12.251	11.101	10.227	8887	8450	6035	4906	4692

In the 1923, according to İzmir province statistics, Selçuk district which contains Küçük Menderes Delta is a district connected to Kuşadası residential. Total population of the centre was 227 person, with its villages the population was 1620 people.

Table 5.4 Population of study areas (Selçuk Kaymakamlığı, 2015)

Village/Years	2009	2010	2011	2012	2013	2014
Barutçu	226	224	220	213	220	184
Zeytinköy	928	901	894	852	862	839

Işık (1997), made, the increase in Selçuk centre in 1950-1960 and 1980-1990 resulted from migrations. The migration after 1950's relates to populations coming from Yugoslavia and Greece. The population of Selçuk increased 3.87% in this period. The increase in population in 1980-1990 period was 4.8%. The reason of this was migration inside the country. The source of the migration consists of with 32.75% Aegean region; with 15.85% inner Anatolia region, with 15.2% East Anatolia region, with 12.7% abroad, with 11.5% southeastward. The increase of population in Selçuk is not intensive.

In summer seasons, the population increases approximately double due to tourism (Report of Ministry of Forestry and Water Management, 2012). In the villages, the population tends to decrease. The reasons can be listed based on the interviews; as follows young families prefers centre of Selçuk although they continued agricultural production in their village and the youth immigrate to other cities so as to study or find job. (Report of Ministry of Forestry and Water Management, 2012). Nearly half of the population works in agriculturel, farming and fishery. A second plurality, service industry; the rest are other facilities (Report of Ministry of Forestry and Water Management, 2012).

5.1.4.2 Settlement

It can be said with the help of both written sources and archaeological datas that the phenomenon of urbanization date back to the Hellenistic era in the basin of Küçük Menderes. The presence of an intensive settlement in the basin is emphasized by Strabon also (Meriç, 1998).

The region, which was one of the 4 large cities in ancient times, was once the centre of Aydın after the Anatolian Selçuk domination and it was observed that literary and scientific activities were alive at this time. As mentioned in the study of Scherzer 1873, İzmir province was divided into 4 towns (Saruhan, Aydın, Menteşe, Sığla), and among these, Sığla town centred at İzmir; residentals are Foça, Menemen, Urla, Çeşme, Bayındır, Ödemiş, Tire and Kuşadası. Selçuk district was connected to kuşadası for that duration. In 1957 it was combined into İzmir province and received the title of district. In the district, Central Municipal Organization services to 5 neighborhood and Belevi Munipicial organization services to 2 neighborhood. Mass residental is dominant in 8 villages connected to district. Villages generally settled on the foothils have the characteristics of edge of the mountan village. There is no Sub- residental units such as avenue hamlet, encampment and farm connected to district (Selçuk Kaymakamlığı, 2015)

5.1.4.3 Agriculture and Farming

Today, in the lands of absolute watered agriculture land where planted agriculture is not done; corn, sunflower, cotton, potato and open field vegetable are done. In the absolute unwatered agriculture lands mostly wheat, barley, chickpeas and sesame seeds are produced. Economy of Selçuk district is based on agriculture generally. In Barutçu and Zeytinköy, olives, figs, citrus, pomegranate and peach production are made within the boundaries of wetlands. Half of the agriculture lands are olive gardens, 26% of the lands are fruit areas, 6% of the lands are citrus, 9% of the lands are fields, 3% of the lands are vegetation, 3% of the lands are vineyards, and the rest are fallow and empty lands (Report of Ministry of Forestry and Water Management, 2012).

Küçük Menderes basin has agriculture-based economy in ancient and medieval ages as it is today.

The greenhouse agriculture is not observed in wetlands. An intensity pasturage does not exist. (Report of Ministry of Forestry and Water Management, 2012).

Geographical structure, flora and climate of the lands within the boundaries of the district have characteristics preventing pasture farming. Whereas, small sheep herding can be developed in the lower garden (Selçuk Kaymakamlığı, 2015). The number of animals is affected by the semi-nomadic nomads population (Telci, 1999). There are 2333 cattle, 10.550 ovine, 240 equidae and total 109.000 winged animals in the district since 2014 (Selçuk Kaymakamlığı, 2015).

5.1.4.4 Industry and Tourism

There are some small industrial organizations in Selçuk and its surroundings. Since 2014, 8 seasonal olive oil factories, 2 cotton gins, 4 dairies and 2 wine factories are operating (Selçuk Kaymakamlığı, 2015). There is a ceramic factory at Belevi. The reason for undeveloped industry in the region is because the economy is based on tourism and agriculture and there are natural, archeological, urban conservation areas (Zaimoğlu, 2003).

In Selçuk district, there are 13 accommodations with business license, 2 restaurant with business license, 15 accomodations with municipal certificate and 20 hostel with municipal certificate (Selçuk Kaymakamlığı, 2015). Soykan mentioned that first hotel for tourism was opened in 1960 in Selçuk. First facility established for the camping in the beginning of 1970s. Ephesus festival began in Selçuk in 1962, international Selçuk camel wrestling began in 1979, 7 touristic facilities were established after 1980 near Pamucak coasts. Selçuk has been the sister city with Lienz, Siegburg, Radoviş, Kobuletti. The Ephesus open air museum is visited by 2 million people per year. Selçuk district has not benefited from tourism despite high income and great number of tourists. Tourists generally visit historical places with daily tours. Kuşadası is preferred for accomodation (Report of Ministry of Forestry and Water Management, 2012).

Main touristic property of Selçuk arises from its historical potential. Ephesus city forms the basis of historical-cultural elements. The city was established 5 times from

14th century B.C. to 2nd century A.D. and the part open to the visitors is known 3rd and centre of the Selçuk district is known as 5th Ephesus (Soykan, 1997).

The symbol of the religious tourism in Selçuk is Meryemana house (Erdemgil, 1993; Soykan, 1997). Other historical artifacts are St. Jean Grave and Church, Byzantine Aqueduct, The Temple of Artemis, Cave of the Seven Sleepers, Inside the castle (Selcuk Castle), İsabey Mosque, mosques, tombs and baths and mausoleum in Belevi (Soykan, 1997).

There exists a project which covers the study area. The ancient road encompassing İzmir and known as Ephesus Mimas road has been opened.

Ephesus-Mimas Road, is the common name of the routes throughout the history in the İzmir peninsula in which the settlement dates back 8000 years.

Figure 5.18 Efes & Mimas way in Pamucak

Six cities of Ionia civilization form the backbone of routes located in the Efes-Mimas road. Walk is 709 km long and 49 racecourse begins from the Temple of Artemis in ancient Ephesus city and finishes in Karaburun which has mythological name Mimas (İzmir Büyükşehir Belediyesi, 2016) (Figure 5.18).

A new center of attraction to be created introducing modern age people with the open-air museum constructed at Ephesus port and channel around the port (Poseidon Tarihi Gemiler, 2015) (Figure 5.19 and Figure 5.20). First stage of the project was completed at 2008 (Esa Komposit, 2014).

Figure 5.19 Ephesus ancient port

Figure 5.20 Ephesus ancient port

There are projects such as 2 big hotels, volleyball courts for international matches and reviving of Ephesus ancient port. Eleman Swamp and salt meadows located at the north of the Selçuk- Pamucak road were allocated by tourism ministry for golf area (Report of Forest and Water Management Ministry, 2012).

5.1.4.5 Mining

In some located places in Selçuk and around it, marble, limestone, iron and coal mines are available. There are lime kilns close to Çamlimanı promontory southwest of Selçuk, south of Selçuk city center and north of the Belevi. Iron mines are located in the areas north of the Selçuk and Küçük Menderes River. Quarries are near, at north and south of the Selçuk city center and there is also a quarry near the highway entrance (Zaimoğlu, 2002).

First underground marble quarry which Ephesians took advantage of, is at Kuşini near Ephesus. Marble of the Temple of Artemis was supplied from here. It was detected that aproximately 16-17 thousand m^3 marble obtained here by Ephesians was not just for city needs, but they were also selling it to other centres of the empire. An equipped marble workshop has been discovered in the excavations that was done at the hillside houses (Türkoğlu, 1999).

5.1.4.6 Forestry

Selçuk forest management units have 11,638.5 Ha forested area, 16,487.1 Ha deforested area and total 28.125.6 area.

Forests were planned as 10 business class connected to 3 main functions according to refurbishment of Functional Forest Management Plan done for Selçuk forest management units forests (Report of Ministry of Forestry and Water Management, 2012).

5.1.4.7 Transportation

Selçuk is on İzmir-Aydın highway. Selçuk is of 75 km from İzmir, 50 km from Aydın, 19 km from Kuşadası, 60 km from Didim, Milet, Priene ruins and 190 km from Çeşme. It is connected to Kuşadası from southwest, Seferihisar, Urla and Çeşme from northwest. Railway constructed in 1860 serves İzmir, Söke, Denizli directions, east provinces of Turkey with İzmir-Afyon connection and İzmir-Ödemiş line indirectly. Air transportation is from the Ephesus airport at Selçuk which has a is of 50 km from İzmir Adnan Menderes Airport. Kuşadası port is 12 km away and the county's rural roads are asphalted (Zaimoğlu, 2003).

A historical road that starts at Selçuk county is King road. Persians built a military road from Iran to Aegean costs in order to achieve political purposes. This road known as King road, in which traces unearthed in Polatlı near Gordion were built from little stones type of "Makadam" having hard and firm floor. According to Heredot, one can go in 93 days by foot from one end to the other side which is ever 2000 km (Akural, 1993; Atilla, 2002).

Historians have some opinions about why the railway was constructed in Selçuk (Ayasuluğ) .While say because there were Virgin Mary house and St Jean grave in Selçuk or it was the best possible route that can be reached in the difficult geographical conditions during the construction of Izmir-Aydın railway, others say there was no better route to go from Küçük Menderes plain to Büyük Menderes plain. During the time construction of İzmir- Aydın railway, some problems occured in the slew which is located northeast of the Küçük Menderes Delta. The 4 km Cellat Lake which was the hardest part of construction, was dried for the fight against malaria (Atilla, 2002). Today, ground-water rising after rainfall on the plains bring temporary wetlands especially for winter seasons.

A station was built under the aqueducts remaining from Roman era an 15 September 1862. The importance of Ephesus city, which was first metropolis of the ancient ages, has been revealed by the construction of railways (Atilla, 2002).

In 1988, Kuşadası Seferihisar road which divides Eleman Swamp into 2 and passes through the area of research was completed (Gencer, 2002).

Selçuk-Efes airport which opened at 1993 in Selçuk, is on the highway of Selçuk-Kuşadası and located at 3 km west from city center (Soykan,1997).

5.1.4.8 Protecting Areas

In 1984, 1000 hectares of forest area including Gebekirse L a k e and Elaman Swamp were declared as The Wildlife Protection Area by the Ministry of Forestry. Pamucak coast was declared as tourism center with the No. 85/10036 by the decision of Council of Ministers at 7 November 1985, boundaries of tourism center were extended by the decison of Council of Ministers No. 87/11608 at 19 March 1987 (Gencer, 2002).

Ancient canal, which provides a connection between Ephesus port and sea, was declared as archaeological site by the Izmir No. 1 protection of cultural and natural heritage committee in 1989. Silik mound at the south of the ancient canal was declared as Archeological Site in 1990 (Report of Ministry of Forestry and Water Management, 2012) (Figure 5.21). In 1991, delta area was declared as natural sites (Sılay and Tomar, 2013).

Figure 5.21 Ancient canal

A section inside the study area was announced as 1st degree archeological protected area by Board of Protection of Cultural and Natural Heritage at 08.20.1991 and with the decision of 3118. In Selçuk - Pamucak, First Degree Natural Protected Area was finalized by the decision of ministry of cultural and natural assets on 18.08.1995, by the law no: 5905 and Second Degree Natural Protected Boundaries had been finalized by the decision of ministry of cultural and natural assets on 07.09.1998, by the law no:7529 (Gencer, 2002).

In addition to the absolute protection of the First Degree Natural Protected Area w.c, wharf, fishing shelter, guard hut in the forest areas, road, parking, restaurants, cafeterias can be built, by the decision of date 1991 and law no 3193 of Izmir No. 1 protection of cultural and natural heritage board. In second degree natural protection areas, tourism and service-oriented applications are available besides protection and development of natural structure (Gencer, 2002) (Figure 5.22).

Figure 5.22 Use of the Küçük Menderes Delta’s coast

Eleman Swamp and Çatal Swamp are wetland areas that have the first priority in protection. According to the conservation of wetlands regulations (30.01.2002/ 24656 official newspaper) wetlands that have the greatest conservation priorities are considered as absolute protection zone (Section:18). Wetland area which mentioned as important conservation area in wetlands includes open water surface of the river mouth, wetland meadows, peat bogs, bushes and agriculture areas in the land base located at the land around "absolute protection zone" within İzmir-Selçuk-Pamucak tourism centre, scaling 1/5000 Ephesus (Selçuk-İzmir) Archaeological Sites Conservation Master Plan was ratified by Tourism Ministry at 17.08.2012 (The report of Ministry of Forestry and Water Management, 2012) (Figure 5.23 & Figure 5.24).

Küçük Menderes has the status of Important Bird Area. Although Küçük Menderes Delta is not Ramsar Area, it is considered have the potential to suit wetlands of international importance.

Figure 5.23 South of the Küçük Menderes Delta's coast

Figure 5.24 North of the Küçük Menderes Delta's coast

CHAPTER SIX
APPLICATION

6.1 Corine Classification for Study Area

Images of years 1975, 1987, 1999, 2010 and 2016 were detected by remote sensing and classified. Areas detected in classification were handled by general averages as of resolutions of the images (Figure 6.1).

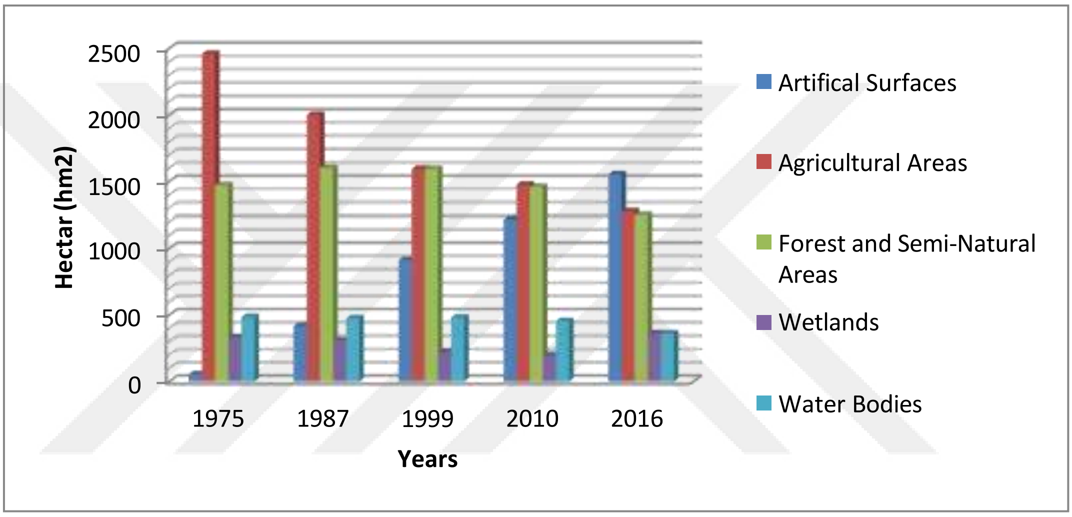

Figure 6.1. Corine areas (Hectar)

Human structures increased, agricultural areas and natural vegetation areas decreased from 1975 to 2016. Wetland areas increased because lakes were dried and converted to swamp from 1975 to 2016. A decrease has occured in water bodies areas including lakes from 1975 to 2016 (Figure 6.1).

Change detection analysis made in 1975 and 2016 years. Changed areas were detected. Darkest color places show the change in opposite directions such as from sea or lake environment to land. Light colors shows areas in which changes did not occur or change direction is not opposite. According to map, change was detected as opposite direction in coast, lake and swamps (from water to land) and as land area transition inside the delta.

6.2 Coastline Changes

6.2.1 Period 1975-1987

According to average measurements taken from sections, changes distance in coastal have an average of 48 meters between 1975-1987 years. The change is in the land way direction. When the shoreline was at forward as it was in updated mouth of the river in 1975, it has been marine environment in 1987 and declined. The decline is 40 meters. Shoreline, which is inside the old mouth of the river, has been land environment for about 50 meter and progressed. Length of the shoreline in 1975 is 6.8 meters. Length of the shoreline in 1987 is 6.6 kilometers. The length shortened 100 meters in 12 years. The change area between shorelines of the years 1975-1987 is 30 hectares (Table 6.1).

Table 6.1 1975 & 1987 Coastline differences

Sections	**1975-1987 Coastline differences**	**Result**
1	33 meters	Forward
2	21 meters	Forward
3	59 meters	Forward
4	51 meters	Forward
5	23 meters	Forward
6	70 meters	Forward
7	63 meters	Forward
8	3 meters	Backward
9	61 meters	Forward
10	42 meters	Forward
11	52 meters	Backward
12	38 meters	Backward
13	33 meters	Forward
14	46 meters	Forward
15	68 meters	Forward
16	55 meters	Forward
17	74 meters	Forward
18	41 meters	Forward
19	13 meters	Forward
20	70 meters	Forward
21	2 meters	Backward
22	30 meters	Forward
23	48 meters	Forward
24	70 meters	Forward
25	30 meters	Forward

Table 6.1 1975 & 1987 Coastline differences (continue)

Sections	1975-1987 Coastline differences	Result
26	61 meters	Forward
27	47 meters	Forward
28	61 meters	Forward
29	94 meters	Forward
30	89 meters	Forward
Average	48.2 meters	

6.2.2 Period 1987-1999:

Change taken from every section between the years 1987 and 1999 is average 26 meters. Marine regression was revealed.

Shoreline regression has been especially in update mouth of river and in its surroundings. It has become the marine environment. The distance is 100 meters.

The 20 meter progress through the inland occured in the old valley mouth of the river. While length of the shoreline was 6.6 meters in 1987, it became 6.5 meters in 1999. Area of change between the shoreline is 17 hectares at 1987-1999 years (Table 6.2).

Table 6.2 1987 & 1999 Coastline differences

Sections	1987-1999 Coastline Differences	Result
1	0 meters	Stable
2	10 meters	Backward
3	10 meters	Backward
4	0 meters	Stable
5	10 meters	Backward
6	10 meters	Backward
7	37 meters	Backward
8	26 meters	Backward
9	50 meters	Backward
10	86 meters	Backward
11	84 meters	Backward
12	110 meters	Backward
13	10 meters	Backward
14	0 meters	Stable
15	21 meters	Forward
16	35 meters	Forward
17	14 meters	Forward

Table 6.2 1987 & 1999 Coastline differences (continue)

Sections	1987-1999 Coastline Differences	Result
18	10 meters	Forward
19	10 meters	Forward
20	22 meters	Backward
21	5 meters	Forward
22	20 meters	Forward
23	26 meters	Backward
24	15 meters	Backward
25	5 meters	Backward
26	15 meters	Backward
27	22 meters	Backward
28	32 meters	Backward
29	40 meters	Backward
30	45 meters	Backward
Average	26 meters	

6.2.3 Period 1999-2003:

In the section measurements between the years of 1999 and 2003, 10.7 meter change occured from marine to terrestrial environment (Table 6.3).

A 30 meter progress occured in the mouth of the river from 1999 to 2003. The mouth of the river's old valley is stationary.

Length of the shoreline in 1999 is still 6.5 km in 2003. The change area between shorelines between of 1999-2003 and 6.2 hectares.

Table 6.3 1999 & 2003 Coastline differences

Sections	1999-2003 Coastline Differences	Direction
1	8 meters	Forward
2	7 meters	Forward
3	0 meters	Stable
4	5 meters	Forward
5	12 meters	Forward
6	15 meters	Forward
7	14 meters	Forward
8	7 meters	Forward
9	7 meters	Backward
10	10 meters	Forward
11	14 meters	Forward
12	0 meters	Stable
13	10 meters	Forward

Table 6.3 1999 & 2003 Coastline differences (continue)

Sections	1999-2003 Coastline Differences	Direction
14	10 meters	Forward
15	16 meters	Forward
16	10 meters	Forward
17	5 meters	Backward
18	5 meters	Forward
19	11 meters	Forward
20	16 meters	Forward
21	22 meters	Forward
22	21 meters	Forward
23	13 meters	Forward
24	22 meters	Forward
25	15 meters	Forward
26	17 meters	Forward
27	15 meters	Forward
28	10 meters	Forward
29	6 meters	Forward
30	0 meters	Stable
Average	10.7 meters	

6.2.4 Period 2003 - 2010

A coastal regression was seen in the sections taken from 2003 to 2010. A 85 meter regression occured in the river's updated mouth from 2003 to 2010, it converted to marine environment. Progression of the river's old valley mouth paused. Length of shorelines between 2003 and 2010 is 6.5 kilometers. Change area was measured as 12 hectares (Table 6.4).

Table 6.4 2003 & 2010 Coastline differences

Section	2003-2010 Coastline Differences	Direction
1	20 meters	Backward
2	17 meters	Backward
3	25 meters	Backward
4	23 meters	Backward
5	23 meters	Backward
6	28 meters	Backward
7	18 meters	Backward
8	23 meters	Backward
9	30 meters	Backward
10	30 meters	Backward
11	75 meters	Backward
12	57 meters	Backward

Table 6.4 2003 & 2010 Coastline differences (continue)

13	37 meters	Backward
14	16 meters	Backward
15	10 meters	Backward
16	16 meters	Backward
17	6 meters	Forward
18	0 meters	Stable
19	26 meters	Backward
20	15 meters	Backward
21	21 meters	Backward
22	23 meters	Backward
23	12 meters	Stable
24	0 meters	Stable
25	0 meters	Stable
26	0 meters	Stable
27	5 meters	Forward
28	0 meters	Forward
29	6 meters	Forward
30	0 meters	Stable
Average	18.7 meters	

6.2.5 Period 2010-2016:

Shoreline progressed towards sea between 2010-2016. Change occured towards land increase direction. The old riverbed's mouth progressed 30 meters in 6 years but stagnation was observed in the updated mouth of the river. Change areas between the shorelines in 2010 and 2016 is 13 hectares (Table 6.5).

Table 6.5 2010 & 2016 Coastline differences

Sections	**2010-2016 Coastline Differences**	**Directions**
1	20 meters	Forward
2	30 meters	Forward
3	26 meters	Forward
4	32 meters	Forward
5	23 meters	Forward
6	10 meters	Forward
7	0 meters	Stable
8	7 meters	Backward
9	0 meters	Stable
10	0 meters	Stable
11	15 meters	Backward
12	12 meters	Forward
13	11 meters	Forward
14	13 meters	Forward
15	37 meters	Forward

Table 6.5 2010 & 2016 Coastline differences (continue)

16	53 meters	Forward
17	41 meters	Forward
18	31 meters	Forward
19	40 meters	Forward
20	23 meters	Forward
21	20 meters	Forward
22	25 meters	Forward
23	15 meters	Forward
24	10 meters	Backward
25	5 meters	Backward
26	8 meters	Backward
27	15 meters	Backward
28	10 meters	Backward
29	0 meters	Stable
30	0 meters	Stable
Average	17.7 meters	

6.2.6 Period 1975-2016

The shoreline length which was 6.8 kilometers in 1975, decreased to 6.4 meters in 2016. The 48 hectares change area was formed in 42 years. The river's updated mouth regressed 214 meters and marine area increased (Table 6.6).

The 90 meter marine transgression occured in the part of construction of ancient port and it has evolved into terrestrial areas. The greatest mobility is in the updated mouth of the river as in the other years.

Table 6.6 1975 & 2016 Coastline differences

Sections	1975-2016 Coastline Change	Directions
1	46 meters	Forward
2	28 meters	Forward
3	60 meters	Forward
4	57 meters	Forward
5	18 meters	Forward
6	51 meters	Forward
7	25 meters	Forward
8	44 meters	Backward
9	25 meters	Backward
10	67 meters	Backward
11	215 meters	Backward
12	202 meters	Backward
13	11 meters	Forward

Table 6.6 1975 & 2016 Coastline differences (continue)

14	58 meters	Forward
15	134 meters	Forward
16	140 meters	Forward
17	130 meters	Forward
18	86 meters	Forward
19	48 meters	Forward
20	62 meters	Forward
21	30 meters	Forward
22	70 meters	Forward
23	36 meters	Forward
24	78 meters	Forward
25	40 meters	Forward
26	56 meters	Forward
27	30 meters	Forward
28	28 meters	Forward
29	56 meters	Forward
30	46 meters	Forward
Average	66 meters	

6.2.7 The Years of 1975-1987-1999-2003-2010-2016:

The longest shoreline detected belongs to 1975 comparing all years. The smallest shoreline detected belongs to the year of 2016. The length of the shoreline shortened 400 meters in 42 years (Table 6.7).

Table 6.7 The average lenght of coast

Years	**The Average Length of Coast**
1975	6.8 kilometers
1987	6.6 kilometres
1999	6.5 kilometres
2003	6.5 kilometres
2010	6.5 kilometres
2016	6.4 kilometres

The 42 years change between 1975-2016 is 48 hectares and the change area between 1975 and 1987 is 30 hectares. These years are second period with greatest changed land. Periods between 1987 and 1999 were calculated as 17.2 hectares. It has a rank of 3rd in change periods. 1999-2003 is the period in which least area changed.

These averages correspond to annualy 3 hectares change area within 42 years. It shows the 42 years of coastal change. This change occured in land direction (Table 6.8, Table 6.9, Table 6.10 & Table 6.11).

Table 6.8 Difference areas

Years	**Differences Areas (hectar)**
1975-1987	29.7
1987-1999	17.2
1999-2003	6.2
2003-2010	12
2010-2016	13
1975-2016	48
Average	3

Table 6.9 Back next image

Sections	**Back Image**	**Next Image**	**Difference**
1	1975	2016	47 meters
2	1975	2016	28 meters
3	1975	1987	60 meters
4	1975	2016	57 meters
5	2010	2003	24 meters
6	1975	1987	70 meters
7	1975	1987	63 meters
8	2016	1975	46 meters
9	2016	1987	85 meters
10	2010	1987	111 meters
11	2016	1975	214 meters
12	2010	1975	210 meters
13	2010	2003	37 meters
14	1975	2016	58 meters
15	1975	2016	134 meters
16	1975	2016	140 meters
17	1975	2016	131 meters
18	1975	2016	86 meters
19	1975	2016	49 meters
20	1975	1987	70 meters
21	1975	2016	31 meters
22	1975	2003	70 meters
23	1975	1987	48 meters
24	1975	2016	79 meters
25	1975	2010	40 meters
26	1975	2010	61 meters
27	1975	1987	47 meters
28	1975	1987	61 meters
29	1975	1987	95 meters
30	1975	1987	90 meters
Average	74.7 meters		

Table 6.10 Coastline differences

Years	Coasline Differences (Average)
1975-1987	48.2 meters
1987-1999	26 meters
1999-2003	10.7 meters
2003-2010	18.7 meters
2010-2016	17.7 meters
42 years average	3 meters

Table 6.11 Maximum and minimum sections coordinates

Sect.	Max. and Min. Coordinates	Sect.	Max. and Min. Coordinates
1	27°15'8"E-37°57'41"N and 27°15'9"E-37°57'42"N	**16**	27°16'18"E-37°55'57"N and 27°16'23"E-37°55'59"N
2	27°15'12"E-37°57'36"N and 27°15'13"E-37°57'37"N	**17**	27°16'22"E-37°55'45"N and 27°16'28"E-37°55'47"N
3	27°15'16"E-37°57'30"N and 27°15'18"E-37°57'31"N	**18**	27°15'27"E-37°55'32"N and 27°16'30"E-37°55'34"N
4	27°15'20"E-37°57'23"N and 27°15'23"E-37°57'24"N	**19**	27°16'29"E-37°55'25"N and 27°16'31"E-37°55'25"N
5	27°15'25"E-37°57'14"N and 27°15'27"E-37°57'15"N	**20**	27°16'30"E-37°55'19"N and 27°16'34"E-37°55'20"N
6	27°15'27"E-37°57'10"N and 27°15'31"E-37°57'11"N	**21**	27°16'31"E-37°55'16"N and 27°16'33"E-37°55'16"N
7	27°15'31"E-37°57'1"N and 27°15'34"E-37°57'2"N	**22**	27°15'32"E-37°55'11"N and 27°16'35"E-37°55'12"N
8	27°15'33"E-37°56'56"N and 27°15'35"E-37°56'58"N	**23**	27°16'34"E-37°55'3"N and 27°15'36"E-37°55'4"N
9	27°15'34"E-37°56'51"N and 27°15'37"E-37°56'52"N	**24**	27°16'34"E-37°55'0"N and 27°16'38"E-37°55'1"N
10	27°15'36"E-37°56'44"N and 27°15'41"E-37°56'46"N	**25**	27°16'35"E-37°54'55"N and 27°16'37"E-37°54'55"N
11	27°15'44"E-37°56'31"N and 27°15'50"E-37°56'37"N	**26**	27°16'36"E-37°54'50"N and 27°16'39"E-37°54'51"N
12	27°15'46"E-37°56'25"N and 27°15'52"E-37°56'31"N	**27**	27°16'36"E-37°54'49"N and 27°16'38"E-37°54'49"N
13	27°15'58"E-37°56'22"N and 27°15'56"E-37°56'23"N	**28**	27°16'35"E-37°54'46"N and 27°16'38"E-37°54'47"N
14	27°16'4"E-37°56'18"N and 27°16'6"E-37°56'20"N	**29**	27°16'35"E-37°54'43"N and 27°16'39"E-37°54'44"N
15	27°16'12"E-37°56'8"N and 27°16'18"E-37°56'10"N	**30**	27°16'35"E-37°54'40"N and 27°16'39"E-37°54'41"N

CHAPTER SEVEN
RESULTS

The results for 30 sections were interpreted and the section interpretations are defined as old mouth and the current mouth of the Küçük Menderes River.

When we look at the coastline from 1975 to 1987, we see that jagged lines of the coastline were filled. A 100 meter abbreviation of shoreline illustrates this fill. From 1975 to 1987, ponds in the water; caused sediment movement and this is detected by slow headway in terrestrial direction. Between 1975 and 1987, the area surrounding the Küçük Menderes River was not developed and the scale of buildings for tourism purposes was less than today in the Corine classification mapping, interventions made by the local inhabitants were for agricultural purposes not for tourism. The regression in the current mouth of the river from 1975 to 1987 developed due to wave abrasion. The abundance of wetlands in the Corine classification shows the prosperity of rivers and ground-water. This prosperity led to activity in coastal areas. The area was shaped by both marine and terrestrial based water activities.

The length of coastline, which was shortened by 100 meters between 1987 and 1999, shows that indentations and protrusions were decreased. A slowdown occurred in the rate of deposition, which in turn slowed down the development rate of the delta. River current values are scarce for this time period, compared to previous periods. This reduction in the current values could have affected the amount of sedimentation at the updated river mouth. Compared to the old river mouth there has been less progress. The current mouth of the river is exposed to more seasonal changes than the old mouth due to a variety of nutritional sources. This progress of the current mouth may come to a standstill. However, because nutrition resources of old mouth are weaker than the other mouth, it leaves itself to the activities of wave erosion and deposition.

Movement in the terrestrial environment is more stable and faster compared to the current mouth. As illustrated in the Corine map, the swamp areas in the delta were drained and this decrease is continuing for Eleman Swamp and Gebekirse and Çatal Lakes. The main factor fort this condition is the pressures a population increase has put on the environment.

The river current and sediments carried by the river accumulation accelerated at the mouth of the river and environs from 1999 to 2003. The progression may be observed in a cross section taken across the points is proof of this. A cessation in the abbreviation in the coastline at present shows that wave abrasion activities have decreased.

Beydağ Dam construction was completed in 2007 and ancient port reconstruction was completed in 2008. Thus, important changes have occurred from 2003-2010. Quay was constructed inside the old riverbed for the reconstruction of the ancient port. Old river mouth was reopened at the closed sand bar. The mouth is 6 meters. The waterway has been revived after opening the channel to the sea and ancient port connection. The length of the channel opened for waterway between quay and ports is 140 meters long and 5 meters wide. The length of the quay, which is on the right side of the port, is 60 meters A great deal of accumulation had occurred parallel to the quay and 30 meters in length. This project is the most important artificial activity inside the coastline during the time span that this study encompasses.

According to a cross-section of the coastline, the amount of change observed may be ranked as the greatest from 1975-1987, next 1987-1999 and third greatest change from 2003 to 2010. A regression in the reservoir decrease is also observed from 2003 to 2010. The progress area is in the old river valley environment. Human interventions have also increased in the stable delta area. Examples of these interventions are intensive land use and drought conditions which are observed in the draining of Eleman Swamp and decrease in the water tables of Çatal and Gebekirse Lakes. The proof is agricultural and settlement areas which seem stream flow graphic and Corine maps.

Length of the delta coast was shortened 100 meters from 2010 to 2016 due to the construction of the Beydağ Dam and reopening of the ancient port. During this period, 13 hectares, which was half of the total amount of change for the time period analyzed, were changed. Stability that started in the previous years south of the delta is continuing at present. As seen in the Corine mapping in 2016, the lakes reached their minimum boundaries for the study time period. There are increases in areas of swamp since the lakes dried up. There is also drying in old swamps. There has been an increase in agriculture and artificial intelligence. This increased pressure on the basin has slowed down the coastal change rate.

The results obtained from the study area shows that there has not been any serious coastal erosion during the selected 42 years of the period. The map of the coastline of 1975-2016, soil erosion may be observed and a flattening of the coastline is observed. The length of the coast decreased 400 meters from 1975 to 2016. Also, 48 hectares of land underwent a change over this 42 year period.

The previous research results support the reason for the regression in the delta mouth (Cita et al., 1977; Kraft et al., 1980; 1981; Gökçen et al., 1990). The reasons for this regression are aerial and coastal pressures in the study area combined with climate changes. The geological and morphological processes such as tectonic effects contribute to the delta progression.

In the other studies (Darkot, 1938; Eiesma, 1962; Gökçen et al., 1990), It was detected that delta development is not river dominant but wave dominant. This wave dominance was also observed between 1975-2016. Evidence of the wave dominance is seen in the annual recession of the growth in the coastline and the delta.

In the field studies, withdrawal of sand and gravel was not observed. Sand and gravel removal from the basin, lake, pond or other similar facilities affect the amount of sediments and triggers coastal change.

Corine classification maps were used for the safety of the research. The fields on these maps are also concurring with coastal lines drawn from Landsat images. The features of Corine classes and boundaries of classes in the delta have assisted in understanding the reasons for the changes in the coastline.

CHAPTER EIGHT
DISCUSSION AND CONCLUSION

Materiel affecting delta development is due to erosion. Studies of combating erosion for Küçük Menderes Basin, done systematically and continuously, will continue up to the year 2040 in the medium term. Monitoring of current and quality of groundwater and surface water, reuse of treated wastewater, monitoring and control of studies of decreasing water use for agricultural purposes are some of the studies that are required to combat erosion spring this midterm period (Tubitak MAM Çevre Enstitüsü, 2011). Short term effects of reopening the ancient channel and ancient port Project to coastal change were determined. However, further studies should be done to determine the effects on the ecological environment other than the physical changes for ongoing processes.

Government Department of Waterworks foresees the construction of 4 dams on the river and on its arms in order to irrigate ten thousand hectares in the areas upstream. These dam and irrigation projects will significantly decrease the river flow and may lead to the draining of Akgöl and Eleman Swamps. Another change in the area that has attracted attention as important as coastal change is the draining of swamps and lakes in during the 42 years period that was analyzed and mapped.

The number of touristic hotels and holiday residences has grown and threaten the study area. Furthermore, a proposal for the construction of a golf course on the coastal meadow in the south delta will lead to problems in the coastal area. The potential affects of this Project need to be investigated further. Illegal poaching of the wildlife in the area is threatening the ecosystem of the area.

Chemical industrial waste associated to districts and towns of the Küçük Menderes Basin and household waste has drained into the Küçük Menderes River without any filtering. This has resulted in advanced pollution and damage to the biological diversity of the area. Güler (2002), also pointed out that these areas should be protected regarding all living things. A solution to the pollution observed in the field studies has not been found despite the efforts of local officials. The effects of the local airport to the ecosystem of the area should be examined even though the airport is rarely used.

With the construction of the Ödemiş Beydağ irrigation Project, 37.6 km of the riverbed will be decreased to 29.5 km and thus 940 decare area will be reclaimed for agricultural purposes. The possible effects of this project should be researched further.

Güler (2002), also mentioned that the increase in tourism is another pressure to the ecosystem and passive recreation areas may reduce the tourism pressure in the area. Güney and Hepcan (1999), pointed out that a specific region should be alloted for tourists and the rest must be taken under protection in order to prevent tourism pressure.

In the identification of coastline change, it is possible to use different methods separately or a combination of methods in the same study. The diversity of methods increases the reliability.

Integrated Watershed Management is the operation of planning, management and application of every facility with the purpose of sustainable use of natural resources in basin, taking into account social, political, economics and corporate factors inside the basin. The main elements of a watershed protection plan is the preparation of the action plan, including characterization of the basin, abstract of important pressure and impacts of human activities, identification of protection areas, formation basin maps, identification of protection action plan according to the outputs, informing the public, connecting with institutional stakeholders, the results of the exchange and sharing of ideas (Şeker et al., 2009). For the action plans, Geographic Information Systems and Remote Sensing are the main tools.

Using Landsat images in studies requiring high resolution affects the accuracy of the study. Analysis steps and analysis results apply for the aim of resolving the pixel problem and increasing the accuracy was encountered when comparing the Landsat images in different resolutions in this study and this information will be helpful in making decisions for the display preferences of later studies.

Although the coastal change in the study area was a short period of 42 years when geomorphological development time is taken into account, it is actually a sufficient interval to examine the unnatural processes due to increased amount of human activity in terms of the rate of change. The increase in anthropogenic activities on nature accelerates change as well as control.

Sustainability of the Küçük Menderes Delta, which is known world wide due to historical values it has and which has hosted many civilizations throughout the history, should be actualized for the protection of the natural and cultural interaction without regarding the advantages in which unity of the delta has provided and will provide.

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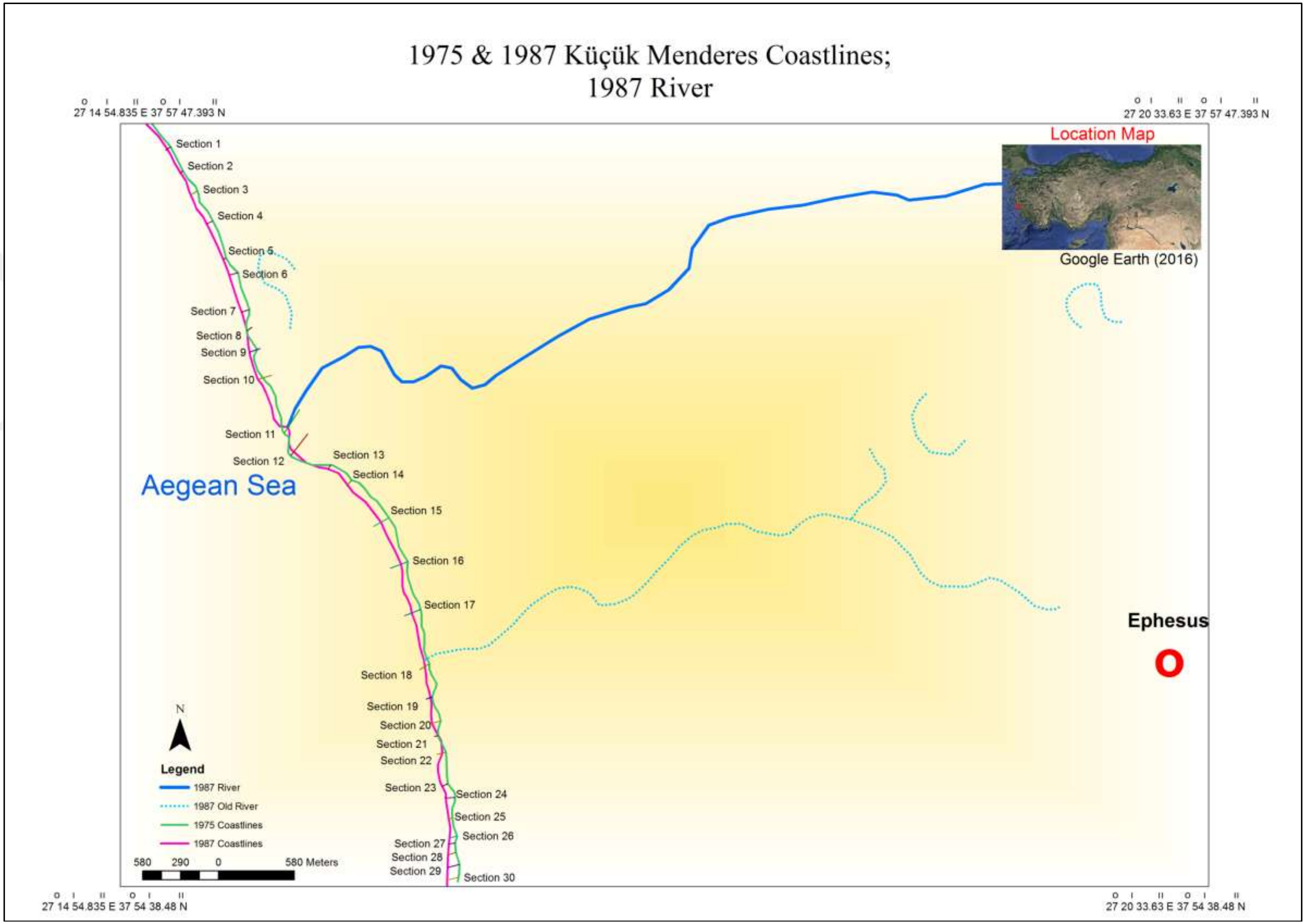
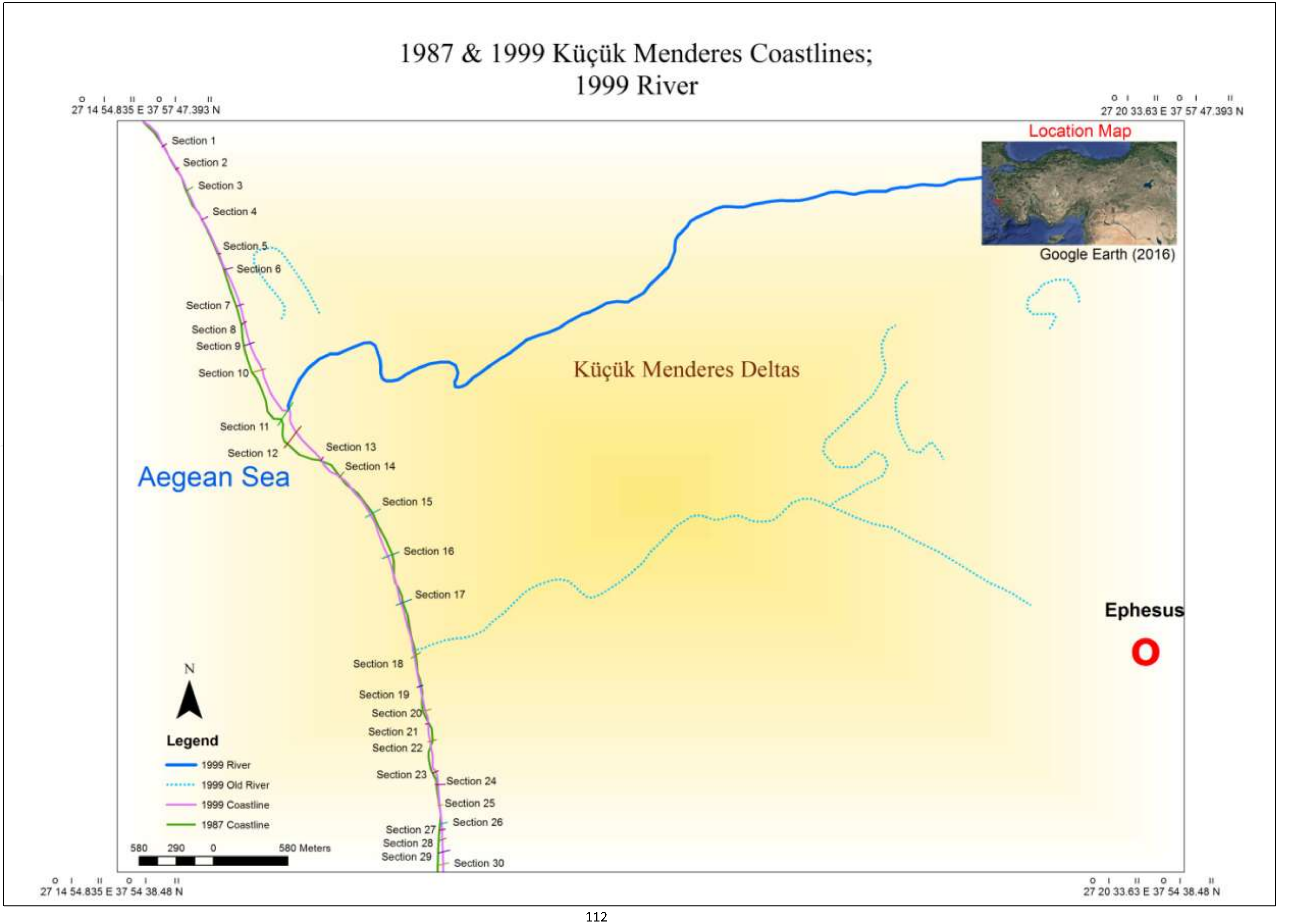
APPENDICES

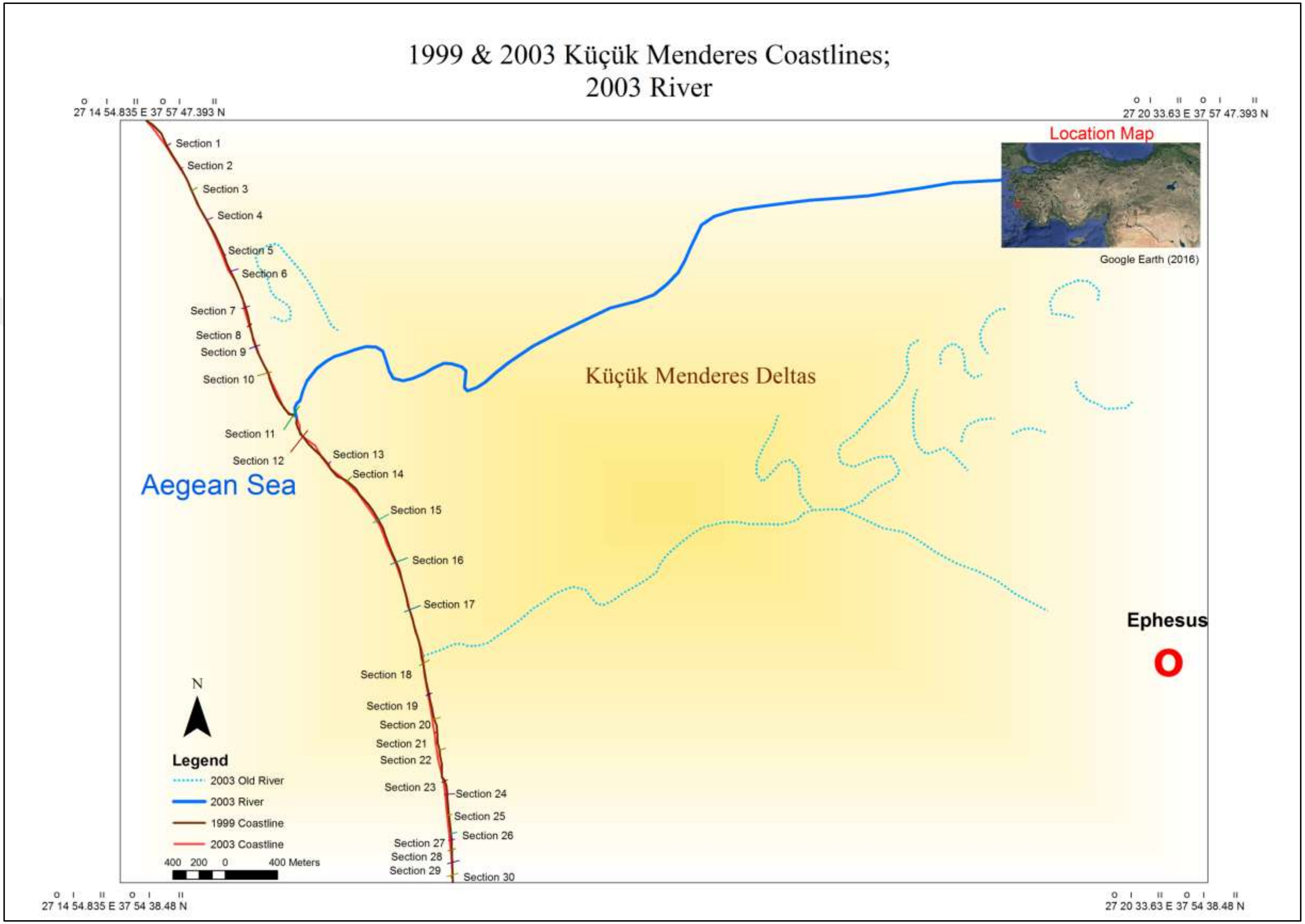
APPENDIX 1 1975 & 1987 Küçük Menderes Coastlines and 1987 River's Map



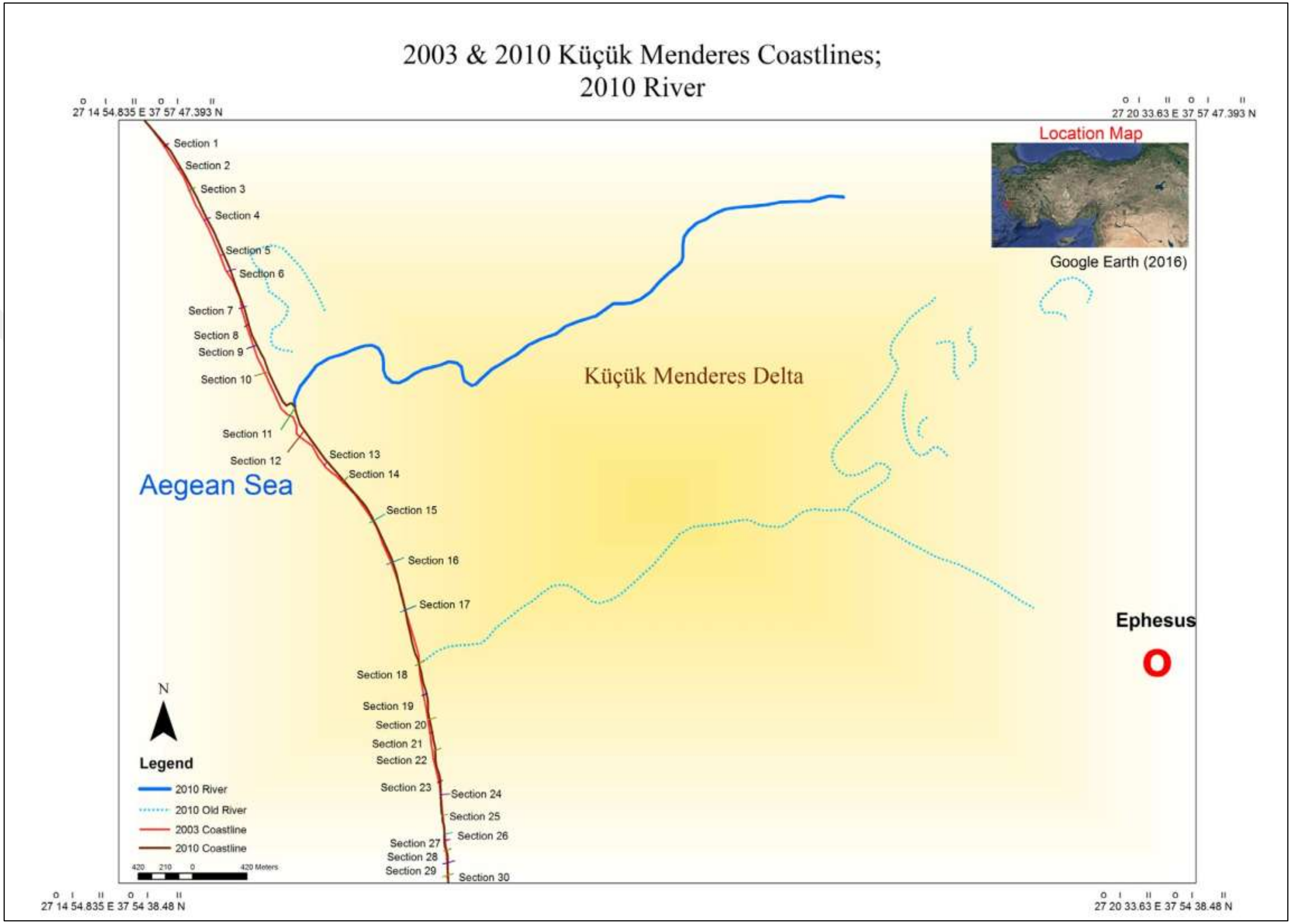
APPENDIX 2 1987 & 1999 Küçük Menderes Coastlines and 1999 River's Map



APPENDIX 3 1999 & 2003 Küçük Menderes Coastlines and 2003 River's Map

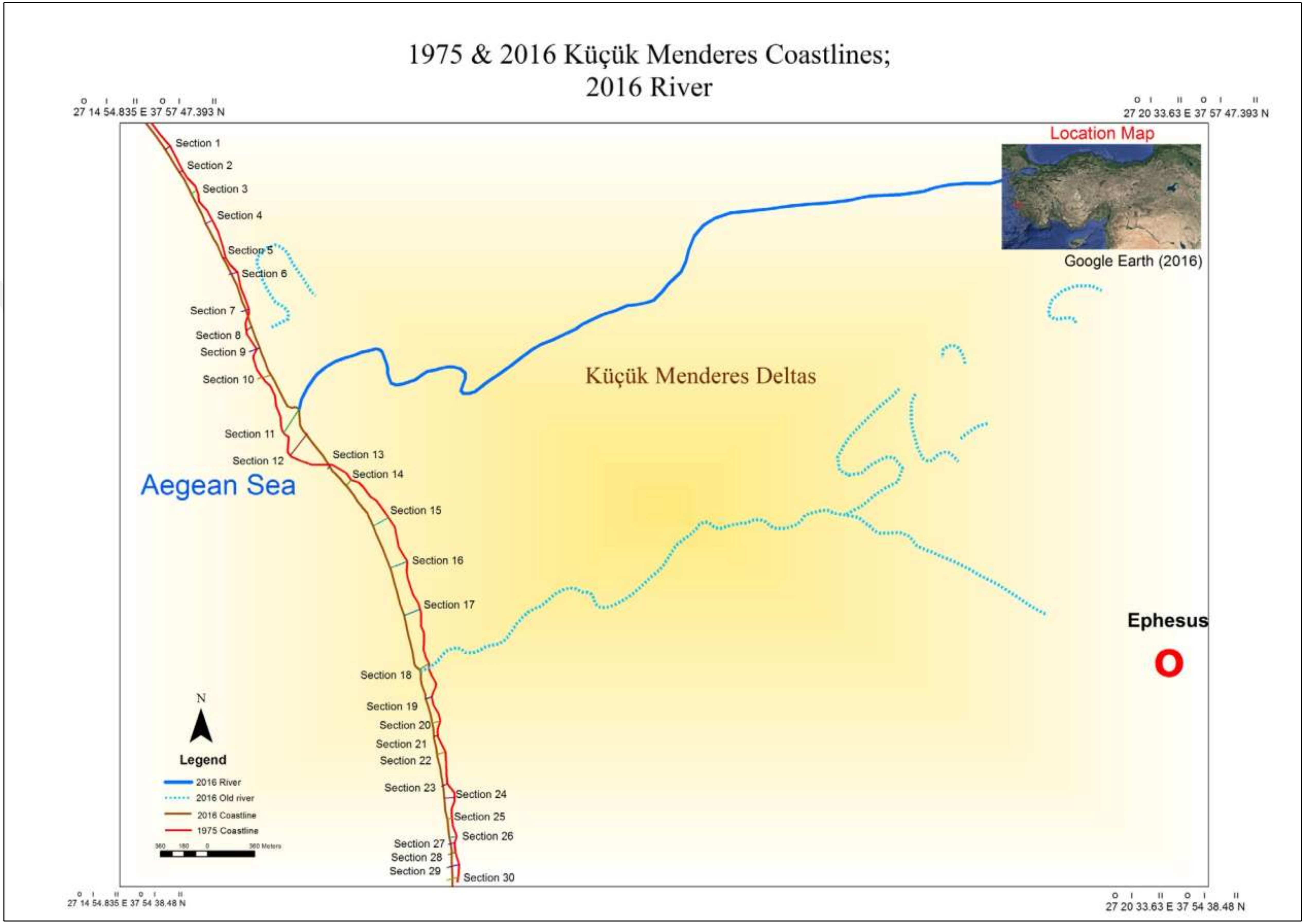


APPENDIX 4 2003 & 2010 Küçük Menderes Coastlines and 2010 River's Map



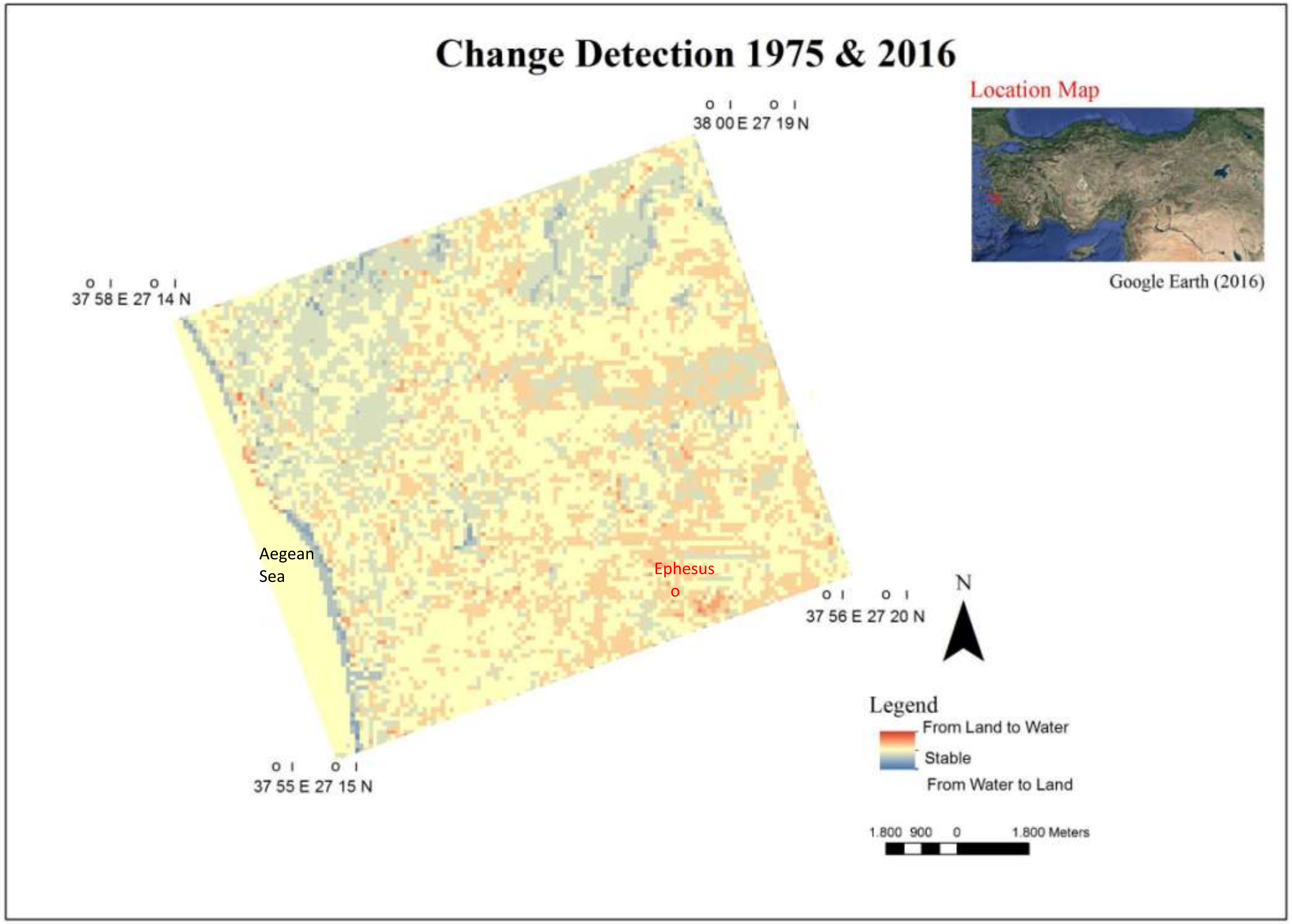
APPENDIX 5 2010 & 2016 Küçük Menderes Coastlines and 2016 River's Map

APPENDIX 6 1975 & 2016 Küçük Menderes Coastlines and 2016 River's Map



APPENDIX 7 1975, 1987, 1999, 2003, 2010 & 2016 Coastlines Map

APPENDIX 8 Change Detection 1975 & 2016 Map



APPENDIX 9 1975, 1987, 1999, 2003, 2010 & 2016 Landsat Images Corine Classification Map