# RELATIONSHIPS BETWEEN TOPOGRAPHY AND KERKENES (TURKEY), A GIS ANALYSIS

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Approval of the Graduate School of Social Sciences

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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# ABSTRACT

RELATIONSHIPS BETWEEN TOPOGRAPHY
AND KERKENES (TURKEY), A GIS ANALYSIS



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This study investigates the effect of topography in ancient city "Kerkenes" using Geographic Information Systems (GIS).

Kerkenes, an Iron Age city located on a batholith in Yozgat province, Turkey, was chosen because of its exceptional size, short life and the availability of extensive data. Approximately seven kilometres of city wall in Kerkenes, including towers and seven gates, enclose 2.5 km².

The research comprises topographic analysis and settlement data analysis. Elevation values collected by Global Positioning System (GPS) and 1:25000 scaled topographic maps are used to create and analyze elevation, slope and aspect maps. Basic statistics of the city wall, towers and gates are calculated and a procedure is then followed to examine the city wall, towers and gates to understand reasons for the line of the city wall, the uneven distribution of gates, the position of each individual gate, the positions and spacing of towers, and the water catchments.

Advantages of the elevated site of Kerkenes for the foundation of a new capital within the region are demonstrated.

The GPS data do not show statistically significant differences then the 1:25000 scaled topographic maps in regional scale, especially analyzing the elevation and slope data.

Topographic analyses reveal that approximately 75% of the city wall coincides with the topographic divide which shows the city walls may serve both for urban water collection and for defence.

City wall has divided into two as East section and West section by a north-south axis from the north end point of the city. There are 41 and 27 towers are detected on the West and East section, respectively. Towers on the West section are more closely spaced than the East section. There are also two and five gates in the West and East section, respectively. The East section of the city wall overlaps with the topographic divide only in the northeastern part. This situation can not be traced along the southeastern part of Kerkenes which may be the reason to include the strategically important two higher altitude areas (Kiremitlik and Kale) inside the city. The city wall in the West section, however, runs along the topographic divide which affects the number and the distribution of the towers.

**Keywords:** Kerkenes, GIS, City Wall, Topography, Turkey

# ÖZ

TOPOĞRAFYA İLE KERKENES (TÜRKİYE)
ARASINDAKİ İLİŞKİ, CBS ANALİZİ

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Yüksek Lisans , Yerleşim Arkeolojisi Bölümü
Tez Yöneticisi: Yrd. Doç. Dr. Geoffrey D. Summers
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Bu çalışma, topoğrafyanın eski bir yerleşim yeri "Kerkenes"e olan etkisini Coğrafi Bilgi Sistemleri (CBS) yöntemleri ile araştırmaktadır.

Türkiye'de Yozgat ilinde bir batholit üzerinde bulunan Kerkenes sıra dışı büyüklüğü ve kısa yaşamı ile erişilebilir kapsamlı verilere sahip olması nedeniyle seçilmiştir. Yaklaşık yedi kilometre olan şehir duvarı, kuleler ve yedi kapıyı içermekte ve yaklaşık 2.5 $km^2$ lik bir alanı kaplamaktadır.

Bu araştırma topoğrafik ve yerleşim verisi analizlerinden oluşmaktadır. Küresel Konumlandırma Sistemi (GPS) ve 1:25000 ölçekli topoğrafik haritalardan elde edilen veriler yükseklik, eğim ve bakı haritaları üretilmesinde ve analizlerinde kullanılmıştır. Şehir duvarı, kuleler ve kapıları içeren temel istatistik bilgileri hazırlanmıştır. Şehir duvarı, kuleler ve kapılar ile şehir duvar hattı, kapıların düzensiz dağılımı ile her bir kapının konumu, kulelerin pozisyonları ile dağılımı ve su toplama havzalarını incelemek için bir yöntem izlenmiştir.

Bölgedeki yeni başkentin temeli olan yüksekte kurulmuş Kerkenes şehrinin avantajları gösterilmiştir.

GPS ile 1:25000 ölçekli topoğrafik harita bilgileri arasında özellikle bölgesel anlamda üretilecek yükseklik ve eğim verileri açısından istatistiksel anlamda bir farklılık bulunmadığı belirlenmiştir.

Topoğrafik analizler sonucunda şehir duvarının %75 oranında topoğrafik bölüm çizgisini takip ettiği anlaşılmış ve bu özelliğin şehir suyu toplanması ve şehir savunmasına hizmet ettiği düşünülmektedir.

Şehir duvarı Doğu ve Batı olmak üzere duvarın kuzey ucundan kuzey-güney doğrultusunda bölünmüştür. Batı kesimde 41 adet, Doğu kesimde de 27 adet kule olduğu ve Batı kesimde kulelerin daha sık aralıklarla inşa edildikleri tespit edilmiştir. Batı kesimde 2, doğu kesimde ise 5 adet kapı olduğu belirlenmiştir. Şehir duvarının Doğu kesimi topoğrafik bölüm çizgisini sadece kuzeydoğu kesiminde takip etmektedir. Kerkenes'in güneydoğu bölümlerinde bu durumun izlenmemesi alanda stratejik öneme sahip olduğu düşünülen iki adet yüksek alanın da (Kiremitlik ve Kale) şehrin içine katılmak istendiği sonucunu doğurmuştur. Şehir duvarının Batı kesimi ise topoğrafik bölüm çizgisi ile tamamen örtüşmektedir ve bu durum Batı kesimdeki kule ve kapı sayıları ile dağılımlarını etkilemektedir.

**Anahtar Kelimeler:** Kerkenes, CBS, Şehir Duvarları, Topoğrafya, Türkiye

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No matter how this thesis is attributed, its contents are actually the fortunate product of a concerted effort by a large, multi-national team of mentors over a 13 year period. I sincerely thank all of the current and former members of the Kerkenes Project. Detailed information can be found at: www.kerkenes.metu.edu.tr

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1:25000 topographic maps provided by Geology Department, METU.

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# INTRODUCTION

## 1.1. PURPOSES AND SCOPE:

The purpose of this thesis is to demonstrate the connection between the topographical characters of the Kerkenes region with the ancient settlement pattern at Kerkenes using remote sensing methods with Geographic Information Systems (GIS). Kerkenes is an Iron Age city which is located in Yozgat province, in Central Anatolia (Figure 1.1). The site is registered as 1$^{st}$ degree of Archaeological Site by the Kayseri Kültür ve Tabiat Varlıklarını Koruma Kurulu[1] in 1989 granted by the article of 16.8.1989/481.

Remote sensing methods have been used at Kerkenes since 1993. These remote sensing methods at Kerkenes have revealed evidence of city planning which includes a network of streets, a zone of public buildings, walled and terraced urban blocks and sophisticated water system.

In this thesis GIS analysis is applied to remote sensing data, collected from archaeological remains on Kerkenes, for understanding the relation between topography and the location of Kerkenes and city wall. The research comprises topographic analysis and settlement data analysis. Topography of Kerkenes and its region were analyzed using two data sets to create elevation, slope and aspect maps. A method is developed to examine the city wall, towers and gates to understand reasons for the line of the city wall, the uneven distribution of gates, the position of each individual gate, the positions and spacing of towers, and the urban catchments. To do this the city wall, and the areas, elevations, and slope and angle values between towers are evaluated and basic statistics applied for analysis.

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[1] The Board for the Protection Culture and Natural Heritage of Kayseri


Source: http://www.kerkenes.metu.edu.tr/kerk1/01intro/-location/index.htm

Figure 1.1. Location map of Kerkenes

In this study the location of Kerkenes is analyzed using GIS to understand the reasons that lay behind the choice of this particular place and location and distribution of the towers and gates along the city wall. This study will be the part of a wider research.

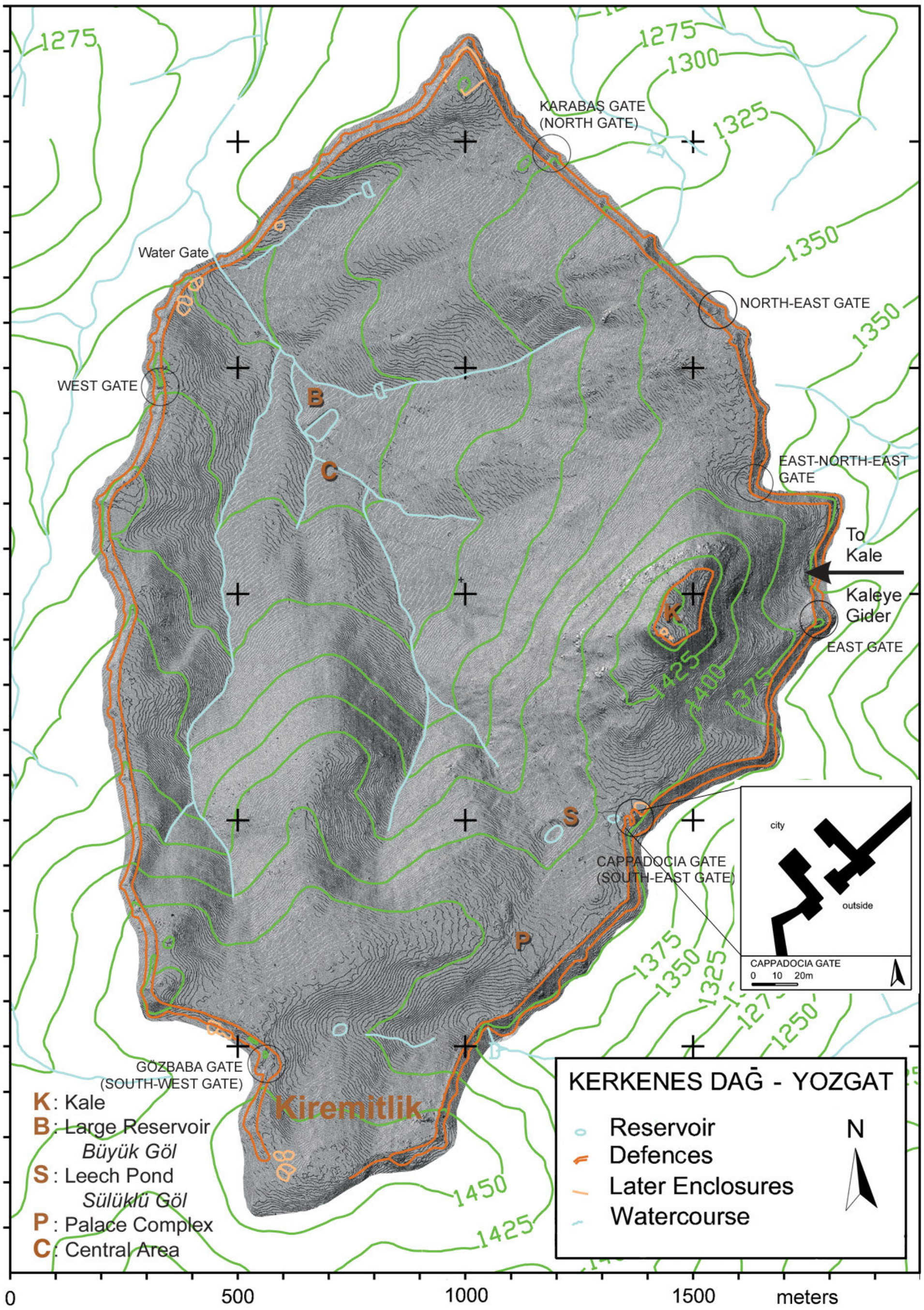
## 1.2. STUDY AREA

### 1.2.1. Kerkenes and its region

Kerkenes is an Iron Age ($7^{th}$-$6^{th}$ centuries B.C.) city located on a low granite batholith in Yozgat province, Turkey (Figure 1.1). It is in the territory of Şahmuratlı village (Figure 1.2) which is located at a distance of 12 km from Sorgun, Yozgat. The city is surrounded by approximately seven kilometers of city wall, pierced by seven gates and enclosing an area of 2.5 km² (Figures 1.3 and 1.4).

Figure 1.2. Şahmuratlı village from the Kale. (Photographed by Nurdan Atalan)

The Kale (Figures 1.5 and 1.6) commands the best panaromic view over the region and in good weather conditions the view extends as far as the Erciyes Dağ near Kayseri (Figure 1.7). The landscape which spreads from the Kale towards the west (Yozgat) and north is mountainous with higher peaks surmounted by tumuli.




Source: Adapted from Summers and Summers 2001: p. 14

Figure 1.3. A detailed map of Kerkenes.

Source: The Kerkenes Project Archive-93slhb0233

Figure 1.4. Balloon photograph showing Kerkenes (in the middle) and its surroundings. Photograph was taken from Cloud 9 Cappadocia Hot Air Balloon in 1993.

Figure 1.5. Kerkenes from the road of Sorgun to Şahmuratlı village. (Photographed by Nurdan Atalan)

Figure 1.6. The view of the Kale from Şahmuratlı village (Photographed by Nurdan Atalan)

Source: The Kerkenes Project Archive-02dpjv0811

Figure 1.7.View from the Cappadocia Gate, Erciyes Dağ can be seen.

The largest tumulus, which is called Gözbaba, lies southward and is visible from the Kerkenes. The Konak Su flows with its many tributaries from Kerkenes. The Eğri Öz Suyu valley which lies on the north of the Kerkenes channels snow and rain water coming from the mountain (Summers et al. 2001: 341).

Numerous tumuli can be seen on the mountains as well as on the slopes of the Kerkenes. A steep mountain called Sivri Dağ protrudes from the plain at about 23 km from the site (Osten 1928: 86).

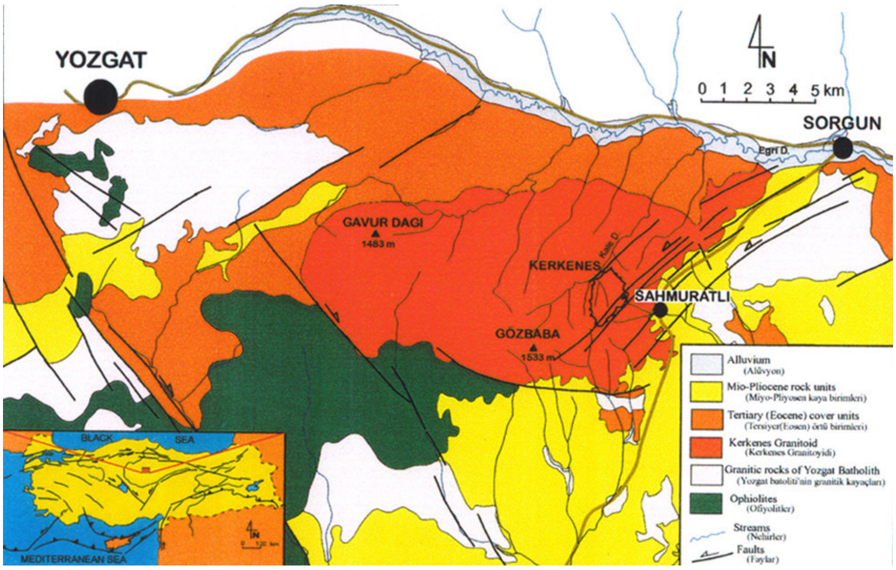
Figure 1.8 shows the map of the Kızılırmak region which includes Kerkenes. That can be seen from the map, Kerkenes has a special location which seems to be the center of the Kızılırmak (Halys) region.


Source: Adapted from Tübinger Atlas des Vorderen Orients (TAVO) 1991

Figure 1.8. Tübinger Atlas des Vorderen Orients (TAVO) map of the Kızılırmak region shows settlements between 700-500 B.C.

### 1.2.2. Geology and Geomorphology of Kerkenes

Central Anatolia is in the Alpine-Himalayan system. The Central Anatolian Crystalline Complex (CACC) is the combination of magmatic, metamorphic and ophiolitic rocks and includes Kırıkkale, Yozgat, Kırşehir, Sivas, Nevşehir, Kayseri and Niğde triangle. The Upper Cretaceous on the northern part of this complex is highly fractured due to continuous deformation. The CACC can be divided into three principal lithologic units; Central Anatolian Metamorphics, Central Anatolian Ophiolites and Central Anatolian Granitoids. Among these granitoids dominate the geology of the CACC: the Yozgat batholith comprises predominantly granitic rocks and covers an area of about 750 km². Kerkenes granitoid belongs to the composite Yozgat batholith group and it is the north-eastern sub-unit of the Yozgat batholith and covers an area of about 130 km². (Figure 1.9). The walls and ruins at the site lie over the Kerkenes Granitoid (Figure 1.9) (Demirel 2004: 11-13 and 16, 20, Erler and Göncüoğlu 1996: 718).




Source: Aydın 2004: Figure 1.2

Figure 1.9. Map showing the geology, main drainage system and major faults at the Kerkenes region.

The distribution of the rock units in the region are controlled by the NE-SW trending faults. As granitoids are highly resistant to erosion they are forced to be raised by the faults and therefore occupy topographically high erosional areas such as hills. The formation of a very steep slope on the eastern edge of the fault zone is due to a large vertical displacement. The terrain where the ancient city is located has a gentler slope and dissected by surface water and tributaries. Granites are generally weathered and lower areas are covered by granitic soil. Faults and fracture systems also control the water resources (Erler and Göncüoğlu 1996: 715, 715 and 718).

### 1.2.3. History of Research at Kerkenes

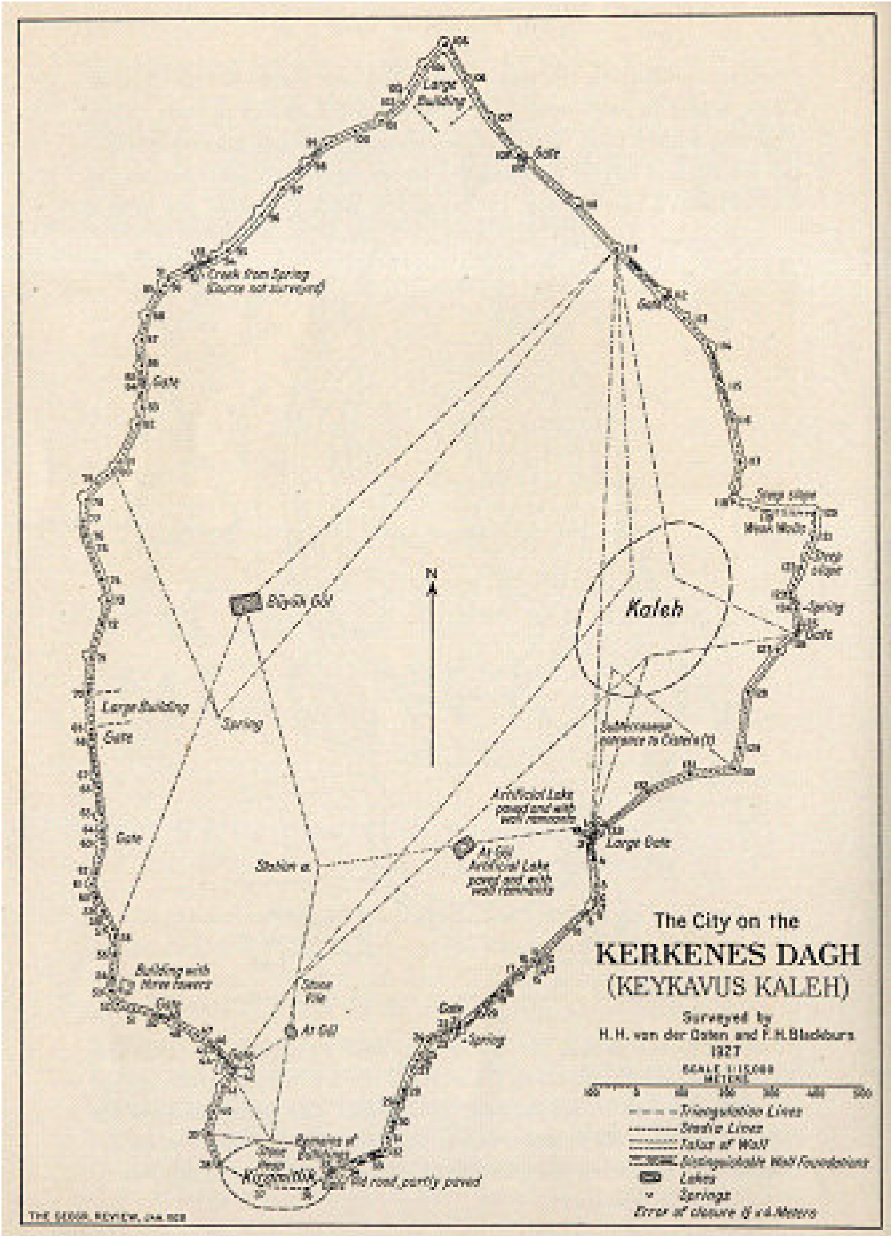
The earliest description of Kerkenes was given by J.J.C. Anderson in 1903, he identified it with Galatian Mithradation. H.H. von der Osten and F.H. Blackburn visited the site in 1926 and in the following year they produced a remarkably accurate map in three days (Figure 1.10) (Osten 1928:91). E. Forrer visited the site in 1926. In 1928 Erich Schmidt, who was working for the Alişar Höyük expedition, was granted a permit for preliminary excavations in Kerkenes and dug 14 trenches in a week (Schmidt 1929: 223).

Although a number of scholars visited Kerkenes after Schmidt's prompt publication of his results, however no work was carried out until 1993. That year Geoffrey and Françoise Summers began the first survey season with a small team (Summers and Summers 1998: 25).

Blimp photographs of the site were taken from Helium blimp using remote controlled camera and high altitude photographs of the site were taken from Cloud 9 Cappadocia hot air balloon in 1993 to get a general view of archaeological site (Figures 1.4) (Summers 1995: 569).

To use aerial photographs for archeological sites photographs need to be corrected to avoid camera distortion, so that the plan of the remains can be used for the studies. This process is called photorectification. The photographic rectification programme AERIAL was donated to the Kerkenes Project by John Haigh of the University of Bradford. The Balloon photographs were first rectified and mosaiced over a digitized base map by Levent Topaktaş using this program (Summers et al. 1998: 630). In 1996 detailed measurements of the city wall were taken by Total Station (Summers et al. 1998: 627).

Dr. Lewis Somers of Geoscan Research started a gradiometer survey at Kerkenes and he established the survey strategy in 1993. A gradiometer survey covered a portion of the city during the three survey seasons in 1993-1998 (Aydın 2004: 13). Because, natural (convenient geological structure) and archaeological (destroyed settlement by a large fire and the depth of archaeological remains is generally no more than 80 to 100 cm) conditions at Kerkenes were considered suitable for the conduct of a geomagnetic survey (Aydın 2004: 12-13).




Source: Osten 1928: Figure 4

Figure 1.10. First map of Kerkenes, drawn in three days by H. H. von der Osten and F. H. Blackburn in 1927 using a plane table, accurately showing the city wall.

The gradiometer survey expanded to include almost the entire site during 1998-2002. The Kale, the Kiremitlik and the city wall were excluded. The Kale and the city wall were not surveyed due to rubble and bedrock outcrops as high background noise prevented the gradiometer from recording the features. The existence of a Byzantine settlement at Kiremitlik resulted in the omission of this area as this period remains beyond the scope of the Kerkenes Project (Aydın 2004: 14).

Areas were created for groundtruthing and archiving purposes according to the site grid. These areas are used to create composite files for each area from approximately 6000 gradiometer grid files (Aydın 2004: 15).

An accurate and detailed topographic map of 10 to 25 cm and coordinates were prepared by conducting a Global Positioning System (GPS) survey which started in 1997 and ended in 2000. A terrain model was created from more than 1.4 million collected data points (Branting 2004: 61).

The first resistivity survey was done by Dr. Lewis Somers of Geoscan Research at Kerkenes (Summers and Summers 1998: 179). Harald von der Osten conducted the resistivity survey in 2001 and got successful results. (Summers et al. 2003: 449). The resistivity survey is still continuing every spring season at Kerkenes.

Geophysical survey produce a city plan for nearly the entire site, many buildings can be identified from the map. Test Trenches (TT15 to TT19 following on from Schmidt's trench numbers) were excavated by Mr. Musa Özcan, who was then the director of the Yozgat Museum, and Geoffrey Summers in 1996 to test the geophysical survey results, to understand the function of the buildings and to obtain the micromorphological and dendrochronological samples (Summers et al. 1998: 633). In 1998 after discovering illegal digging in the site test trenches (TT20 and TT21) were excavated by Mr. Musa Özcan and Geoffrey Summers to save material culture (Özcan et al. 2000: 219). Clearance Trenches were excavated in 1999 and 2000 at what has been dubbed as the Cappadocia Gate to understand the structure of the gate and at the so-called Palace Complex. Geoffrey Summers was granted an excavation permit by the Ministry of Culture of the Turkish Republic. Between 2001 and 2005 Summers dug trenches to understand the function of the structures in the city. Between those years excavations revealed the Phrygian inscriptions and small scale relief pieces at the Palace Complex.

Scott Branting studied transportation using Geographic Information Systems for Transportation methods (GIS_T) at Kerkenes (Branting 2004) and three Test Trenches (TT22-TT24) were dug by Branting in 2004 to test aspects of his study.

## 1.3. METHOD OF THE STUDY

The author was a member of the Kerkenes Project from 1998 to 2005 and worked as a team member conducting the GPS and geophysical surveys. Most of the thesis, however, was completed after that time as an office work supplemented by research field trips to Kerkenes itself.

Office work involved using computer utilities to transform process and analyze the data. The following software packages were used in the course of the research (Table 1.1).

Table 1.1. Software packages used in this study.

| *SOFTWARE NAME* | *PURPOSE OF USAGE* |
|---|---|
| Word (Office) | Word processing, page layouts |
| Excel (Office) | Making histograms |
| Autocad 2000 and 2004 | Digitizing maps |
| ArcGIS 8.x to 9.x | Transformation of data, creation of maps, data analysis |
| SPSS[2] 11.x | Creating databases and grouping the data |
| Photoshop | Finalizing the images |

To do the topographic analysis the elevation, slope and aspect maps were produced for Kerkenes and its region. Kerkenes is analyzed using two different data sets; the GPS data of Kerkenes, and the extraction of Kerkenes from 1:25000 topographic maps of the Kerkenes region. The surrounding area of Kerkenes was analyzed using 1:25000 topographic maps. The maps are produced in *ARCGIS 9.x* software and exported as jpg and finalized in Photoshop.

[2] Statistical Package for the Social Sciences (SPSS)

The results of the elevation slope and aspect maps are demonstrated in histograms. Intervals of 20 m were chosen to create histograms for Kerkenes, which is in the local grid system that was used for balloon photography and then set out as a 20 m grid for the geophysical survey of the ancient city. Intervals of 250 m are chosen for the Kerkenes region because 20 m would be too detailed for the entire area which has to be analyzed and displayed at a smaller scale than the area of the ancient city.

20 m and 250 m grids were overlaid on maps in *ArcGIS 9.x* program. The data were exported to *Excel* from *ArcGIS 9.x* and imported into the *SPSS* program. The variables in the data were grouped in SPSS and new histograms were created in *Excel*.

The data intervals for the elevation histograms are set at 50 meters for the bar charts. The data interval for the slope and aspect histograms is the same as that given in their map classifications.

Terrain profiles samples were taken from inside Kerkenes in order to understand and quantify the marked differences in elevation within the city.

To analyze the city wall, due to the hardware and problems while processing GPS data, the GPS data was overlaid with the wall plan (which was measured with a total station and drawn in 1993), and buffered at 30 meters to reduce the amount of the data for the processing. The towers were drawn by combining measurements from the wall plan with the GPS data for the entire city except the Kiremitlik Area. Normally, the remains of the city wall and the towers are visible on the ground and the remote sensing data; however the city wall is not clearly visible at the Kiremitlik Area Where it is overlain by later, principally Byzantine, occupation).

The topographic divide at Kerkenes is drawn from 1:25000 topographic maps of the city to determine the relation between location of the city wall and the topographic divide.

Analyzing the towers was not easy because no original tower is fully preserved on the city wall. The city wall was deliberately in the mid first millennium BC and further eroded by time and shepherds who continue to use the stones for building enclosures for their animals on and near the city wall. Remains of the original towers have been drawn from total station survey data and overlaid with

GPS survey data outputs. 75 polygons have been drawn as towers including 14 gate towers. Each gate is assumed to have had two towers (although the Gözbaba and Cappadocia Gates had more and are of complex design while the perhaps has East Gate only one). Two functions are given to the towers: 1. Tower; 2. Gate Tower. However accepting two towers for each gate for the analysis of the towers affects the results for basic statistics. For example gate towers were closer than other towers in distance analysis so that the central points were placed in the middle of the gate centroids and accepted as being one tower, a process which reduced the number of towers to 68 (for the purpose of analysis). The towers are labelled as T1, T2.

Terrain profile samples are taken from the city wall to find out the location of the city wall.

Elevation, slope and aspect maps are created from the GPS data and points were put in the center of the towers (polygons). Elevation, slope and aspect values are calculated for the central points of the towers for the analysis and histograms are created for all towers along the city wall.

The area of each tower is calculated in *ArcGIS 9.x*.

Lines were drawn from the central points of the towers to determine the distance between towers, and segments are classified as T1-T2, T2-T3.

To understand the distribution of the towers and their placement along the city wall basic mathematic formula was applied. Measuring the distance between the centroids of the towers gave the direct distance (which is not the real distance because it does not account for slope). To find out the real distance and elevation differences between towers in addition to slope a formula is applied.

Formula implemented in the tower analysis so as to obtain the slope values between two towers is:

$$\text{Slope} = \mathrm{m} = \frac{\Delta y}{\Delta x} = \frac{Elevation\_difference\_between\_two\_towers}{Dis\tan ce\_between\_two\_towers}$$

The average number of towers along the city wall was calculated and compared with the eastern and western sections of the city wall.

Elevation differences between two towers, slope values and angle between two towers are calculated.

To find out the angle values between towers simply, a line was drawn between T1 to T2 and another drawn between T2 and T3. The angle between those lines is calculated in *AutoCAD*.

Visibility analysis was applied to the gates in an attempt to understand the reasons for the precise location of each gate. This is important in understanding the layout of the city defenses as a whole because of the very uneven distribution of the 7 gates within the 7 km of the defensive circuit.

Photographs were taken during the field trips.

## 1.4. GIS IN ARCHAEOLOGY

There are different definitions of GIS, some of them given below:

> *A GIS is a sophisticated database management system designed for the acquisition, manipulation, visualization, management, and display of spatially referenced (or geographic) data* (Aldenderfer and Maschner 1996: 4).
>
> *A computer-based technology and methodology for collecting, managing, analyzing, modeling, and presenting geographic data for a wide range of applications* (Davis 2001: 13)
>
> *A GIS is an organized collection of computer hardware and software, with supporting data and personnel, that captures, stores, manipulates analyzes, and displays all forms of geographically referenced information* (Sabins 2000: 407).

GIS differs from Computer Assisted Mapping (CAM) and Computer Aided Design (CAD) software as it has a database management system and manipulates the data using lots of operations. GIS can produce thematic maps in a short time and also allows statistical analysis of selected geographical data. On the other side, combining paper maps manually is problematic, time consuming and expensive to produce and difficult to update (White 2002:11).

GIS can be applied to archaeology, because archaeological data can usually be stored in the map format. Archaeological materials can be displayed on the maps and interpreted in GIS. Therefore archaeologists choose to use GIS and begin to understand the complexity of the data. Although archaeologists are attracted by the visual products of GIS, it can be problematic due to misinterpretations of the results. Topographic, environmental and paleo-environmental data are parts of the archaeological GIS and provide information in solving problems (Gaffney et al. 1996: 133).

The context of GIS applications within archaeological research has been connected to the physical analysis of the landscape settlement traces. During the 1960's and 1970's physical analysis of landscapes has taken place in archaeological studies (Gaffney et al. 1996: 133-134).

Already aerial photography was being used in archaeology in the 1930's and still plays a major role today. Also the settlement pattern approach was developed and connected to the ecological approach after the 1960's. With the advent of new archaeology in the 1960's explanation, quantitative thinking, and scientific perspective of the past became important and urged the archaeologists to turn to other fields like geography, tools and ideas for spatial analysis. Spatial analytical techniques (Von Thunen model of agricultural land use, gravity models etc.) were borrowed and quickly integrated into the archaeological fieldwork (Aldenderfer and Maschner 1996: 8).

Launching of the LANDSAT 1 satellite in 1972 was another significant technical innovation which made the regional-scale studies possible by using remote sensing data and archaeologists took advantage of it (Aldenderfer and Maschner 1996: 9).

Until the early 1990's mostly the North American archaeologists were interested in GIS in archaeology. In 1986 Trevor Harris pioneered the GIS in the British archaeological literature and consequently had a position in the United States. The European archaeologists started to get interested in GIS as Gaffney and Stancic used and represented the value of GIS in the interpretation of the regional survey data. The number of archaeological projects which used GIS for regional survey analysis and spatial modeling are increasing since early 1990s (Wheatley and Gillings 2002: 20).

These researchers had the theoretical concept of using spatial data, new technology and analysis for their study, but there were still gaps between the desire to work on a larger spatial scale and the ability to do it in a practical manner. This was the stage when GIS was introduced to archaeological inquiry (Aldenderfer and Maschner 1996: 9).

The applications of GIS in archaeological research are given below; (Aldenderfer and Maschner 1996: 9)

a) Regional data management (Cultural Resource Management, cultural anthropology)
b) Management of remotely sensed data
c) Regional environmental analysis
d) Simulation
e) Locational modeling (Predictive modeling, site catchment analysis,

The archaeologists recognized geomorphology with applications of perspectives and methods, for understanding the site location, function and duration. The perspective and utility of archaeological geology have been extended during the late twentieth century by the incorporation of geochemistry, geochronology and geophysics (Garrison 2003: 2).

People needed some tools to characterize the geomorphic and geologic context of a archaeological site or sites. In the beginning these were basic tools such as maps (geographic, geological and hydrological) used with the rock hammer and compass. Today satellite images, GPS and GIS are the newer tools. The archaeologist uses the most suitable technique or tool to have a better understanding of a site's choice in a particular landscape (Garrison 2003: 3-4). Earlier landscapes are usually concealed by subsequent settlements which necessitate the understanding of both the modern and ancient times.

Mapping techniques for the identification of a landscape are different in archaeology. There are planimetric maps, remote sensing data (such as aerial or satellite imagery) and ground survey.

Archaeologists generally concentrate on the number of the persons or material (population, arrowheads, stone etc) and reliable estimates are best made by using statistical techniques. These include parametric measures of central tendency and dispersion such as mean and standard deviation (Garrison 2003: 247).

Viewshed analysis is one of the most frequently used applications of the GIS in archaeology. GIS calculates the visible areas by Digital Elevation Model (DEM) and one specific point of the site which is named an observer point. Cumulative Viewshed analysis is usually applied to an archaeological site for understanding the relation between the monuments and landscape (White 2002: 16, 20).

Predictive modeling within a GIS for archaeological sites is one of the earliest (from 1970s) and the most common applications. Through this time there is still active debate on predictive modeling. Inductive model (empirical or correlative model), deductive model and coupled model (both inductive and deductive model) are the three models of the predictive modeling that is used for locating sites on the unsurveyed areas. By using predictive models for site analysis it is sufficient to answer "where"; however it is difficult to answer the "why" or "how" without some theoretical base (White 2002: 22, 30).

The city Mantineia is an example of GIS application for an archaeological site which is located in the centre of Peleponennese, Greece. The city has 4 kilometers of fortifications in elliptical formation with 10 gates and 126 towers. A number of watchtowers stand on the surrounding hilltops of the Mantineian plain since 19$^{th}$ century. The defensive network of the ancient settlement and its potential coverage will be studied with GIS. Viewshed, slope and aspect analysis performed. All the towers at Mantineia had been almost equally spaced with 10 gates. The gates connect the Mantineia with neighboring sites (Topouzi et al. 2001: 5-6).

In the study of Mantineia 84 topographic (scale 1:5000) and two geological maps (scale 1: 50000) were digitized and total area was nearly 1000 km². To find the positions of the defensive constructions very accurate GPS data was collected. The coordinates of the four corners of each tower were determined by GPS receivers. DEM model was created and visibility analysis was applied after the combination of the data (Topouzi et al. 2001: 7-9).

The results of the viewshed analysis confirmed that the defensive monuments in the Mantineian plain formed a defense network in combination with the city's fortification walls. The reason for the construction of watchtowers in specific places would have been to control the areas where ancient roads pass and to cover gaps in places, which were not directly visible from the gates (Topouzi et al. 2001: 14-15).

Slope and aspect analysis showed that the city's gates were built on almost flat ground (slope 0-6 degrees), while the watchtowers and a small fortress were built on top of hills (slope max. 39 degree) which indicates the defensive nature of the sites (Topouzi et al. 2001: 17-18).

## 1.5. ORGANIZATION OF THE THESIS

Chapter 2 defines the data used in this study. In that chapter, three different kinds of data and coordination systems are introduced for analysis.

Chapter 3 presents the data analysis to understand the relation between topography and Kerkenes. It includes the topographical analysis (slope, aspect and elevation) and settlement analysis that includes city wall analysis with towers and gates.

Chapter 4 reviews the interpretations of the results.

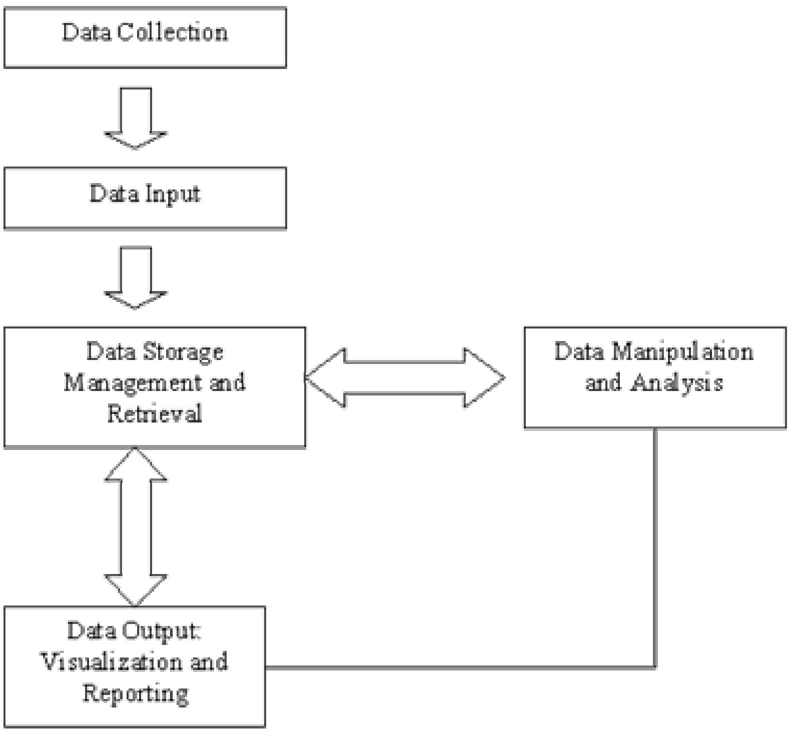
Chapter 5 is the discussion and conclusion section of the thesis.

Chapter 6 comprises recommendations for future studies.

## CHAPTER 2
## DATA

This chapter provides information about the data and data formats, coordinate systems and input data that used in this thesis. Figure 2.1 shows the flow chart of the data which is the fundamental system of GIS.

The data and data formats (raster and vector) are defined first, then coordinate systems such as Universal Transverse Mercator-World Geodetic System 1984 (UTM-WGS84) and Kerkenes local coordinate system is explained, followed by the input data (topographic, remote sensing and archaeological) which is given in this chapter. Table 2.1 presents the creation of GIS Data Sets.




Source: Adapted from White 2002: p.13

Figure 2.1. Fundamental Systems of GIS.

Table 2.1. Creation of GIS Data Sets

| DATA | SCALE | SOURCE | COORDINATE SYSTEM | PROCESSING | RESULTS | DATA FORMAT |
|---|---|---|---|---|---|---|
| Six sheets of digitized topographic maps of Yozgat Area (I33b3, I33c2, I34a3, I34a4, I34d1, I34d2) | 1:25.000 | Geology Department at METU | UTM WGS 84 | Six sheets were merged and interpolated as TIN and created DEM | Elevation, Slope and Aspect Maps | Raster |
| GPS | (digital scale) Accuracy 10-25 cm | The Kerkenes Project Archive | UTM WGS84 | Point data interpolated as TIN and created DEM. | Elevation, Slope and Aspect Maps | Raster |
| Total Station Survey Data | digital scale) | The Kerkenes Project Archive | Kerkenes Local Coordinate System | | Towers, City Wall | Vector |

## 2.1. DATA AND DATA FORMATS

There are different definitions of the data given below.

> *Data is representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means. Any representations such as characters or analog quantities to which meaning is or might be assigned* (http://www.its.bldrdoc.gov/fs-1037/dir-010/_1401.htm).

> *Individual measurements; facts, figures, pieces of information, statistics, either historical or derived by calculation, experimentation, surveys, etc.; evidence from which conclusions can be inferred* (http://indicators.top10by2010.org/glossary.cfm).

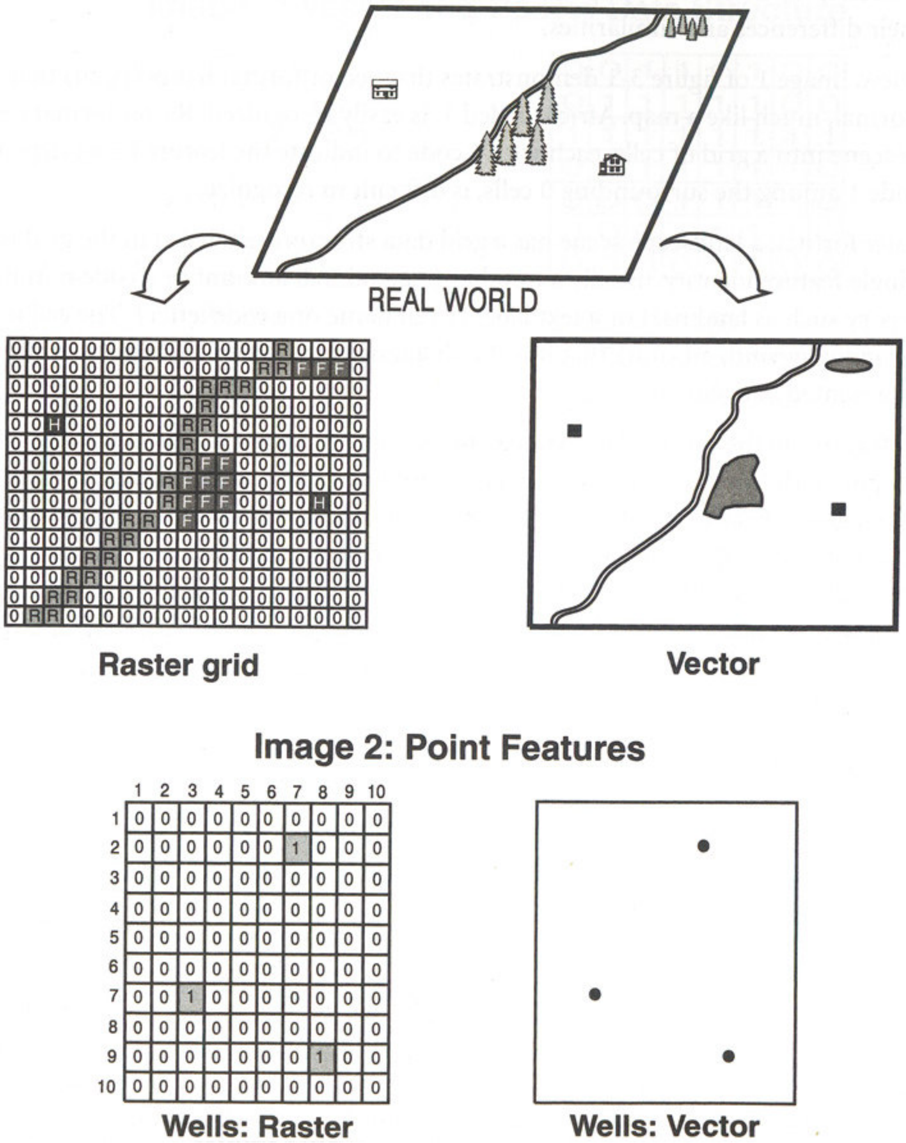
> *The* data is *as a collection of facts in the database; multiple entries. It is the plural of the word 'datum'* (Davis 2001: 30).

In common use data is both singular and plural (Davis 2001: 31). The use of data in this study is both singular and plural.

In GIS, data are illustrated as layers or themes and each layer has specific information that describes the environment within the context of the problem under study. The layers can be two distinct formats: raster and vector (Figure 2.2) (Aldenderfer and Maschner 1996: 4).

Raster data is a landscape scene which has a grid data structure and each cell in the grid has a single feature identity as a number or a text label (Davis 2001: 63) (Figure 2.2). The cell in the grid shows three pieces of information; a unique position defined by two grid co-ordinates and a value to be displayed (Lock 2003: 15). The grid cell resolution is important in raster data. Closer and more detailed representations of a landscape are executed more efficiently by using high spatial resolution in raster data (Wheatley and Gillings 2002: 52).

Vector data is the series of points that can be joined to create lines which represent the feature. Each point has x, y coordinates of the location. The three vector feature types are a line, a point and a polygon (Figure 2.2) (Lock 2003:15).




Source: Davis, 2001: Figure.3.-2

Figure 2.2. Representation of the real world with raster and vector data formats.

The raster and vector data formats each have their advantages and disadvantages.

The raster data sets are convenient for continuous surfaces and images whereas the vector line is useful for detailed line drawings such as site plans. Archaeologists use both of them with different software packages (Lock 2003: 15).

The vector data usually produce smaller files while raster data produce bigger ones because it has a value in each cell. In raster data sets the shape of the feature turns into grid cell, but in vector data sets features are represented in a more realistic way (Figure 2.2). Vector maps can be more understandable for ordinary people than raster maps (Davis 2001: 85-91).

Remote sensing imagery produces raster data sets such as GPS. In this study both raster and vector data sets have been used like GPS and 1:25000 topographic maps with total station survey data.

The vector data sets are used for the city wall drawings. Raster data sets are used for topographical analysis to produce the elevation, slope and aspect maps for the region.

The Digital Elevation Model (DEM) is the representation of the topography of the earth or another surface in raster format using elevation value (Davis 2001: 289). Construction of a valid DEM needs an efficient interpolation algorithm, because different algorithms can cause differentiation of the elevation value for the same space. The DEM for landscape superficially appears to be similar after the application of various algorithms but are both quantitatively and qualitatively different. Unfortunately, there is no specific interpolation method for archaeological studies in the literature (Hageman and Bennett 2000: 113-114).

Interpolation can be defined as the procedure which finds out the value of the unsampled area using existing points. Some interpolation methods for DEMs are;

a) Ordinary Kriging
b) Universal Kriging
c) Inverse Distance Weighting
d) Triangulated Irregular Network (TIN) (Hageman and Bennett 2000: 115).

TIN interpolation is used for analysis in this study. TINs are often used to produce DEMs for predictive modeling studies. It generally needs smaller storage requirements. TIN represents the surfaces as a connected network of triangles between points. Most TIN generation algorithms use Delaunay Triangulation, that is; if a circle is defined by the vertices of each triangle then it does not contain any other point in the data set (Hageman and Bennett 2000: 117).

## 2.2. COORDINATE SYSTEMS

Since GIS is the presentation of the earth then the data used in GIS must have a real-world coordinate system. Latitude and longitude are the world coordinate system. The term georeferencing stands for fixing the data to a standard coordinate system. If a map is georeferenced to a specific coordinate system, the GIS still needs to know the map projection system to give proper spatial characteristics to the features. Projection is the conversion of spherical data from the globe into flat, 2D presentation. Different global projections are being used in GIS such as Mercator and Robinson (Davis 2001: 131,135).

The data that is used in this study comes from different sources such as the archives of the Kerkenes Project and the Department of Geology at Middle East Technical University (METU). The data sets have two different coordinate systems. One coordinate system is the Universal Transverse Mercator (UTM), World Geodetic System 1984 (WGS84) and the other is Kerkenes local coordinate system.

### 2.2.1. UTM-WGS84 (Universal Transverse Mercator - World Geodetic System 1984)

UTM coordinate system is based on Transverse Mercator projection.

UTM is widely used in map projection system that divides the globe into 60 north and south zones of which the longitudinal span of each zone is 6°. The vertical lines are measured from the Greenwich meridian and the horizontal ones from the equator for the grid (http://www.colorado.edu/geography/gcraft/gloss/glossary.html)

> *The World Geodetic System defines a fixed global reference frame for the Earth, for use in geodesy and navigation. The latest revision is* ***WGS 84*** *dating from 1984 (last revised in 2004), which will be valid up to about 2010. It is currently the reference system being used by the GPS* (http://en.wikipedia.org/wiki/WGS84).

In this study 1:25000 topographic maps of the Kerkenes region and the GPS data of Kerkenes are in UTM WGS84 coordinate system.

### 2.2.2. Kerkenes local coordinate system

Kerkenes local coordinate system was based on zero point southwest corner outside the city wall (Figure 2.3). The zero point was arbitrarily chosen during the project in 1993. The site was gridded using the zero point. Each 300 by 200 meters were named A1, A2 etc. At the site 1000 m, 1500 m. and 2100 m. points were fixed along in the north axis using a total station and crosses marked with white lime (Summers and Summers 1996:103).

Reference points that were used for GPS measurements at Kerkenes were named Hans Points (HP) after the topographer Hans Birk who established them (Figure 2.4).

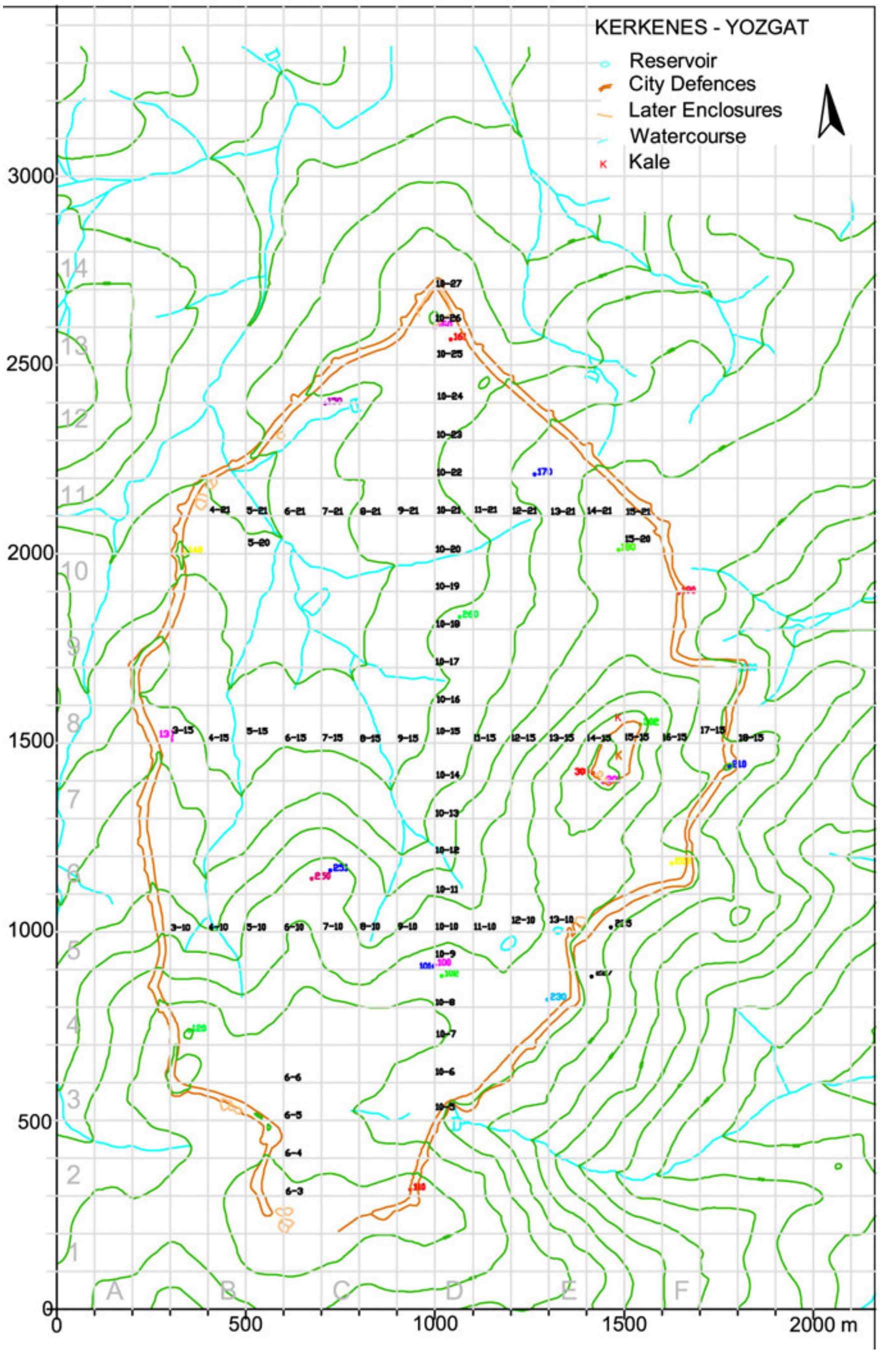
## 2.3. INPUT DATA

### 2.3.1. Topographic Input

Six 1:25000 digitized sheets of the topographic maps of Yozgat area (I33b3, I33c2, I34a3, I34a4, I34d1, and I34d2) were obtained from the Geology Department at METU. In this study six sheets of topographic maps (900 km² area) were chosen due to the availability of the data. Those six sheets covered the study area and no additional topographic maps were digitized (Figure 2.5). The topographic maps were in the UTM WGS84 coordinate system. Triangulated Irregular Network (TIN) models were created from the merged data (the Kerkenes region) and used to produce elevation, slope and aspect maps for overlay analysis.

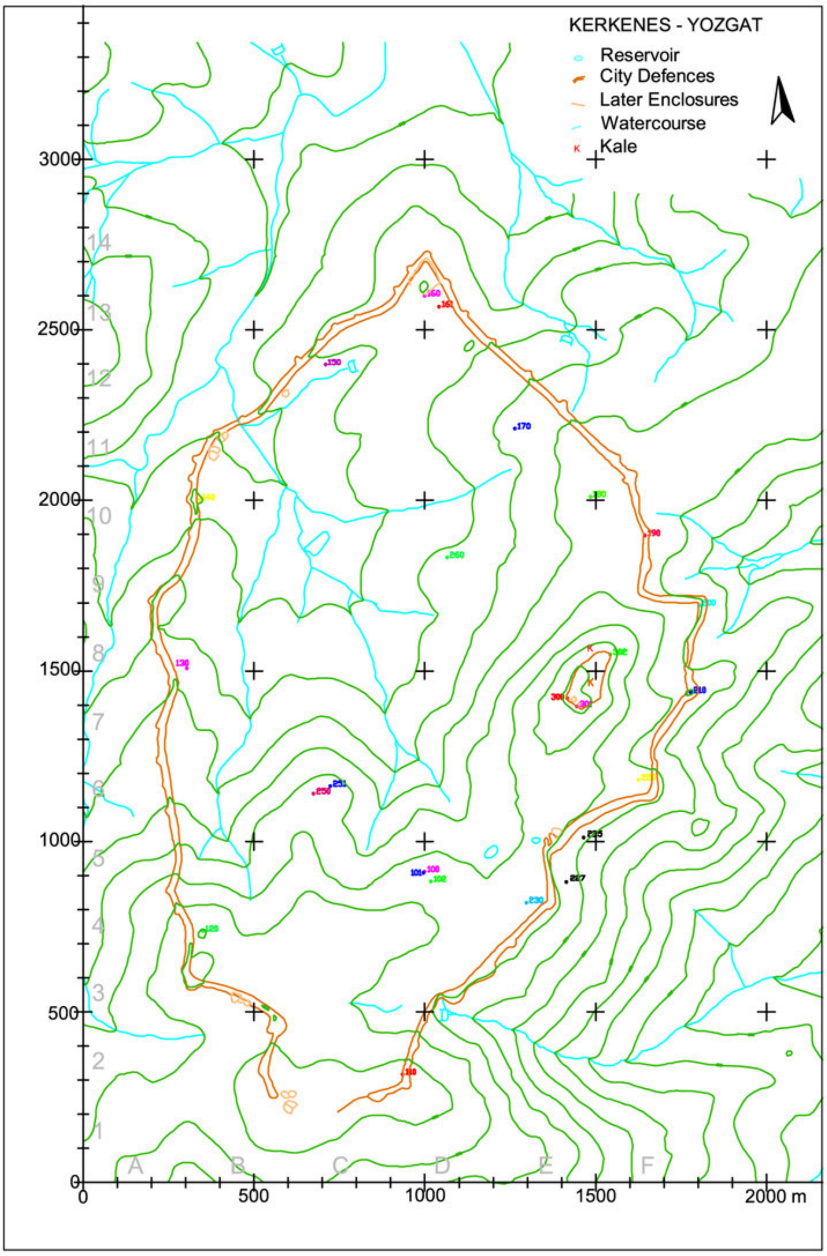
### 2.3.2. Remote Sensing Input

Excavation is a destructive method for archeology. Some archeologists started to think about "non destructive archeology". Some methods were applied to collect the data from the archaeological sites without destroying the site. Those methods called remote sensing. Some of the remote sensing techniques are aerial photography, satellite imagery, geophysical and GPS data (Fagan 1991:185).




Source: The Kerkenes Project digital archive

Figure 2.3. Map of Kerkenes with local coordinates, shows 100 meters crosses.




Source: The Kerkenes Project digital archive

Figure 2.4. Map of Kerkenes, shows Hans Points (red and blue points) and 500 meters crosses.

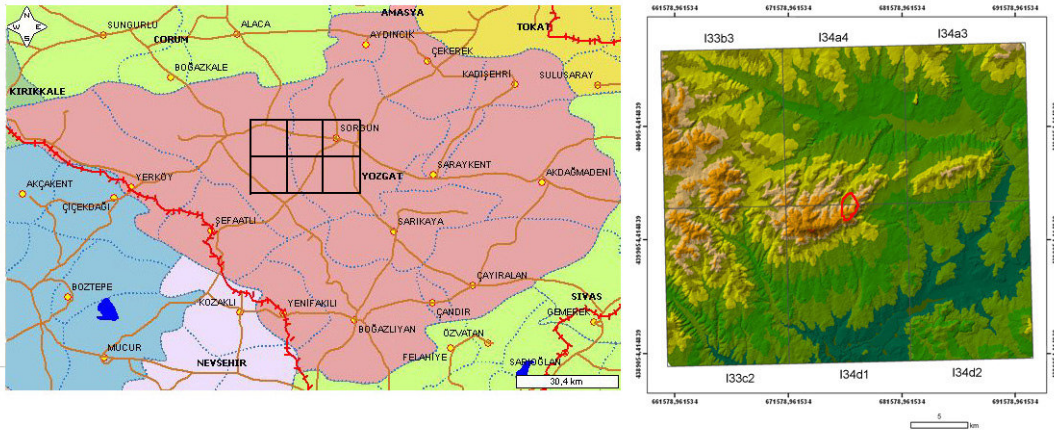



Figure 2.5. Location of six sheets of topographic maps. (I33b3, I33c2, I34a3, I34a4, I34d1, and I34d2)

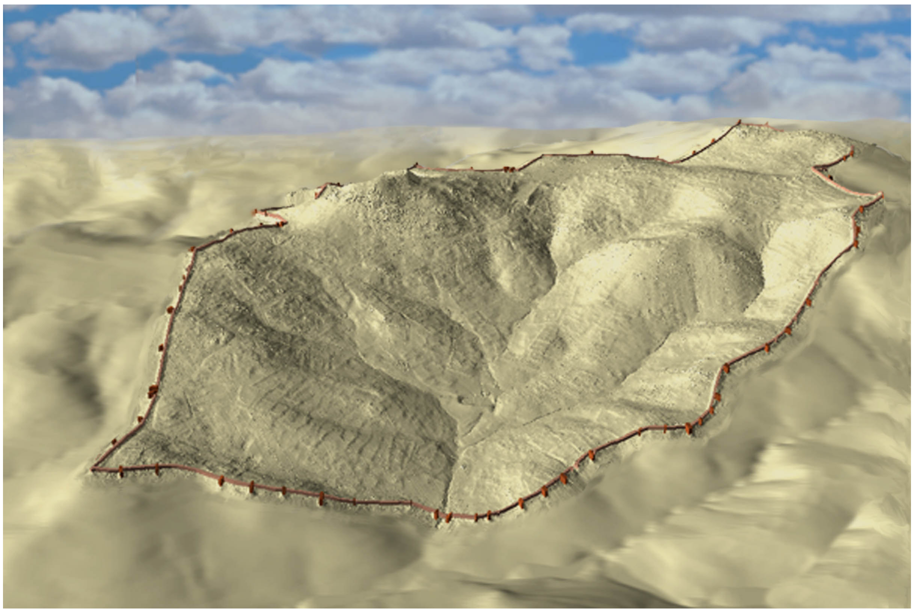
### 2.3.2.1. Global Positioning System (GPS) survey data

NAVSTAR/GPS (Navigation Satellite Timing and Ranging / Global Positioning System ) is a satellite – based navigation system which is developed and maintained by the US Department of Defense and allowed for civil use. People who have a receiver can determine the location with GPS. Also it enables to navigation tracking and timing activities. For archeological survey GPS has rapidly become an important tool (Kahveci and Yıldız 2001:2 and Lock 2003:11).

GPS Survey was initiated by Scott Branting and collected between the years 1997 and 2000 at Kerkenes. This survey was based on local reference points, called Hans Points (HP). Intensive continuous kinematic survey was conducted, using the UTM WGS84 coordinate system, with 4600 LS Trimble equipment. One of the four receivers was set up over a Hans Point as a base station and the other three were roving receivers. Roving receivers were mounted on individuals who walked over the surface on the ground along transects. Individuals were 1 or 2 meters apart while walking. The receivers took a measurement every 2 seconds. The walking distance depended on topography so sometimes it was closer than 1 meter (Figure 2.6). All the data was downloaded and cleared from errors after processing. 1.400.000 readings were collected. This data was considered as accurate to 10-25 cm due to the stability of the roving receivers and the GPS satellites (Branting 2004: 61-63).

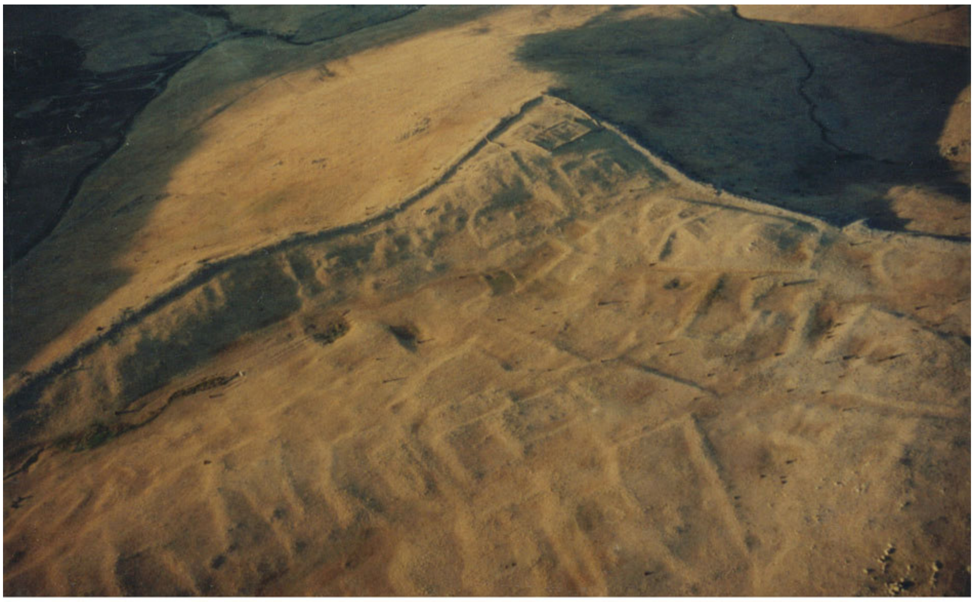
Figure 2.6. Conducting GPS survey at Water Gate. (Photographed by Nurdan Atalan).

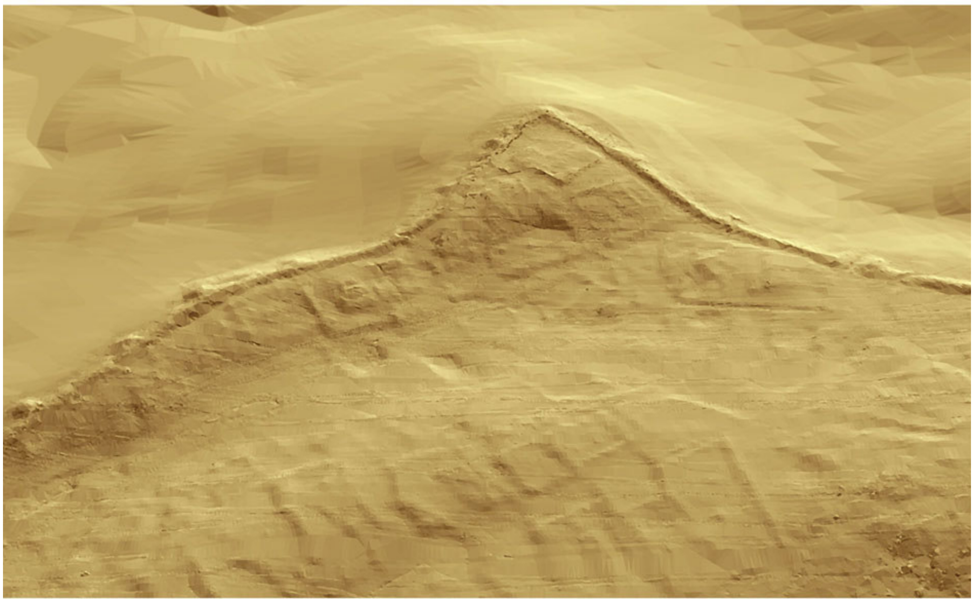
3D simulations of the site were created from the GPS data (Figure 2.7). The GPS data can function as a platform for all the other survey data (Figure 2.8), and it also forms a basis for GIS analysis (Branting and Summers 2002: 639-640).



Source: The Kerkenes Project digital archive

Figure 2.7. 3D map of Kerkenes, created from GPS data.





Source: Branting and Summers 2002: p.640

Figure 2.8. Northend of Kerkenes from the aerial photography (top) and GPS data (bottom).

#### 2.3.2.2. Total Station Survey Data

Total Station equipment has been used at Kerkenes since 1993. The data is collected in a local coordinate system using Hans Points at Kerkenes. 20 x 20 m. grids were set out with a total station for geophysical survey. Plans of the site were made from the total station surveyed points. The city wall with its towers and gates was surveyed with total station in 1996 (Summers et al. 1998: 627). Visible structures and terraces were measured with total station (Özcan et al. 2000: 215). At Kerkenes, trenches with archaeological findings and architectural remains are still being measured by using total station to get coordinates and depth of the remains.

### 2.3.3. Archaeological Input

Clearance trenches at the Cappadocia Gate started in 1999 at Kerkenes. Clearance helped to understand the glacis, towers and the entrance of the Gate (Summers et al. 2001: 340). In 2000 Clearance work at the Cappadocia Gate continued. Twin towers were cleaned and a reconstructed plan of the Cappadocia Gate was redrawn (Summers et al. 2002: 440-441).

In 2003 the inner chamber of the Cappadocia Gate was partially cleared and that resulted in some evidence for the internal structure which included raised wooden flooring. Due to the significant erosion of the Cappadocia Gate, during the excavations it was found that North-West side of the passage on eroded gully had threatened to undermine the passage way. To prevent this, North-Western side that had been supported by the stones along part of the gully edge. The excavations in the Cappadocia Gate show that it was repaired during its use (Summers and Summers 2003: 61).

It was noteworthy that the work in 2005 revealed the passage inside the Cappadocia Gate as being unobstructed by buttresses or architraves. There is no evidence for the exact position of the wooden doors in the Cappadocia Gate except a passage of six m wide which should require at least two sets of double doors. The passage which opens to the interior gate is wider than the passage of the exterior gate and would have provided a space for the defenders to move from place to place and this space should have been immediately behind the doors if these actually existed (Summers and Summers 2005: 38).

In the inner side of the Cappadocia Gate a stele, an aniconic representation of a Phrygian deity atop was revealed with excavation in 2002. A tuff stele was in a bad condition and on a stepped monument (Summers and Summers 2003: 60).

# CHAPTER 3
# DATA ANALYSIS and GIS

This chapter provides information on the nature of the data sets and productions.

Topographic data is used to create the elevation, slope and aspect maps both for Kerkenes and the Kerkenes region.

The relation between the city wall and topography is analyzed including towers and gates.

## 3.1. TOPOGRAPHIC DATA ANALYSIS

In this study the elevation, slope and aspect maps are produced for Kerkenes and its region. Kerkenes is analyzed using two different data sets; the GPS data of Kerkenes, and the extraction of Kerkenes from 1:25000 topographic maps of the Kerkenes region. The surrounding area of Kerkenes is analyzed using 1:25000 topographic maps. The maps are produced in ARCGIS 9.x software and exported as jpg and finalized in Photoshop.

The results of the elevation slope and aspect maps are demonstrated in histograms. Intervals of 20 m were chosen to create histograms for Kerkenes, which is in the local grid system that was used for balloon photography and then set out as a 20 m grid for the geophysical survey of the ancient city. Intervals of 250 m are chosen for Kerkenes region because 20 m would be too detailed for the entire area which has to be analyzed and displayed at a smaller scale than the area of the ancient city.

20 m and 250 m grids were overlaid on maps in *ArcGIS 9.x* program. The data were exported to *Excel* from *ArcGIS 9.x* and imported into the *SPSS* program. The variables in the data were grouped in SPSS and new histograms were created in *Excel*.

The data intervals for the elevation histograms are set at 50 meters for the bar charts. The data interval for the slope and aspect histograms is the same as that given in their map classifications.

Basic characteristics of these outputs are explained below.

### 3.1.1. Elevation Map

Elevation is the height above mean sea level. GIS uses contour lines and points to create the three-dimensional (3D) representation of a landscape. Each line has a value of the elevation for the contour lines. On the other hand, in the point data each point has an elevation value. Usually DEMs are using to produce for the elevation maps because they are reasonably accurate and can be integrated in a variety of GIS software (Davis 2001: 289).

The elevation maps and explanations are given in the next section with their histograms in Figures 3.1, 3.2, 3.3, and 3.4.

#### 3.1.1.1. Kerkenes (GPS Data)

Elevation map is given in Figure 3.1. The elevation ranges between 1255-1488 m at Kerkenes (Figure 3.4A). The highest points are the Kale and the Kiremitlik areas (Figure 1.3). The northern section is the lowest part of the city.

#### 3.1.1.2. The Kerkenes region

The elevation ranges between 984-1522 m in the outlying areas around Kerkenes (Figures 3.2 and 3.4B). Kerkenes and the area at its west are the highest points of the region.

#### 3.1.1.3. Kerkenes (1:25000 topographic maps)

The elevation ranges between 1250-1460 meters in Kerkenes as extracted from 1:25000 topographic maps of the region (Figures 3.3 and 3.4C). The highest points are the Kale and the Kiremitlik areas. The area on the north is the lowest section of the city.

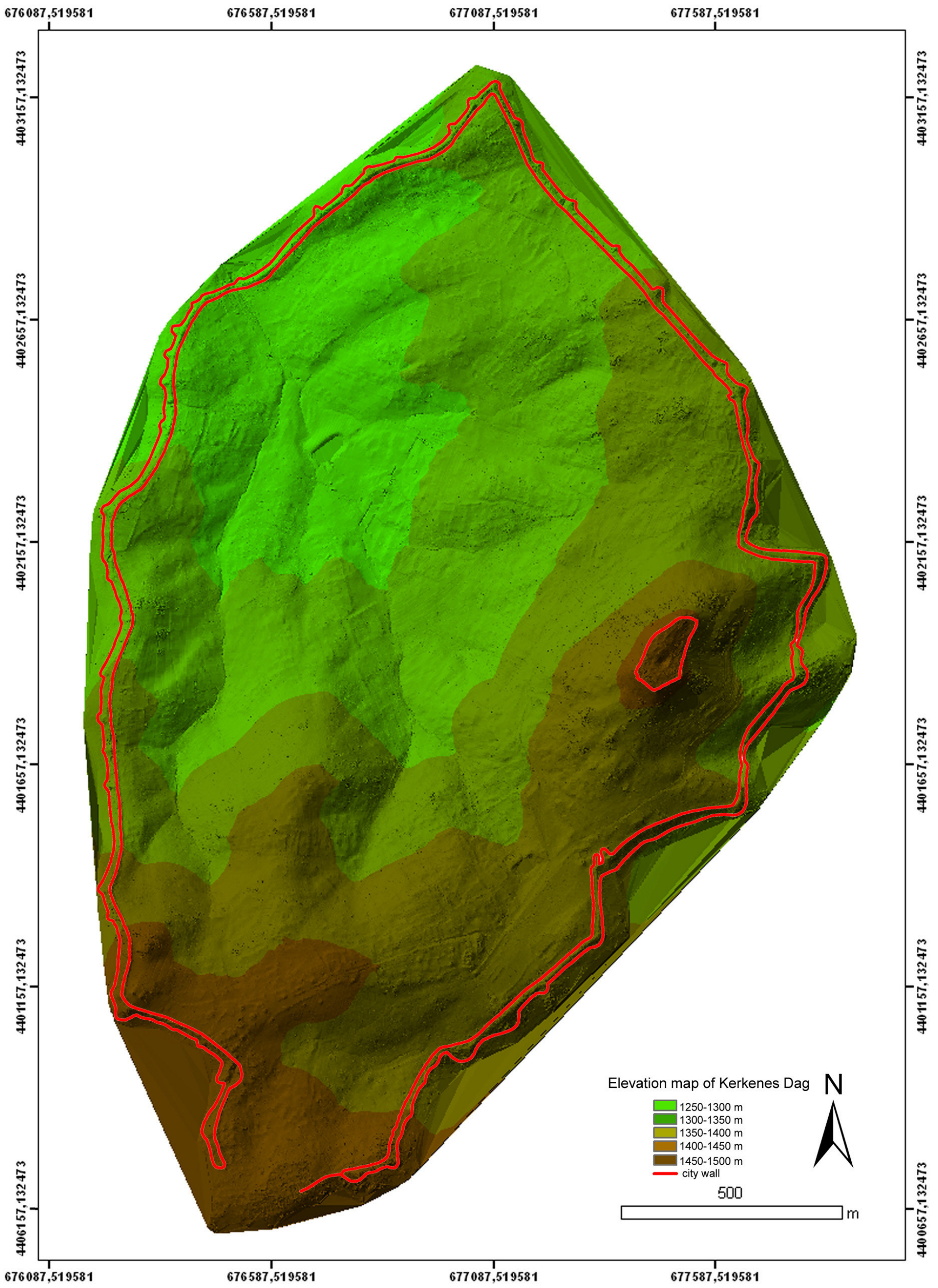



Figure 3.1. Elevation map of Kerkenes produced from GPS Data as a TIN Model.

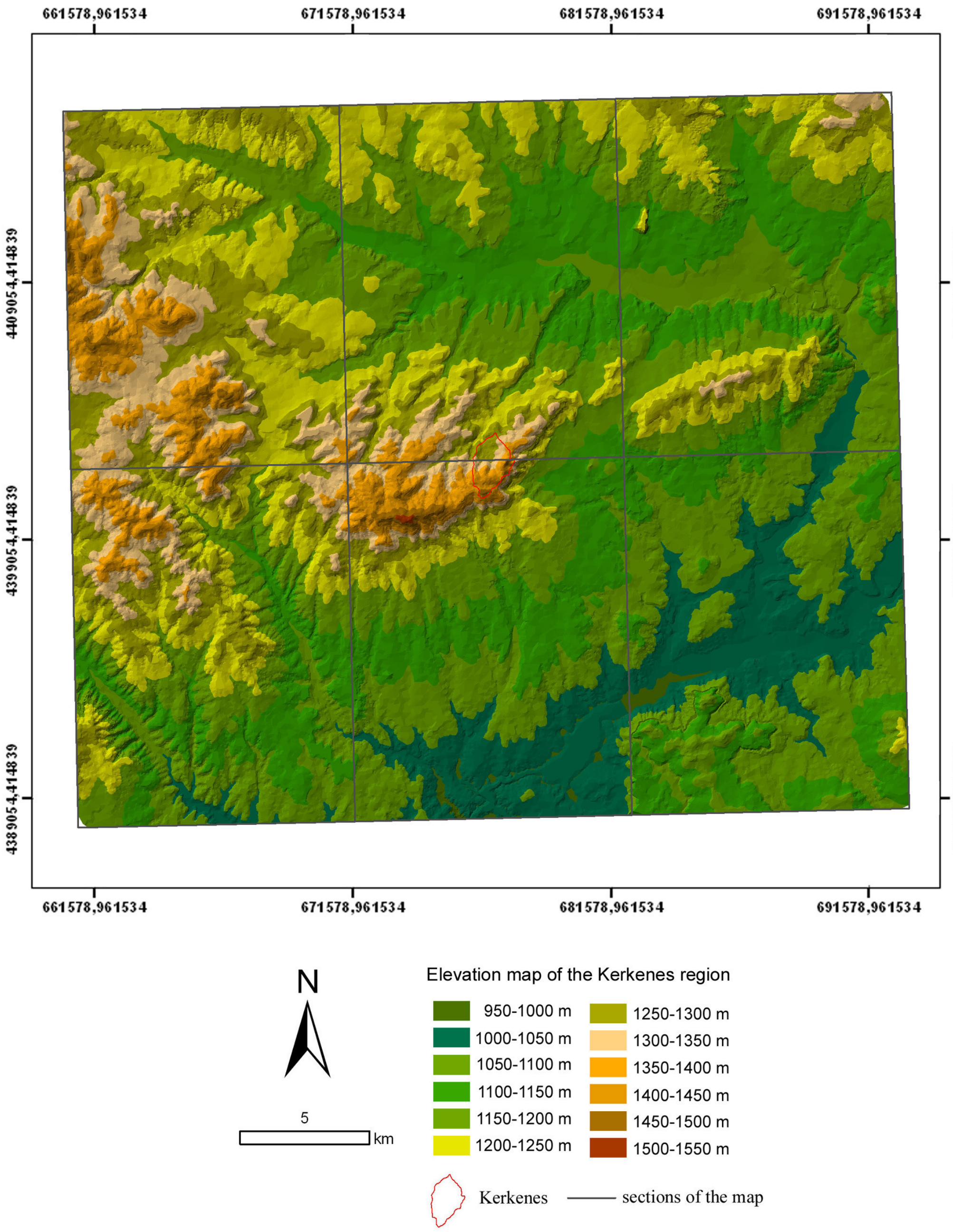



Figure 3.2. Elevation map of the Kerkenes region produced from six sheets of 1:25000 topographic maps as a TIN Model.

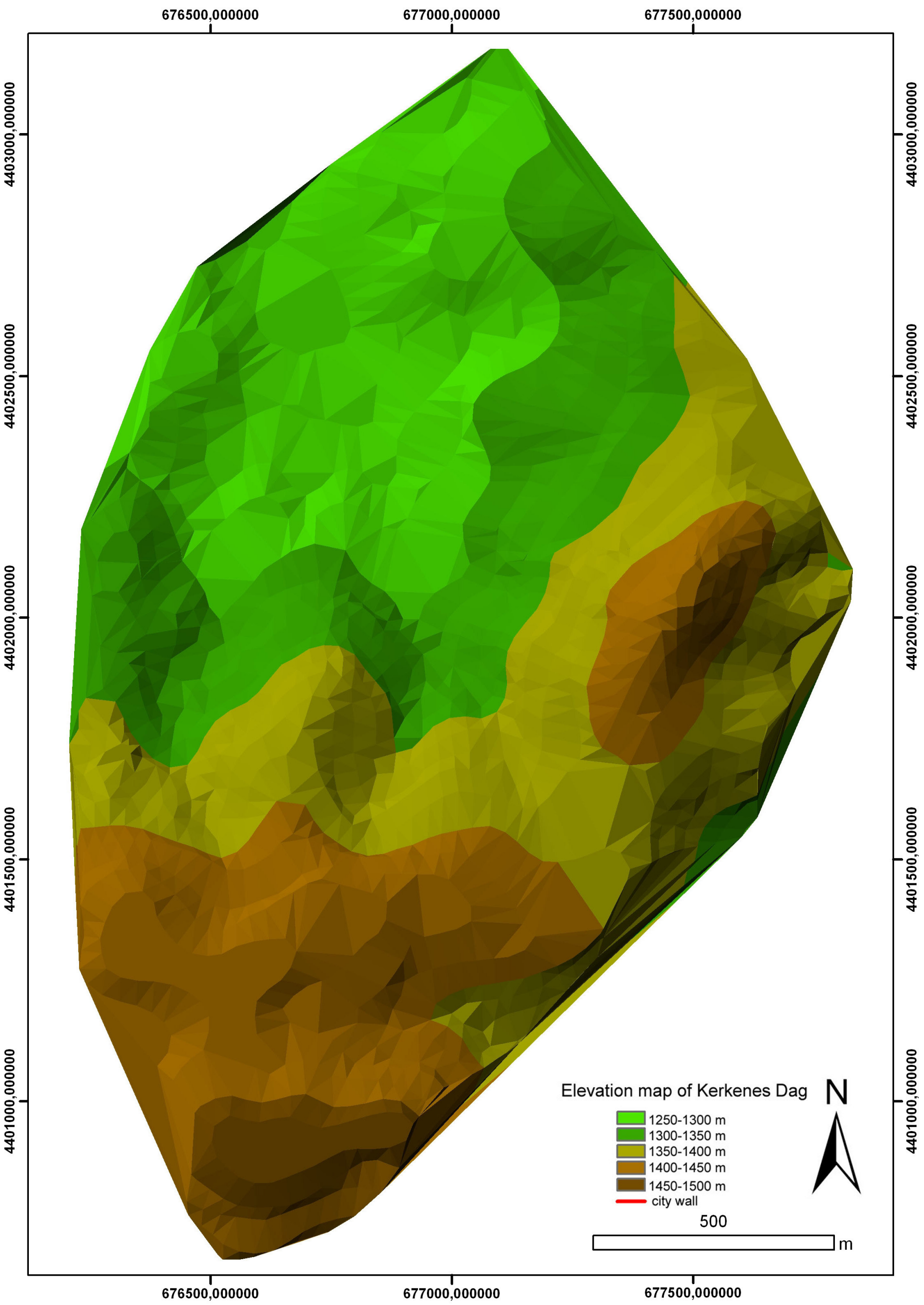
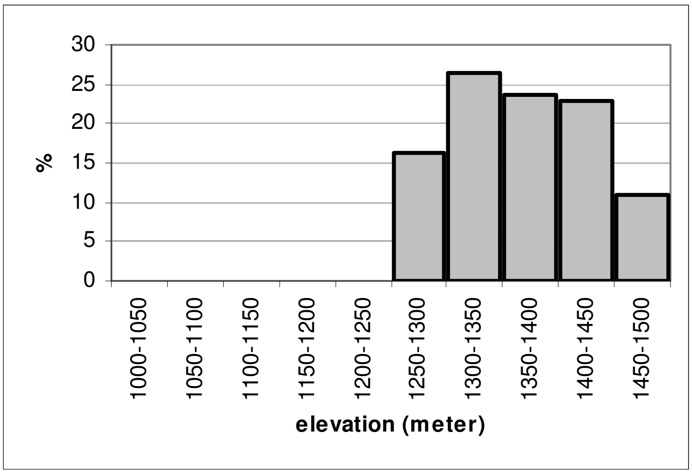
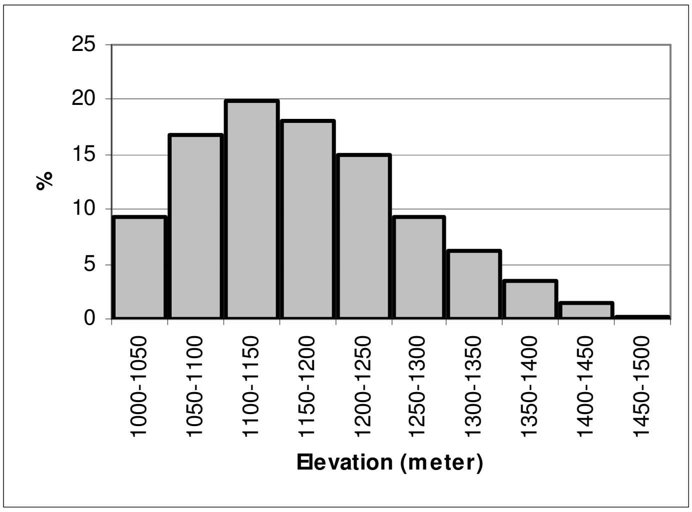



Figure 3.3. Elevation map of Kerkenes produced from extracted of six sheets of 1:25000 topographic maps as a TIN Model.



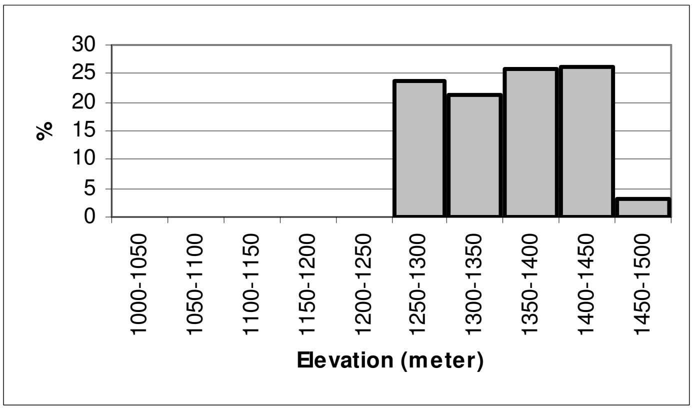

| | |
|---|---|
| Min | 1255,78 |
| Max | 1488,64 |
| Mean | 1367,15 |
| Std.Dev. | 60,1988 |

A) Elevation histogram of Kerkenes from GPS Data.




| | |
|---|---|
| Min | 984,52 |
| Max | 1522,88 |
| Mean | 1172,35 |
| Std.Dev. | 97,27 |

B) Elevation histogram of Kerkenes region from 1:25000 topographic maps.




| | |
|---|---|
| Min | 1250 |
| Max | 1460 |
| Mean | 1357,4 |
| Std.Dev. | 58,34 |

C) Elevation histogram of Kerkenes extracted from 1:25000 topographic maps.

Figure 3.4.Elevation histograms.

### 3.1.2. Slope Map

Slope determines the steepness, gives clues for environmental conditions and affects the land cover and land use so it is an important component in many GIS applications. Slope is one of the factors considered as crucial in settlements and slope maps help the city planners to find a suitable place for settlement. Areas having a steep slope are not very suitable for construction. Slope is usually calculated as a degree (0-90) (Davis 2001:295).

The slope maps and explanations are given in the next section with their histograms in Figures 3.5, 3.6, 3.7, and 3.8.

The slopes in this research are classified as;
0-2 degrees: nearly level
2-5 degrees: very gentle slope
5-10 degrees: gentle slope
10-20 degrees: moderate slope
≥20 degrees: steep slope

#### 3.1.2.1. Kerkenes (GPS data)

The slope amount varies between 0 and 74 degrees in Kerkenes (Figures 3.5 and 3.8A). The steep slope areas are around the Kale and in the South West axis of the city. The areas on the north of the city have gentle slopes.

#### 3.1.2.2. The Kerkenes region

The slope amount changes between 0-89 degrees in the Kerkenes region (Figures 3.6 and 3.8B). Most of the areas are between 0-20 degrees which means they are not steep slope areas. Kerkenes and its west are steep slope areas.

### 3.1.2.3. Kerkenes (1:25000 topographic maps)

The slope amount changes between 0 and 72 degrees in Kerkenes as extracted from 1:25000 topographic maps of the region (Figures 3.7 and 3.8 C). The steep slope areas are situated around the Kale and in the South West axis of the city. Gentle slope areas are in the northern part of the city.

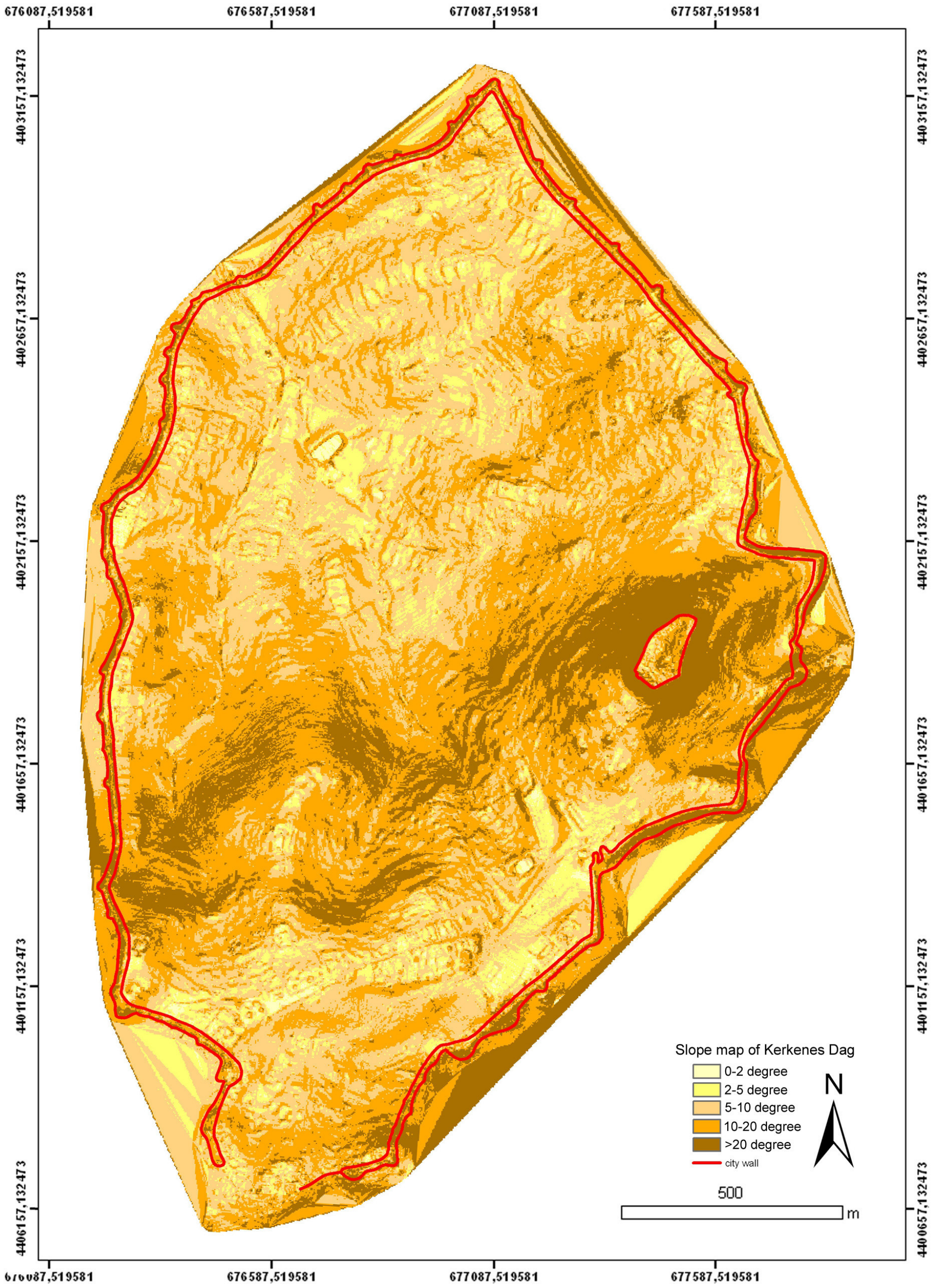



Figure 3.5. Slope map of Kerkenes produced from GPS Data.

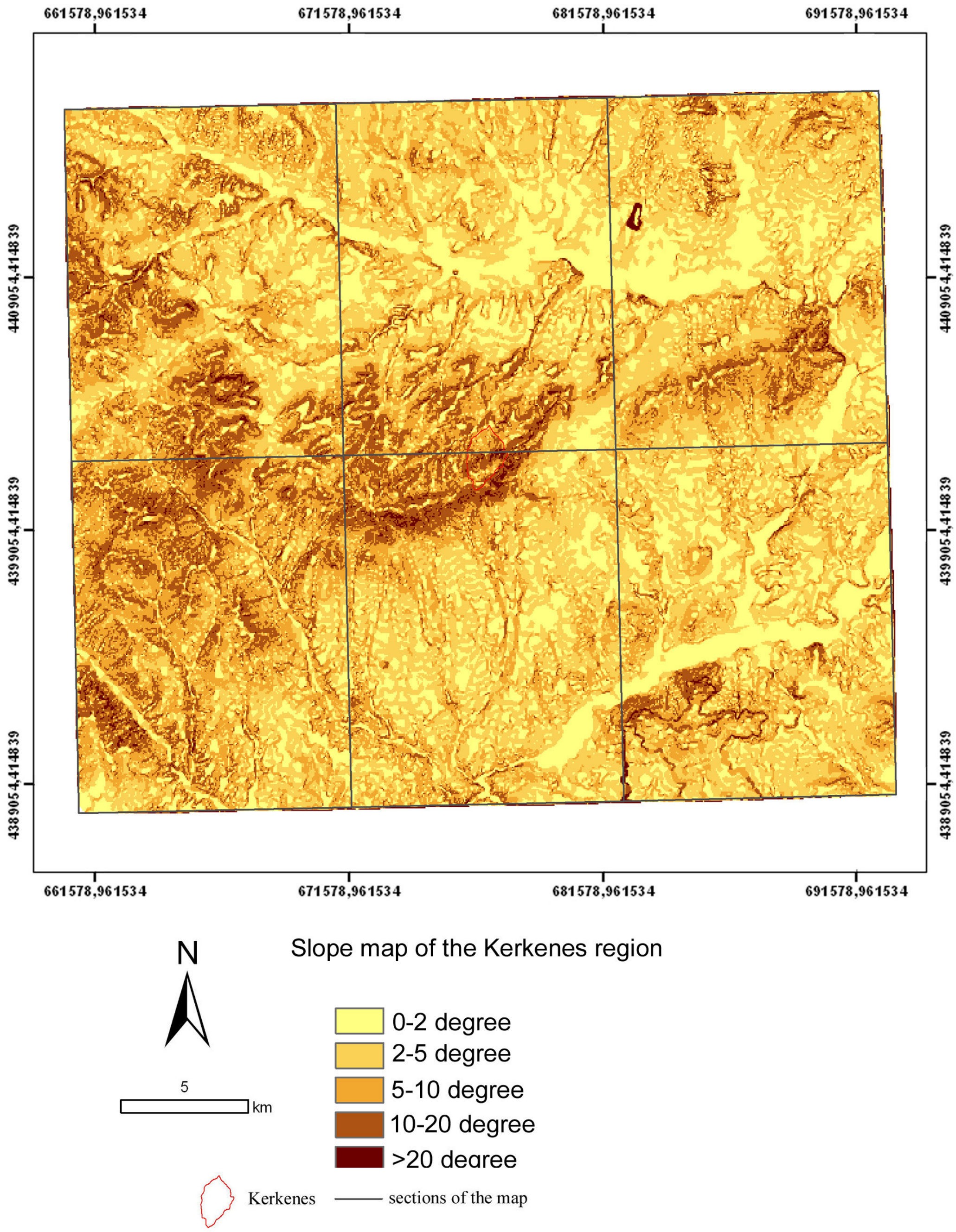



Figure 3.6. Slope map of the Kerkenes region produced from 1:25000 topographic maps.

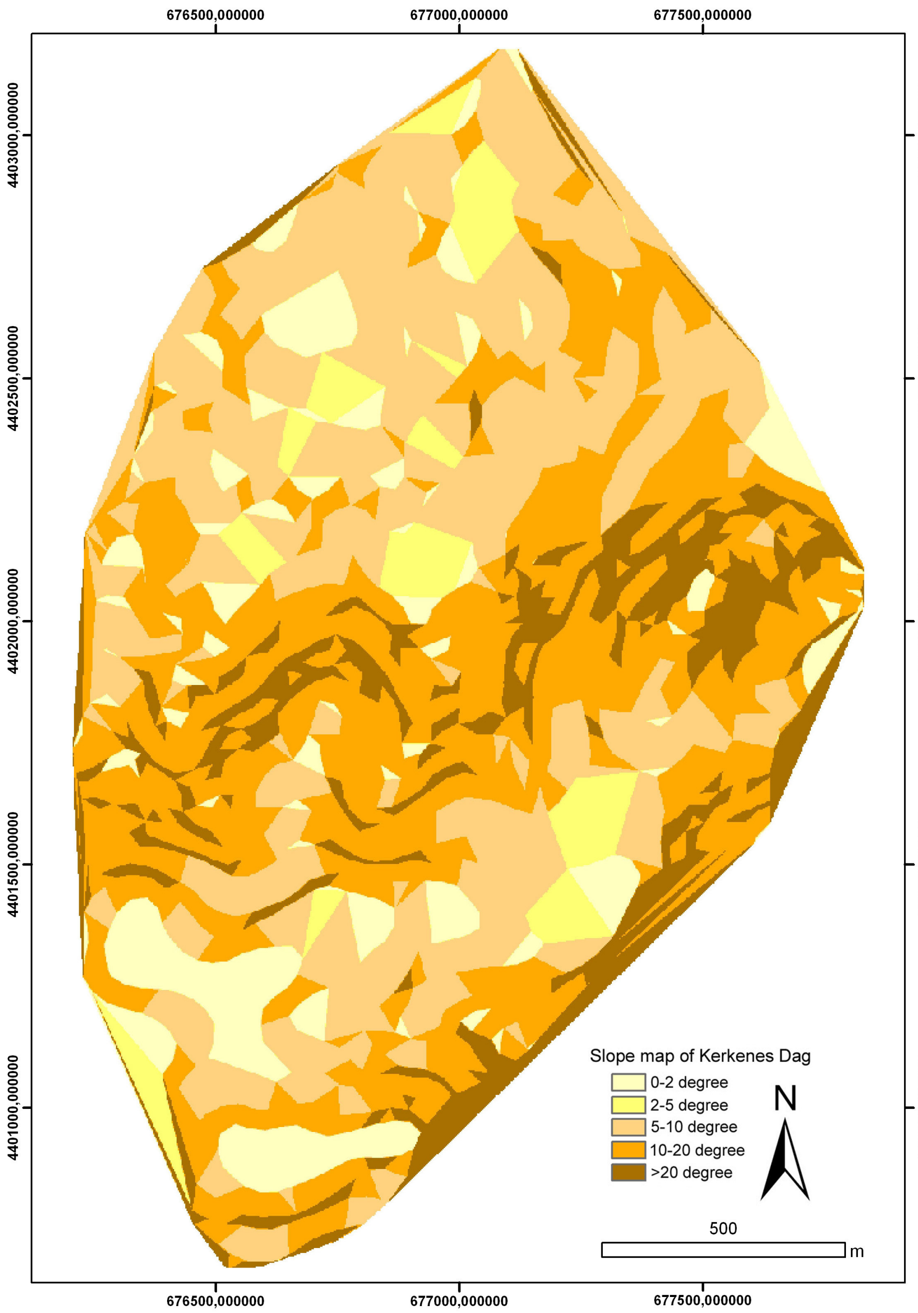
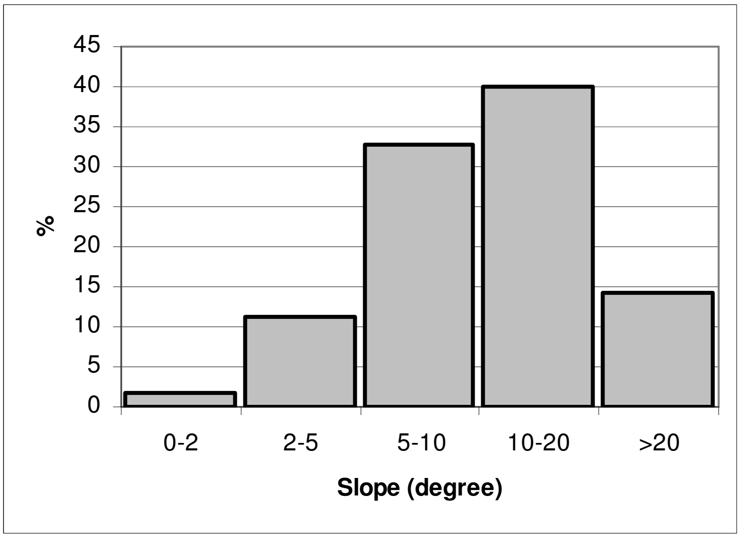
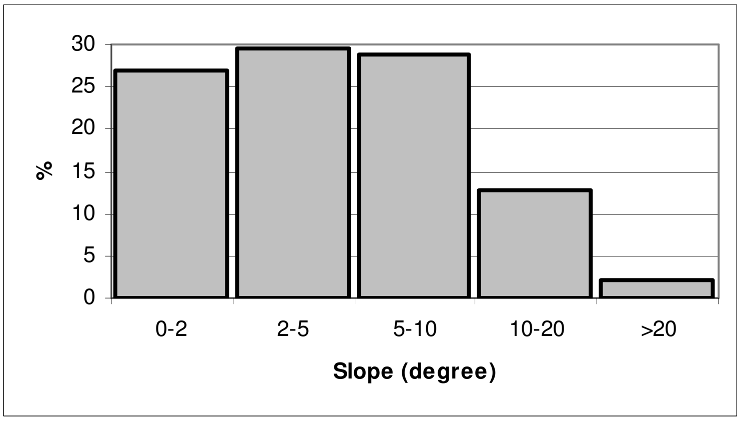



Figure 3.7. Slope map of Kerkenes extracted from 1:25000 topographic maps.



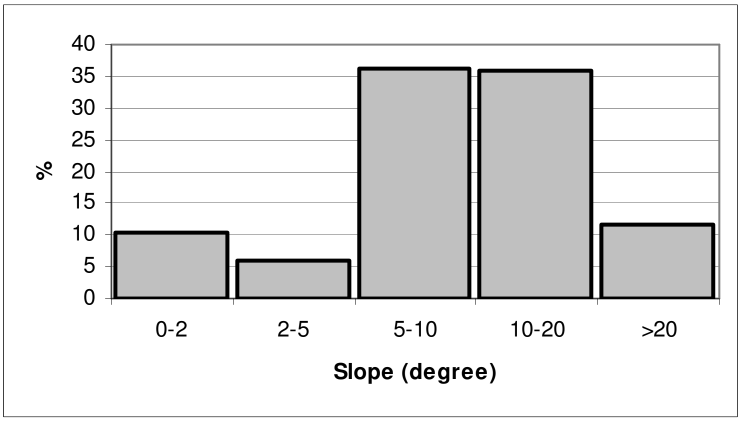

| | |
|---|---|
| Min | 0,26 |
| Max | 74,62 |
| Mean | 12,3 |
| Std.Dev. | 7,59 |

A) Slope histogram of Kerkenes from GPS Data.




| | |
|---|---|
| Min | 0 |
| Max | 88,95 |
| Mean | 5,5 |
| Std.Dev. | 6,19 |

B) Slope histogram of the Kerkenes region from 1:25000 topographic maps.




| | |
|---|---|
| Min | 0 |
| Max | 71,62 |
| Mean | 11,4 |
| Std.Dev. | 8,88 |

C) Slope histogram of Kerkenes extracted from 1:25000 topographic maps

Figure 3.8.Slope histograms.

### 3.1.3. Aspect Map

Aspect is the direction of the slope faces and presented as degree (0-360) or as directions (North, Northwest etc). Aspect is important for receiving sun light for houses, wind direction and vegetation (Davis 2001:295).

The aspect maps and explanations are given in the next section with their histograms in Figures 3.9, 3.10, 3.11, and 3.12.

Table 3.1. The aspect ranges applied in this study

| Degree | Direction |
|---|---|
| -1 degree | Flat |
| 0-22,5 degrees | North |
| 22,5-67,5 degrees | NorthEast |
| 67,5-112,5 degrees | East |
| 112,5-157,5 degrees | SouthEast |
| 157,5-202,5 degrees | South |
| 202,5-247,5 degrees | SouthWest |
| 247,5-292,5 degrees | West |
| 292,5-337,5 degrees | NorthWest |
| 337,5-360 degrees | North |

#### 3.1.3.1. Kerkenes (GPS data)

Aspect values are variations between 0-360 degrees in Kerkenes (Figures 3.9 and 3.12 A). These are usually the areas in the city facing North West and West.

#### 3.1.3.2. The Kerkenes region

Aspect values are changes from -1 to 360 degrees in the Kerkenes region. (Figures 3.10 and 3.12 B). The areas usually face to North East, East and South East.

### 3.1.3.3. Kerkenes (1:25000 topographic maps)

Aspect values are changes in Kerkenes extracted from 1:25000 topographic maps of the region between -1 and 360 degrees (Figures 3.11 and 3.12 C). These are usually the areas in the city facing North West and West. Some unreasonable results such as flat surfaces are gathered from the extracted topographic map due to interpolation of the data.

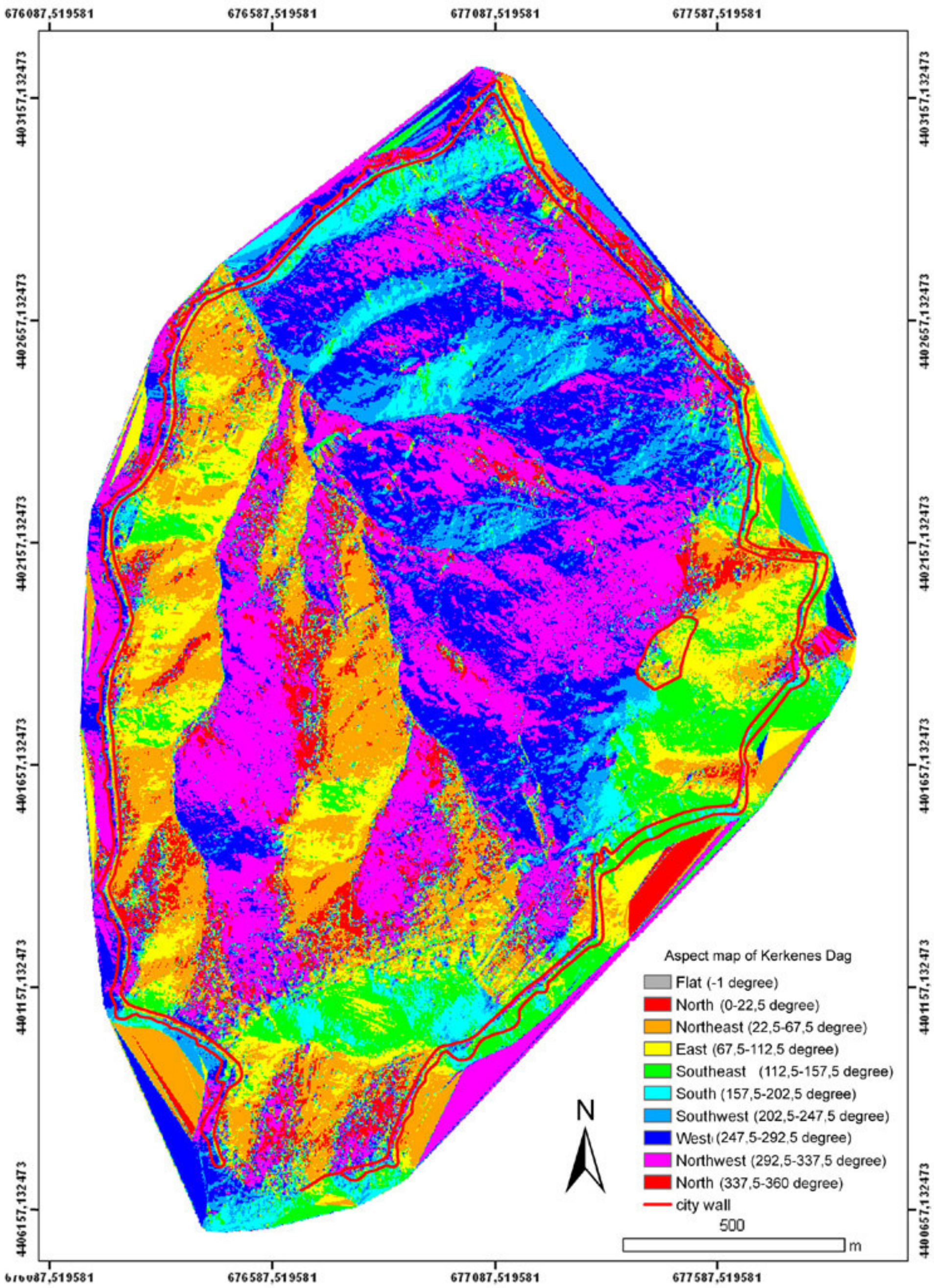



Figure 3.9. Aspect map of Kerkenes produced from GPS Data.

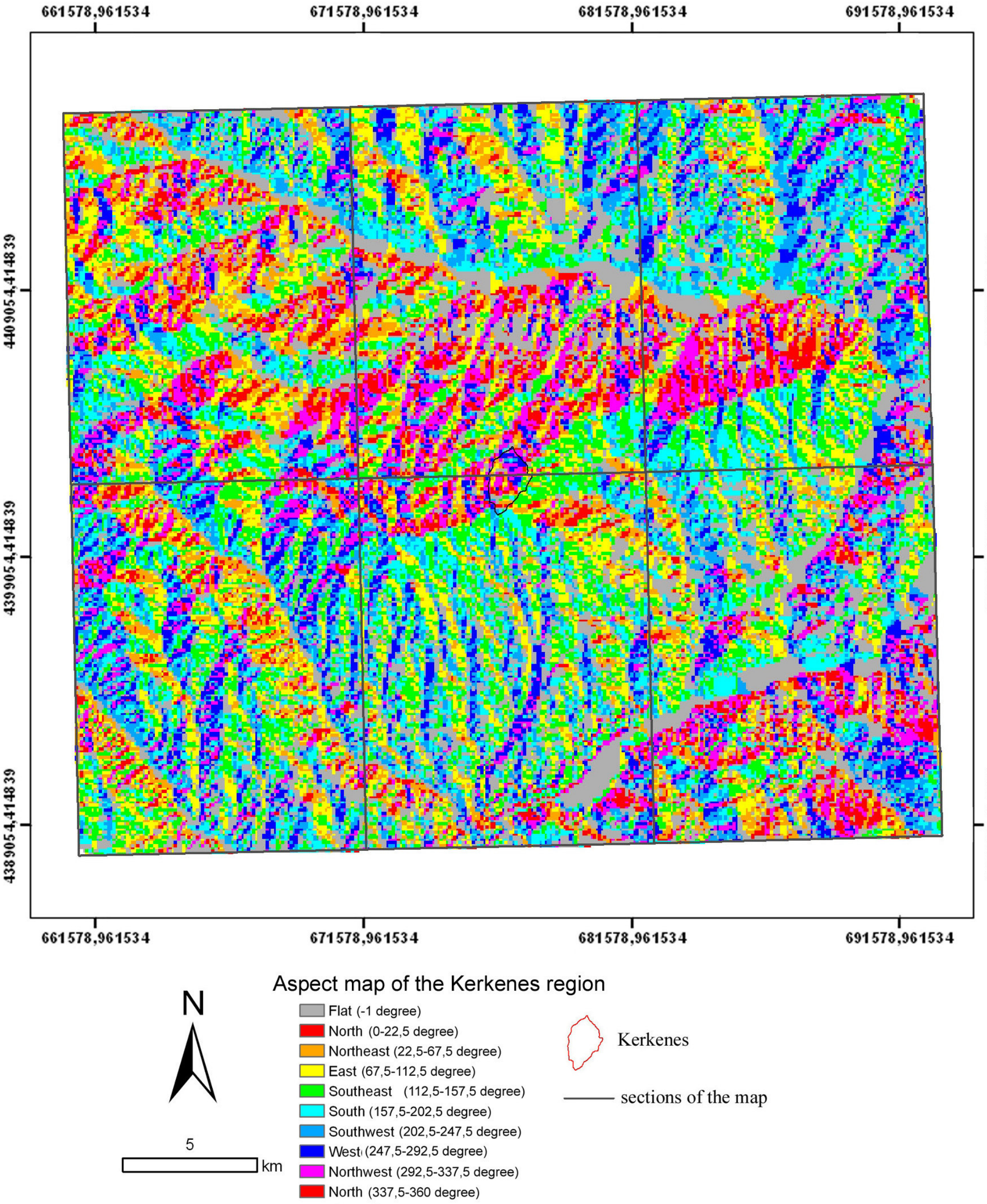



Figure 3.10. Aspect map of the Kerkenes region produced from 1:25000 topographic maps.

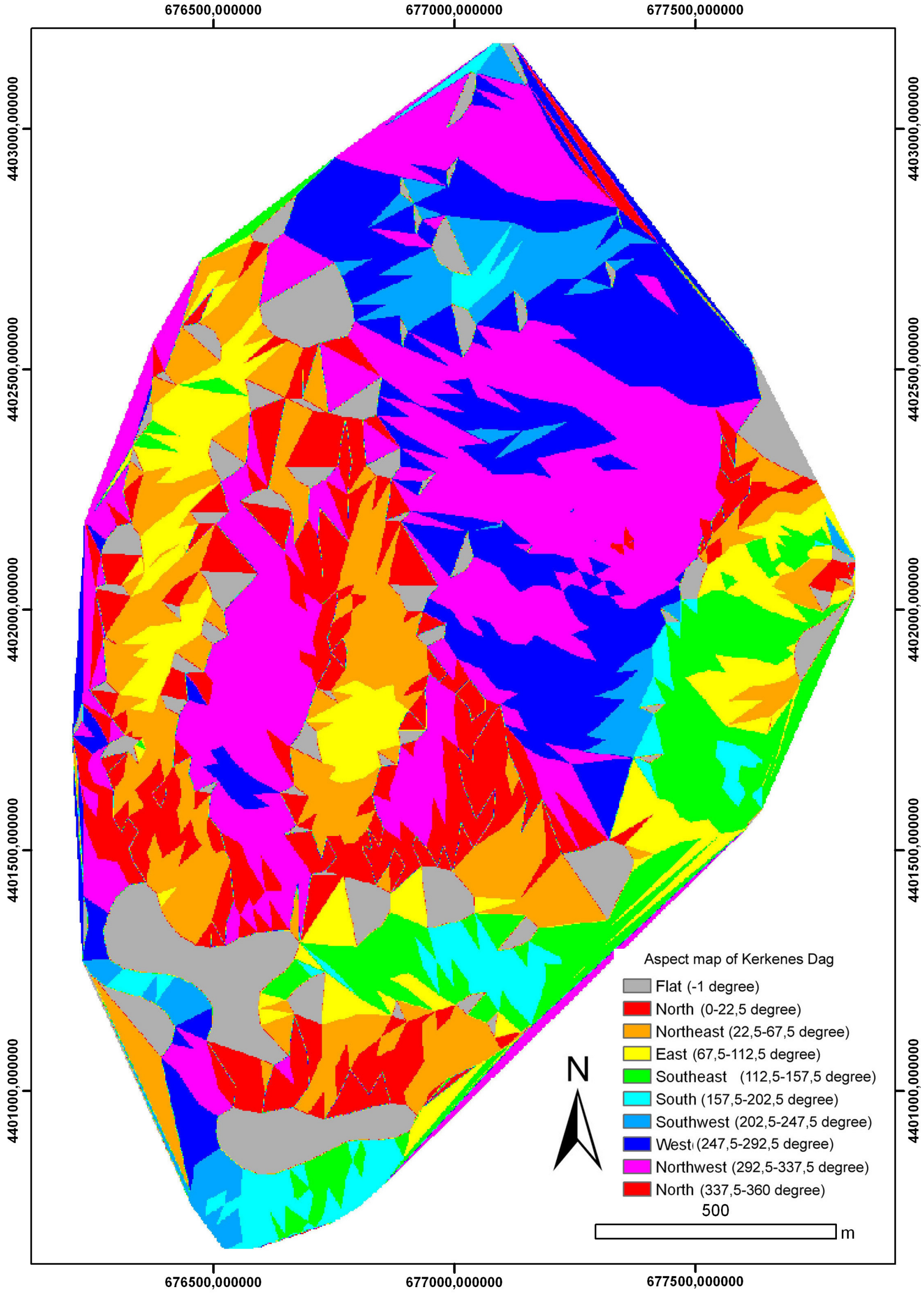
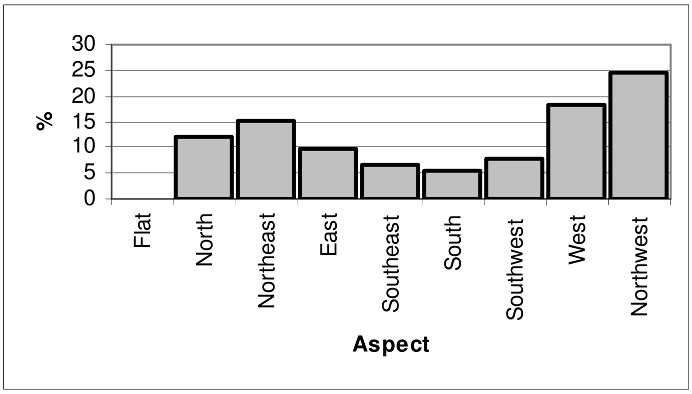
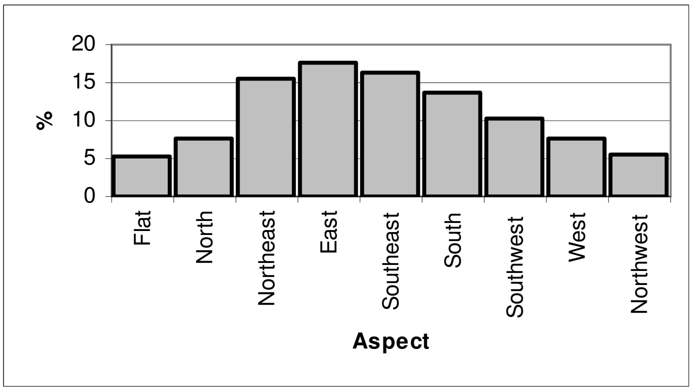



Figure 3.11. Aspect map of Kerkenes extracted from 1:25000 topographic maps.



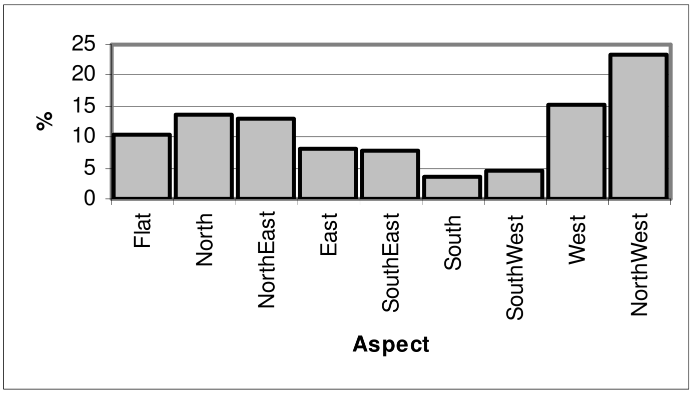

| | |
|---|---|
| Min | 0 |
| Max | 360 |
| Mean | 202,2 |
| Std.Dev. | 113,81 |

A) Aspect histogram of Kerkenes from GPS Data.




| | |
|---|---|
| Min | -1 |
| Max | 360 |
| Mean | 134,4 |
| Std.Dev. | 91,72 |

B) Aspect histogram of Kerkenes region from 1:25.000 topographic maps.




| | |
|---|---|
| Min | -1 |
| Max | 360 |
| Mean | 178,7 |
| Std.Dev. | 127,35 |

C) Aspect histogram of Kerkenes extracted from 1:25.000 topographic maps.

Figure 3.12.Aspect histograms.

### 3.1.4. Terrain Profile

A terrain profile is produced by drawing a line across an elevation theme display, reading elevation values along the line and plotting the “slice” from a horizontal view to represent the shape of the land (Davis 2001: 291).

Terrain profile samples were taken inside Kerkenes every 500 meters (Figure 3.13, profiles 1 to 8) and a random terrain profile sample was taken near the Kale (Figure 3.13, profile 9).The terrain profiles (Figure 3.14) show the elevation differences in the city.

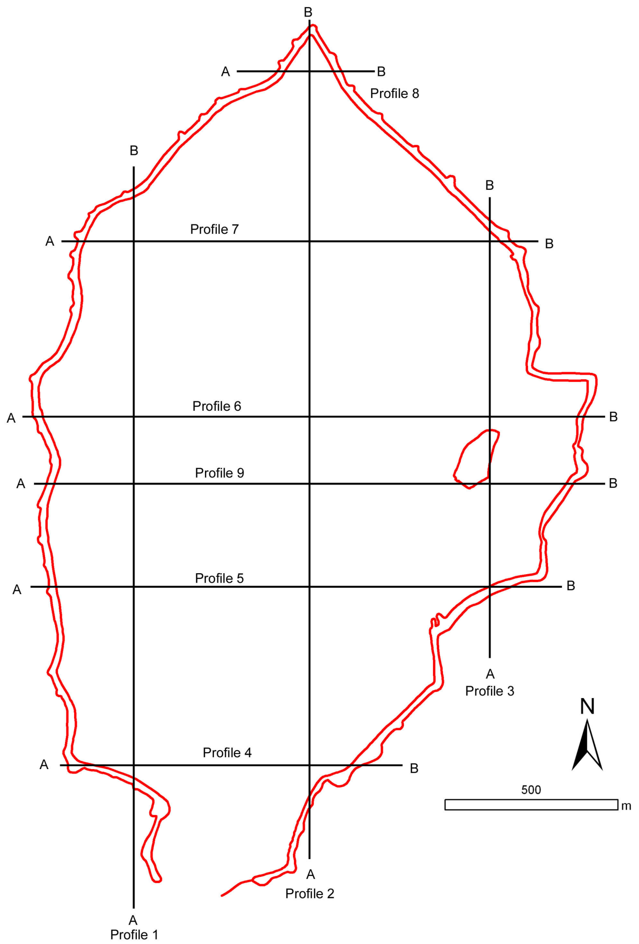



Figure 3.13. Sample terrain profiles for Kerkenes (Profiles 1-8 are every 500 meters and Profile 9 is randomly selected to show the terrain profile for the Kale)

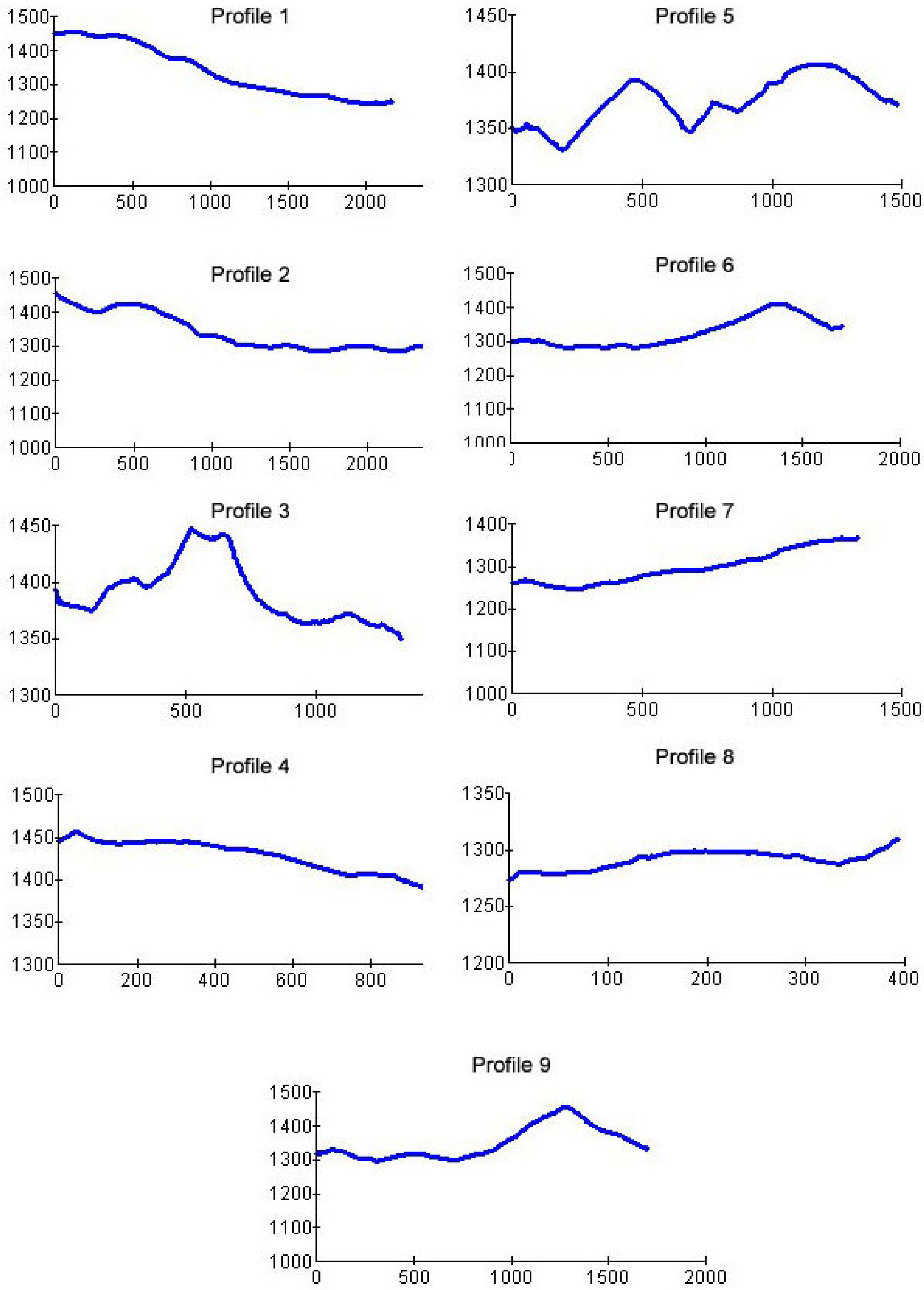



Figure 3.14. Terrain profiles of Kerkenes.

## 3.2 SETTLEMENT DATA ANALYSIS

In this part of the thesis the relationship between the city wall and topography will be analyzed including city wall and its components such as gates and towers.

Approximately 7 km of stone walls, 7 gates (Figure 3.15) and 75 towers (with gate towers) are included in the analysis of the city wall at Kerkenes.

To analyze the city wall, due to the hardware and problems while processing GPS data, the data overlaid with the wall plan which was drawn in 1993, and buffered at 30 meters. The towers were drawn from the wall plan and the GPS data for all city except the Kiremitlik Area. Because, normally the remains of the city wall and the towers are visible from the ground and the remote sensing data; however at the Kiremitlik area the city wall is not visible.

### 3.2.1. City Wall

The city wall (fortification and defensive wall) have a towers and gates for the architectural and defensive purposes.

The Iron Age city wall at Kerkenes is analyzed by its length, and the positions of towers and gates in addition to its relation with the topographic divide (The ridge of the land surface that provides a boundary between adjacent watersheds or basins defines as a topographic divide (http://www.brown.edu/Courses/GE0158 /web2revised/webglossary/tdef/topographicdivide.html)).

#### 3.2.1.1. Characteristics of the city wall

The city wall encloses an area of 2,49 km². The total circumference of the city wall is nearly 6300 meters, excluding the Kiremitlik area and measuring the distance between tower centroids. However, the length of the city wall increases to 6800 m. when it is measured from the outside of the remains.

In this study; the first, measurement that is the distance between towers is applied to the whole of the city wall analysis.

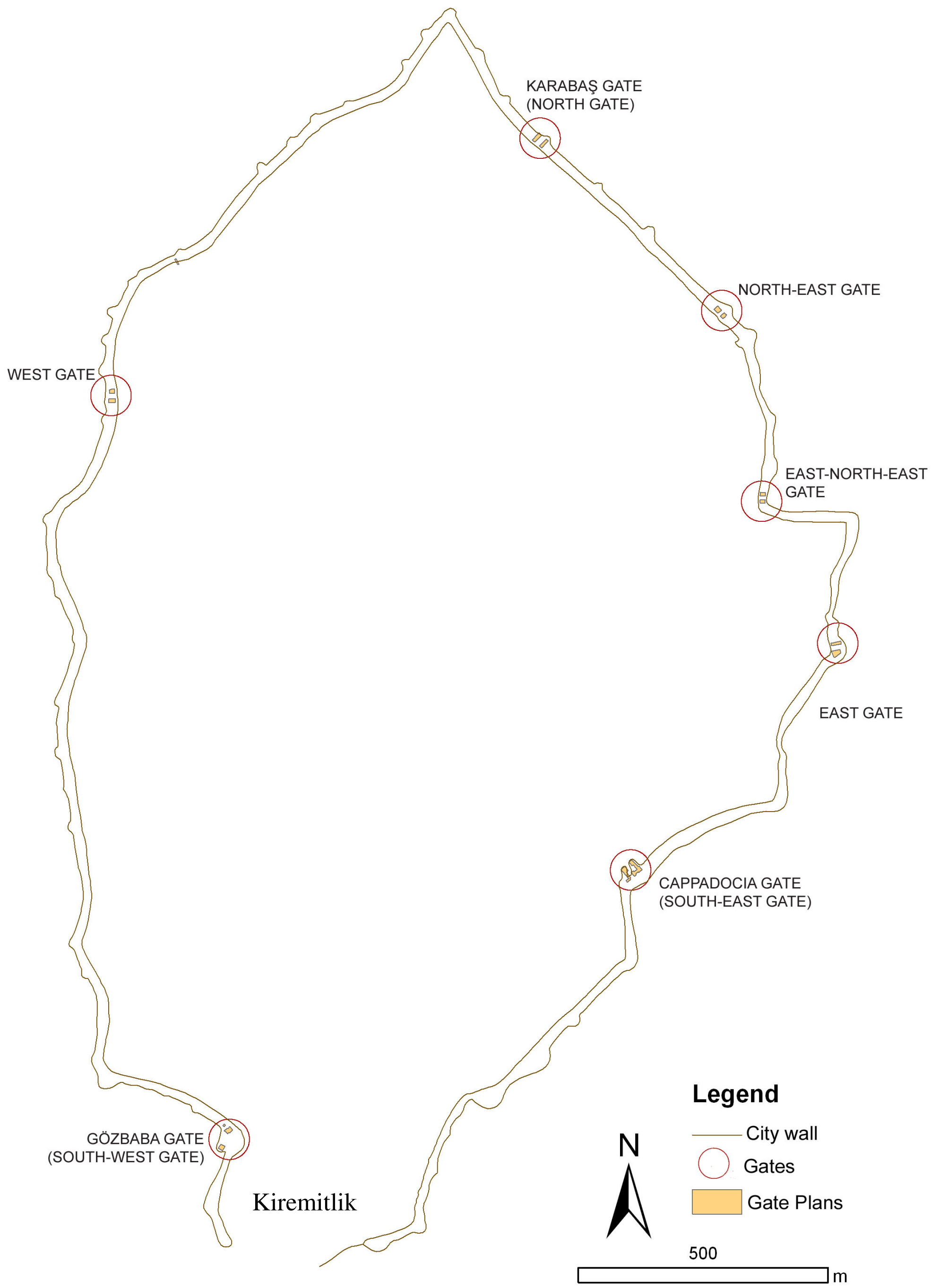



Figure 3.15. City wall and gate plans of Kerkenes.

The height of the city wall could be with its sloping glacis approximately 7 meters (Branting 2004: 47-48).

The defensive system of Kerkenes is constructed from granitic bedrocks (Figures 3.16 and 3.17). The wall itself is some 4.5 to 5m. wide at the preserved top (Summers and Summers 1996: 103).

Source: The Kerkenes Project archive-01dpjv1908

Figure 3.16. The city wall of Kerkenes.

Figure 3.17. The city wall of Kerkenes. (Photographed by Nurdan Atalan)

The studies in 2000 at Kerkenes revealed that the entire city wall and seven city gates were constructed exclusively from stone. Although the seven kilometers of city wall were impressively and powerfully built there must have been some problems of defence. There is a considerable space between the city wall and houses. The width of this space is not accurately established but it is thought to be 5.00 m. minimum. Such a space must have been useful for the manoeuvres of the soldiers during attack as this sort of arrangement facilitated the displacement of the army from one place to another (Summers and Summers 2003: 8).

According to Summers:

> *If this interpretation is found to contain any merit, it should be noted that the surface of this "military road" was never made sufficiently smooth and level for mounted fighters, either on horseback or in chariots. Foot soldiers on the other hand could be quickly despatched from one place to another* (Summers and Summers 2003: 8).

The topographic divide at Kerkenes is drawn from 1:25000 topographic maps of the city to determine the relation between the location of the city wall and topography that proves the city wall lies on the topographic divide (Figures 3.18 to 3.20). The city wall defines five catchment areas in the city.

Table 3.2. Catchment Areas of Kerkenes.

| Location | Area |
|---|---|
| Catchment Area 1 | 2058988 m² |
| Catchment Area 2 | 248038 m² |
| Catchment Area 3 | 38965 m² |
| Catchment Area 4 | 68241 m² |
| Catchment Area 5 | 74502 m² |
| **Total Area** | **2488734 m²** |

The northern part of the city has a drainage basin that consists of one main stream with small tributaries (Figures 3.21 to 3.24) of which 60% is enclosed by the city wall (Table 3.2). This is named as Catchment Area 1 in this study (Figure 3.18). The main stream trends SSE-NNW, it joins with tributaries and flows out through the Water Gate before joining the Kale Dere outside the city wall (Figure 3.24). This area has two reservoirs (Figures 3.21 to 3.26). Catchment Area 1 has a drainage channel through the city wall that is called the Water Gate (Figures 3.24, 3.26 and 27).

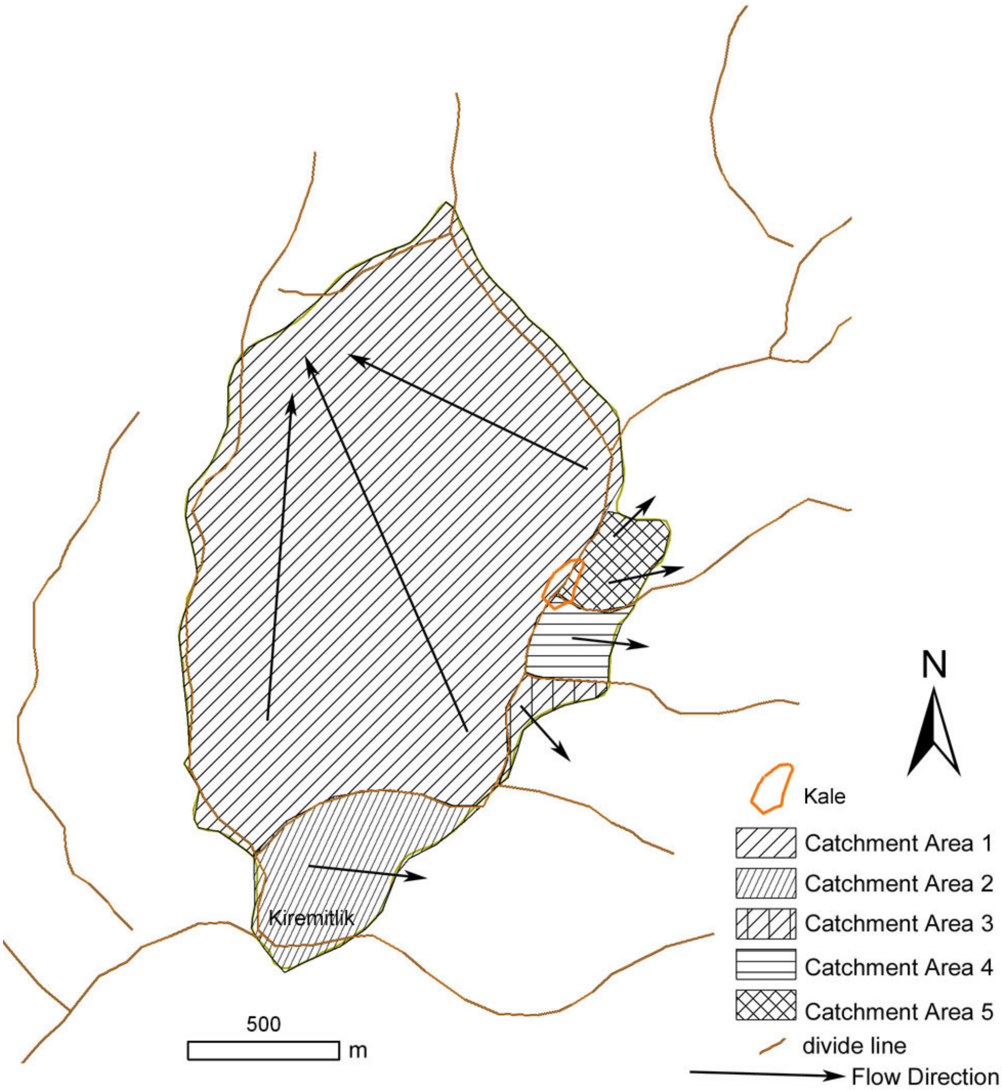



Figure 3.18. Divides and catchment areas of Kerkenes.

Source: The Kerkenes Project archive-93bwhb0229

Figure 3.19. Aerial view of Kerkenes.

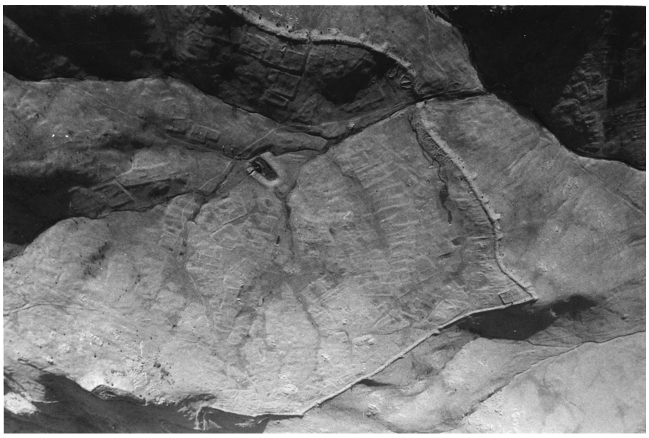
Source: The Kerkenes Project archive-93bwhb0127

Figure 3.20. Aerial view of the southern part of Kerkenes.

Figure 3.21. Catchment Area 1 at Kerkenes.
(Photographed by Nurdan Atalan)

Source: The Kerkenes Project archive-02dpjv0606

Figure 3.22. Northwest of Kerkenes. Looking from the Kale to the West.



Source: The Kerkenes Project archive-93bwhb0128

Figure 3.23. Aerial view of the northern part of Kerkenes.

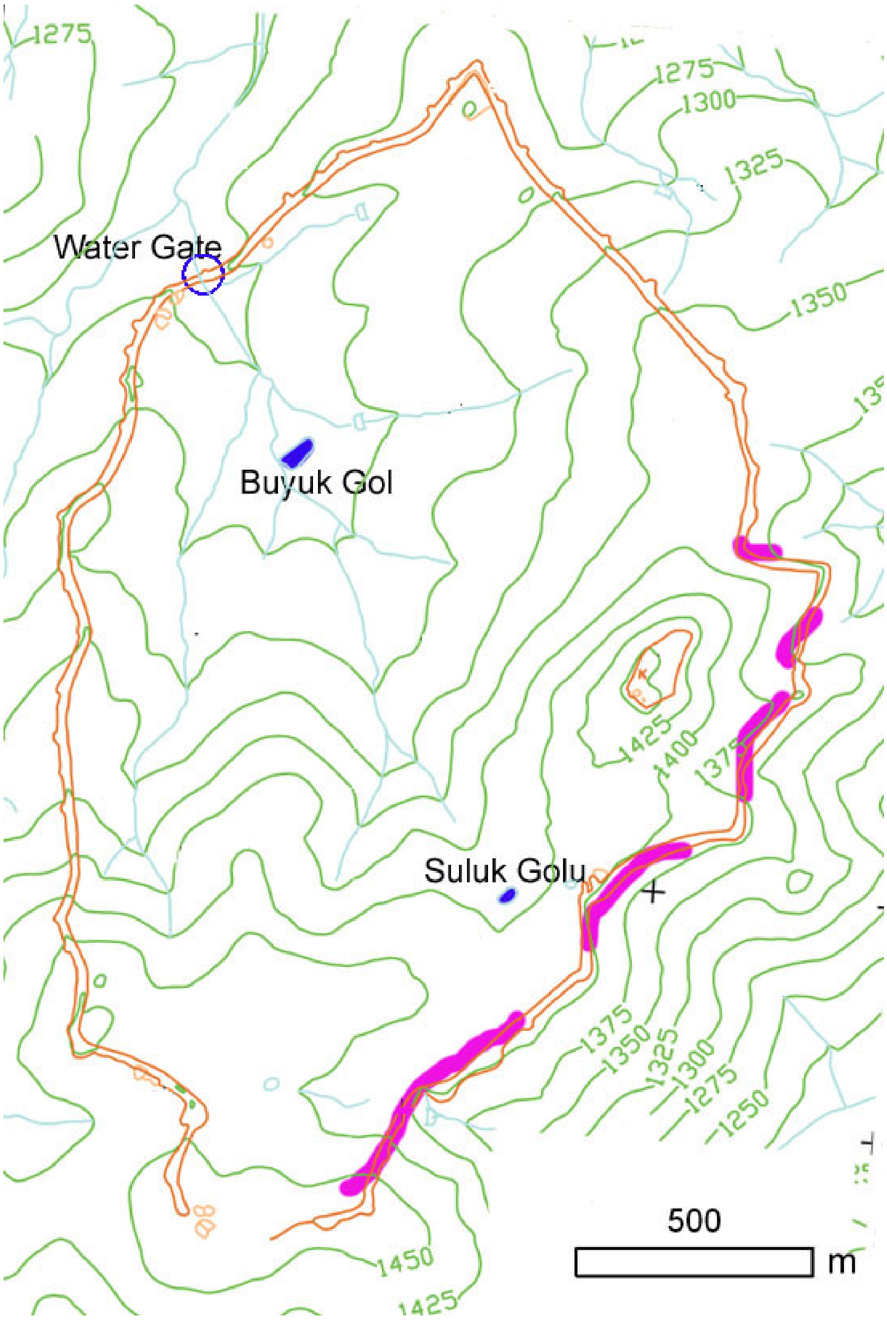
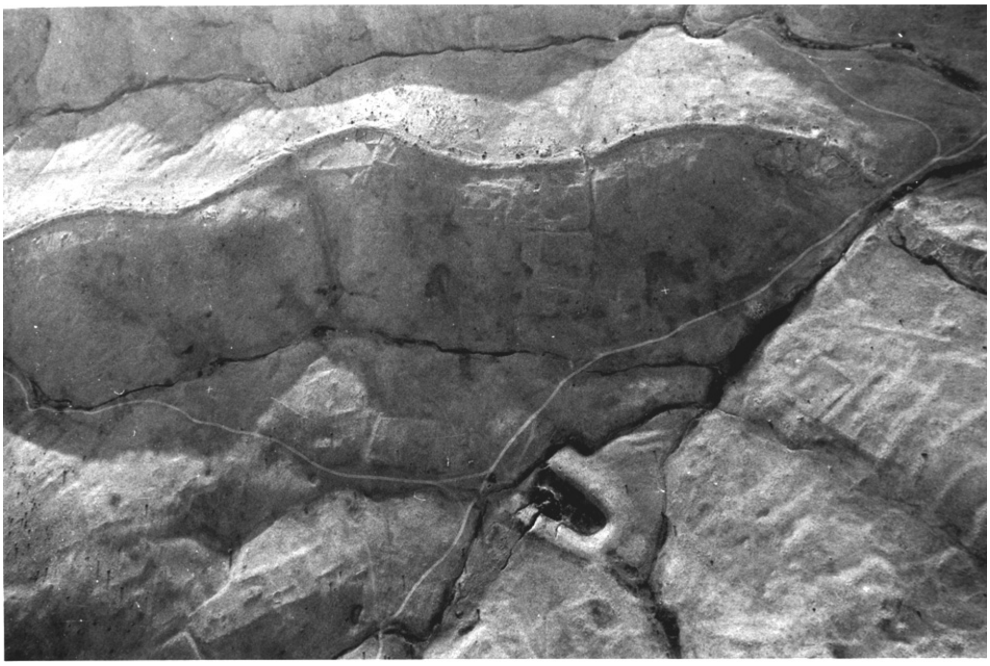


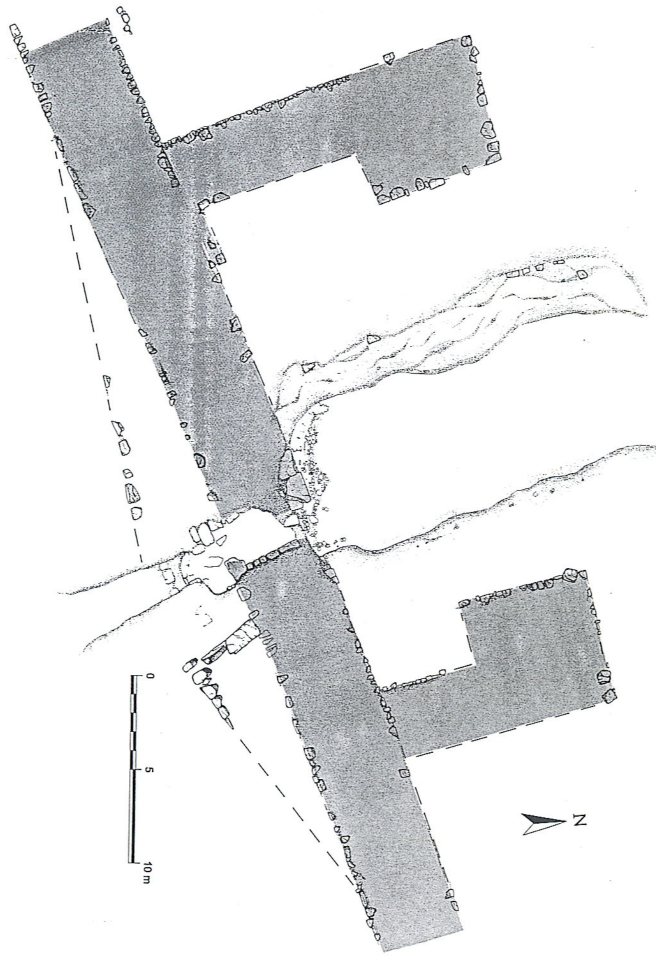

Figure 3.24. The Kerkenes map, which shows streams and reservoirs. The areas colored in pink show possible places for channels in the city wall.

Figure 3.25. Southeast part of Kerkenes. (Photographed by Nurdan Atalan)



Source: The Kerkenes Project archive-93bwhb0401

Figure 3.26. Aerial view of the northwestern part of Kerkenes.




Source: Summers and Summers 1999: Figure 10

Figure 3.27. The Water Gate, showing the internal glacis and the external reservoir. Identification of this structure as a gate is open to question.

The city wall at the Kiremitlik area encloses another catchment area which is Catchment Area 2. Between Kiremitlik and East North East Gate the city wall goes on very steep slope hills and constitutes another catchment area that is Catchment Area 3. Catchment Areas 4 and 5 are on the east of the Kale (Figures 3.18 and 3.28). Those Catchment Areas should have a drainage channel inside the city wall like the Water Gate, to prevent the damage on the city wall by erosion and flow.

The city would be smaller than its actual size if those catchment areas (Area 2-5) were not included. In that case the two high points; “the Kale” and “the Kiremitlik” would be excluded (Figure 3.18). Probably higher sections of the terrain were included inside the city wall to increase the range of visibility (Figures 3.28 to

3.30). Catchment Areas 3-5 had a level road for walking around the Kale. If those areas were not included to the city then people would have to climb the Kale to reach the Cappadocia Gate and the Palace Complex.

Figure 3.28. One of the catchment areas of Kerkenes. (Photographed by Nurdan Atalan)

Figure 3.29. The Kale. Looking from the Kiremitlik to the North. (Photographed by Nurdan Atalan)

Figure 3.30. Outside of Kerkenes. Looking from the Kiremitlik to the South. (Photographed by Nurdan Atalan)

Terrain profile samples are taken from the city wall randomly (Figure 3.31). Figures 3.32 and 3.33 have shown the profiles and the sketch plan of the original city wall. The profiles taken from the city wall shows that the city wall was built on slope areas.

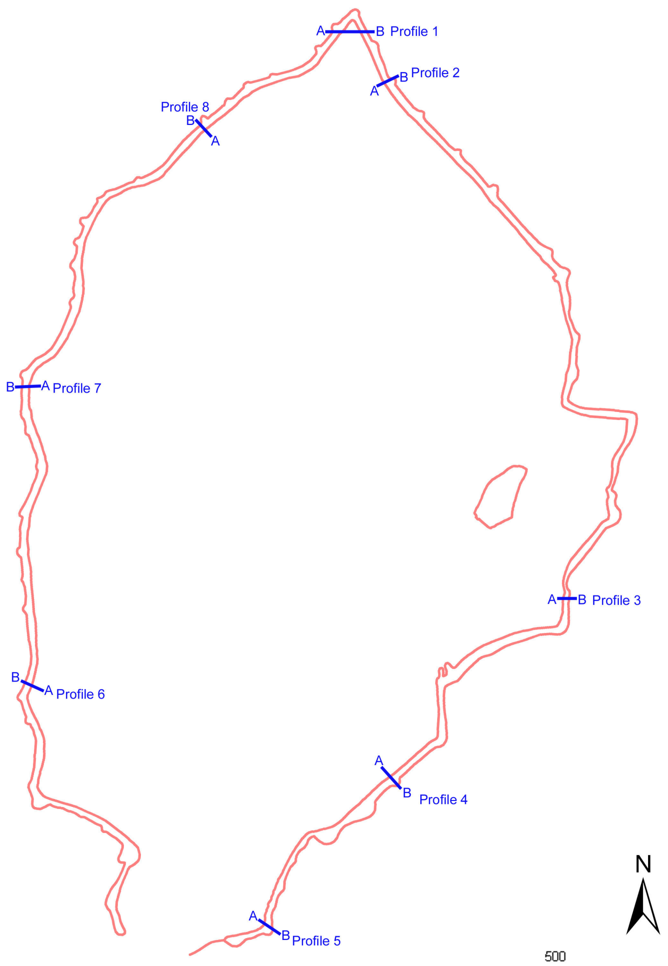



Figure 3.31. Sample terrain profiles along the city wall.

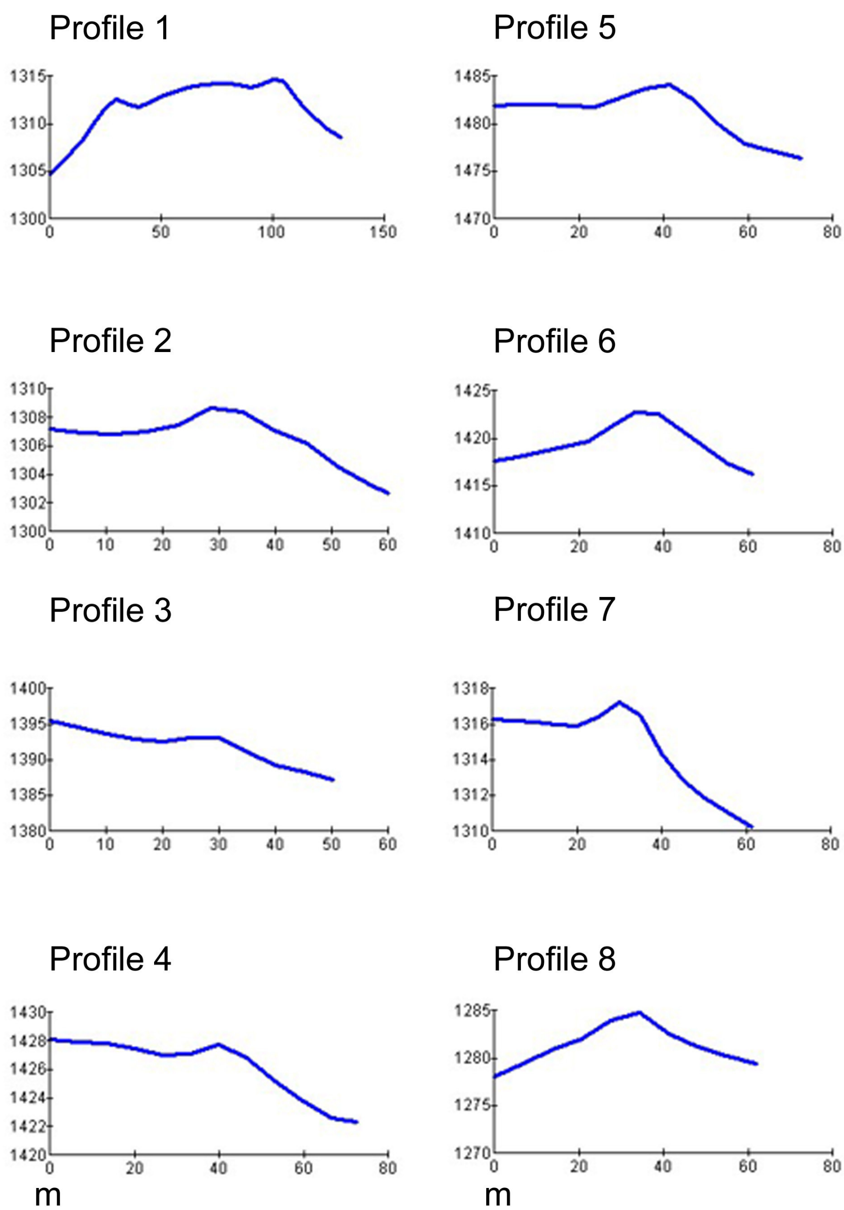



Figure 3.32. Terrain profiles of the city wall.

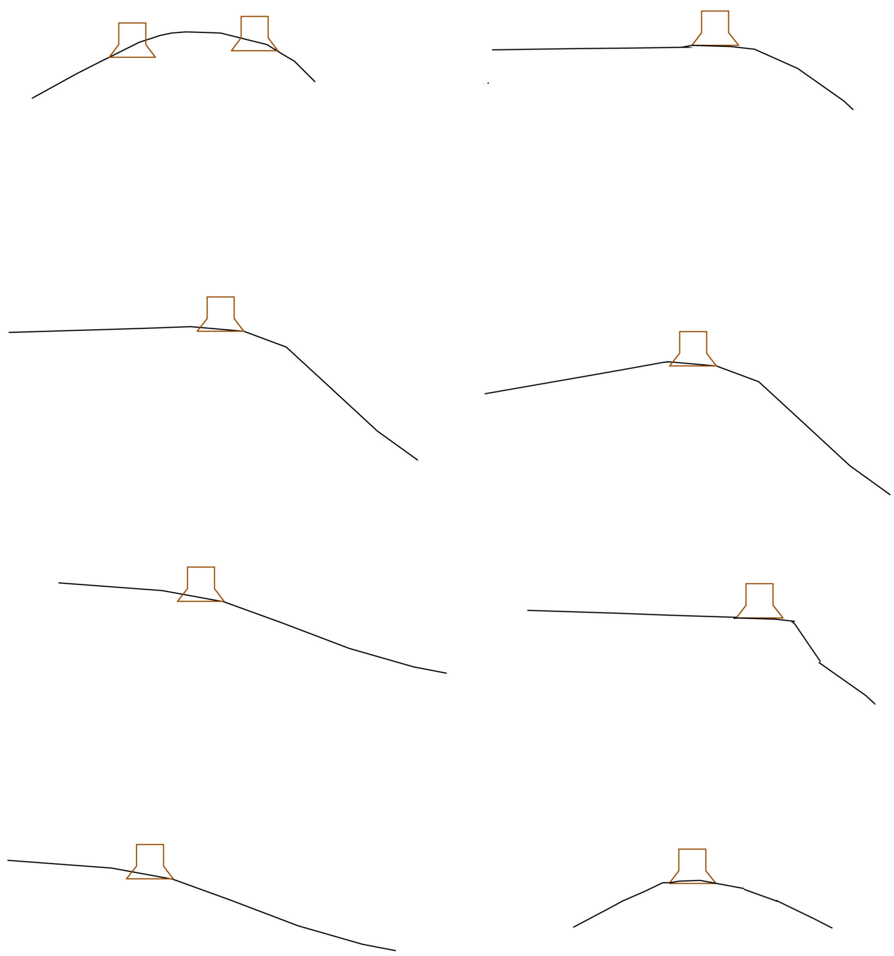


Figure 3.33. Sketch plan of the towers according to terrain profiles.

#### 3.2.1.2. Towers

Analyzing the towers was not easy because no original tower is fully preserved on the city wall. The city wall was deliberately in the mid first millennium BC and further eroded by time and shepherds who continue to use the stones for building enclosures for their animals on and near the city wall. Remains of the original towers have been drawn from total station survey data and overlaid with GPS survey data outputs. 75 polygons have been drawn as towers including 14 gate towers. Each gate is assumed to have had two towers (although the Gözbaba and Cappadocia Gates had more and are of complex design while the perhaps has East Gate only one). Two functions are given to the towers: 1. Tower; 2. Gate Tower. However accepting two towers for each gate for the analysis of the towers affects the results for basic statistics. For example gate towers were closer than other towers in distance analysis so that the central points were placed in the middle of the gate centroids and accepted as being one tower, a process which reduced the number of towers to 68 (for the purpose of analysis). The towers are labelled as T1, T2 (Figure 3.34).

Elevation, slope and aspect maps are created from the GPS data and points were put in the center of the towers (polygons). Elevation, slope and aspect values are calculated for the central points of the towers for the analysis and histograms are created for all towers along the city wall (Figure 3.35). The elevations of the towers are between 1244 m minimum and 1470 m maximum (Table 3.3 and Figure 3.35A). The height of the most of the towers is between 1250-1450 m (Figure 3.18 A). Slopes of towers vary between 2 and 54 degrees. Most of the towers are built on steep slope areas (Figure 3.35B). The tower aspects are between 10 and 355 degrees, including all directions. Most of the towers face to the west and northwest. (Figure 3.35C).

The area of each tower is calculated in *ArcGIS 9.x* (Table 3.3). The smallest tower is 15,57 m² and the largest 2993,52 m² (Figure 3.36). The smallest tower would probably have functioned as a gate tower as the plan of Gözbaba Gate differs from the other gates. If this was the case then the smallest tower would have an area of 101,89 m². The two largest towers, one has an area of 2390 m² and the other one has 2993,52 m², are situated on the SE section of the city wall.

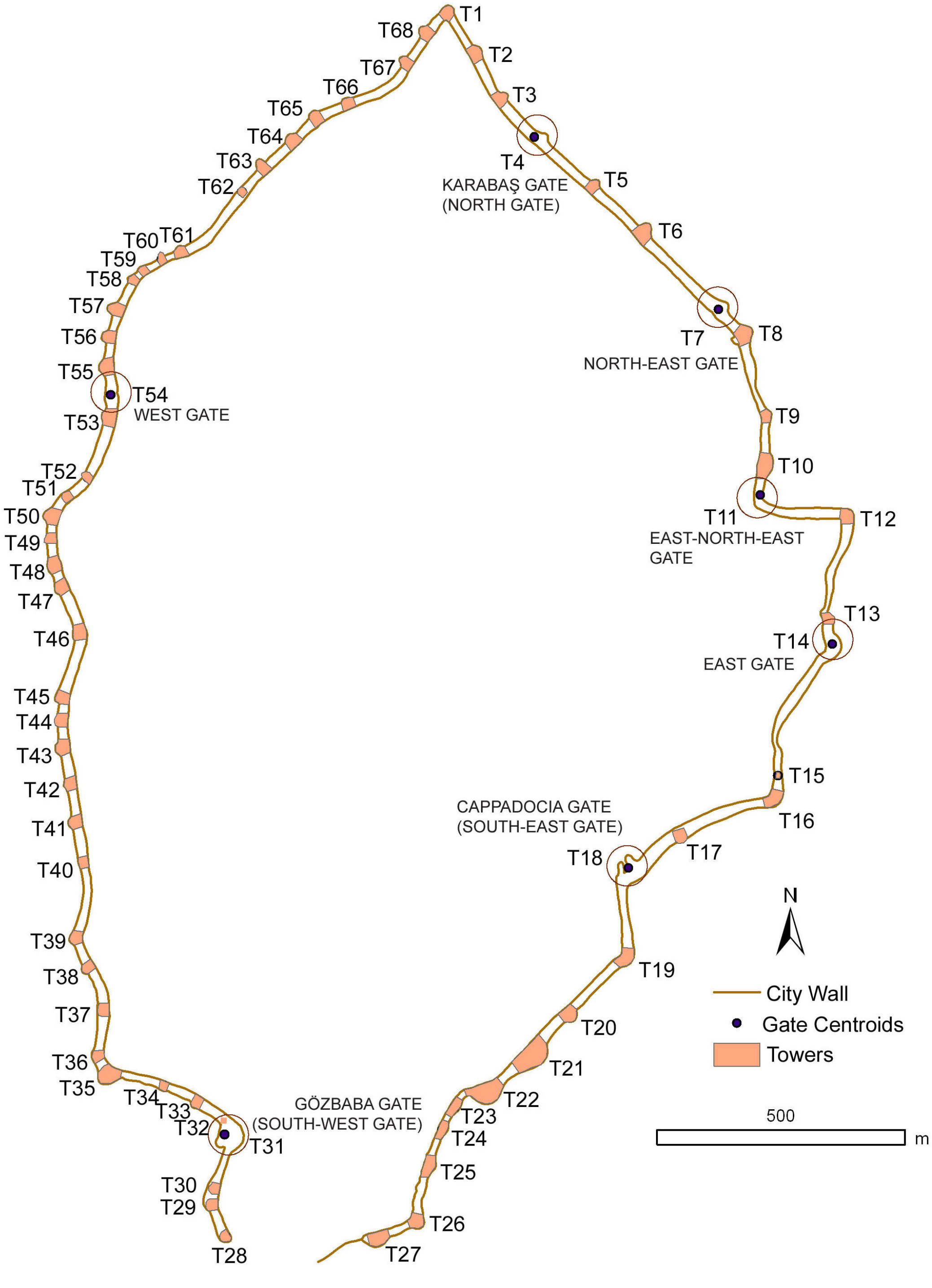
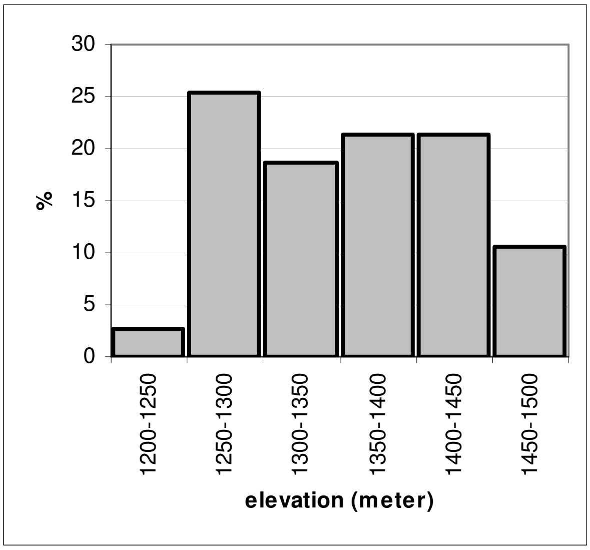
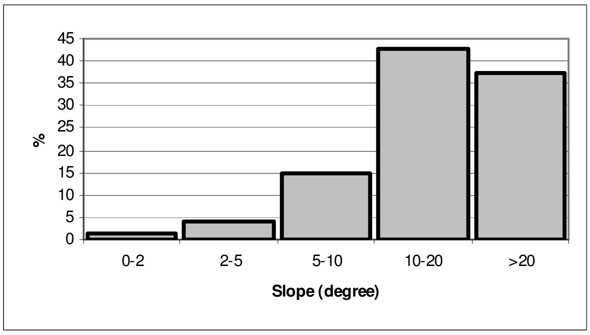



Figure 3.34. Towers of Kerkenes.



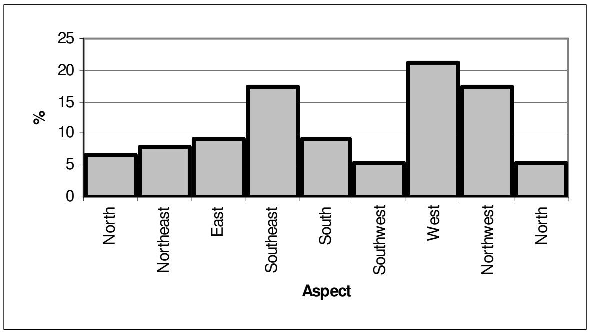

| | |
|---|---|
| Min | 1244 |
| Max | 1470 |
| Mean | 1355,6 |
| Std.Dev. | 67,13 |

A) Elevation histogram of the towers at Kerkenes.




| | |
|---|---|
| Min | 2 |
| Max | 54,34 |
| Mean | 17,1 |
| Std.Dev. | 9,14 |

B) Slope histogram of the towers at Kerkenes.




| | |
|---|---|
| Min | 10 |
| Max | 355 |
| Mean | 197,7 |
| Std.Dev. | 105,13 |

C) Aspect histogram of the towers at Kerkenes.

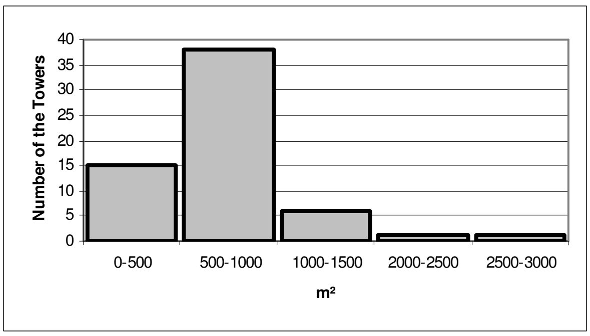
Figure 3.35.Histograms of the towers at Kerkenes.

Table 3.3. Elevation and area values of the towers (Italic and bold ones are the gate towers. Elevation difference between two gate tower is added up and divided into 2 to find the average elevation value for the gate).

| Name of the Tower | X | Y | Area (m²) | Elevation (meter) |
|---|---|---|---|---|
| T1 | 1004,98 | 2714,32 | 669,31 | 1299,63 |
| T2 | 1061,29 | 2633,16 | 805,38 | 1298,33 |
| T3 | 1111,66 | 2542,65 | 731,74 | 1292,77 |
| ***T4*** | ***1181,55*** | ***2466,06*** | ***0*** | ***1299,61*** |
| T5 | 1298,85 | 2366,53 | 582,82 | 1323,24 |
| T6 | 1400,22 | 2272,30 | 1131,01 | 1347,83 |
| ***T7*** | ***1553,22*** | ***2119,52*** | ***0*** | ***1365,58*** |
| T8 | 1602,97 | 2068,72 | 1124,34 | 1379,46 |
| T9 | 1648,32 | 1905,78 | 488,11 | 1374,71 |
| T10 | 1645,52 | 1806,37 | 1362,18 | 1368,62 |
| ***T11*** | ***1637,02*** | ***1747,28*** | ***0*** | ***1361,79*** |
| T12 | 1811,20 | 1703,79 | 752,21 | 1351,10 |
| T13 | 1773,40 | 1499,20 | 535,99 | 1353,88 |
| T14 | 1782,90 | 1447,27 | 0,00 | 1374,58 |
| T15 | 1672,90 | 1183,83 | 101,89 | 1382,91 |
| T16 | 1663,21 | 1137,94 | 971,08 | 1386,94 |
| T17 | 1475,25 | 1062,97 | 667,49 | 1392,70 |
| ***T18*** | ***1371,37*** | ***998,36*** | ***0*** | ***1402,42*** |
| T19 | 1364,52 | 818,93 | 1057,47 | 1409,55 |
| T20 | 1250,35 | 705,04 | 904,38 | 1412,52 |
| T21 | 1175,38 | 621,97 | 2993,52 | 1407,41 |
| T22 | 1084,18 | 549,37 | 2390,79 | 1402,19 |
| T23 | 1019,63 | 518,38 | 676,58 | 1402,54 |
| T24 | 994,83 | 472,66 | 618,43 | 1414,88 |
| T25 | 967,76 | 400,54 | 910,71 | 1436,49 |
| T26 | 942,42 | 289,71 | 794,34 | 1468,35 |
| T27 | 866,16 | 255,48 | 1072,20 | 1470,12 |
| T28 | 557,14 | 258,82 | 393,56 | 1466,49 |
| T29 | 530,80 | 322,48 | 542,96 | 1463,42 |
| T30 | 535,80 | 354,95 | 449,91 | 1458,62 |
| ***T31*** | ***555,68*** | ***463,70*** | ***0*** | ***1449,08*** |
| T32 | 554,04 | 490,36 | 15,57 | 1448,64 |
| T33 | 500,53 | 528,87 | 508,73 | 1447,57 |
| T34 | 432,98 | 561,35 | 328,51 | 1445,32 |
| T35 | 322,78 | 583,64 | 1332,80 | 1454,80 |
| T36 | 300,31 | 621,13 | 498,41 | 1454,01 |
| T37 | 311,97 | 713,86 | 589,92 | 1448,92 |
| T38 | 280,90 | 799,44 | 527,24 | 1428,46 |
| T39 | 257,03 | 858,50 | 618,08 | 1416,68 |

Table 3.3. Continued

| Name of the Tower | X | Y | Area (m²) | Elevation (meter) |
|---|---|---|---|---|
| T40 | 271,14 | 1009,94 | 437,29 | 1371,93 |
| T41 | 255,48 | 1090,82 | 648,19 | 1356,51 |
| T42 | 245,01 | 1167,80 | 622,17 | 1347,66 |
| T43 | 229,95 | 1241,11 | 810,39 | 1344,12 |
| T44 | 227,14 | 1295,31 | 673,44 | 1341,87 |
| T45 | 229,34 | 1340,51 | 672,70 | 1338,53 |
| T46 | 263,39 | 1471,87 | 797,61 | 1323,94 |
| T47 | 227,18 | 1562,78 | 725,15 | 1308,26 |
| T48 | 212,05 | 1607,27 | 812,01 | 1302,85 |
| T49 | 205,12 | 1659,88 | 477,68 | 1301,20 |
| T50 | 208,79 | 1704,44 | 938,12 | 1302,27 |
| T51 | 238,44 | 1743,63 | 379,41 | 1303,92 |
| T52 | 278,88 | 1782,94 | 383,42 | 1300,03 |
| T53 | 324,15 | 1903,21 | 961,97 | 1283,06 |
| ***T54*** | ***325,44*** | ***1947,98*** | ***0*** | ***1275,67*** |
| T55 | 319,42 | 2004,83 | 905,96 | 1276,52 |
| T56 | 323,59 | 2064,97 | 624,06 | 1271,88 |
| T57 | 338,57 | 2119,79 | 779,81 | 1264,05 |
| T58 | 372,35 | 2178,42 | 360,64 | 1253,49 |
| T59 | 392,91 | 2197,57 | 337,80 | 1251,24 |
| T60 | 429,23 | 2221,09 | 347,18 | 1245,58 |
| T61 | 467,86 | 2234,59 | 549,10 | 1244,24 |
| T62 | 591,37 | 2355,72 | 262,24 | 1259,03 |
| T63 | 633,41 | 2404,78 | 662,66 | 1271,34 |
| T64 | 694,14 | 2457,64 | 763,42 | 1280,45 |
| T65 | 741,05 | 2503,42 | 682,67 | 1286,88 |
| T66 | 805,37 | 2532,92 | 574,89 | 1286,58 |
| T67 | 923,00 | 2614,04 | 568,88 | 1292,95 |
| T68 | 963,30 | 2674,39 | 712,40 | 1296,85 |




| | |
|---|---|
| Min | 15,56 |
| Max | 2993,51 |
| Mean | 731,45 |
| Std.Dev. | 451,83 |

Figure 3.36. Histogram shows area of the towers.

Lines were drawn from the central points of the towers to determine the distance between towers, and segments are classified as T1-T2, T2-T3 (Figure 3.37).

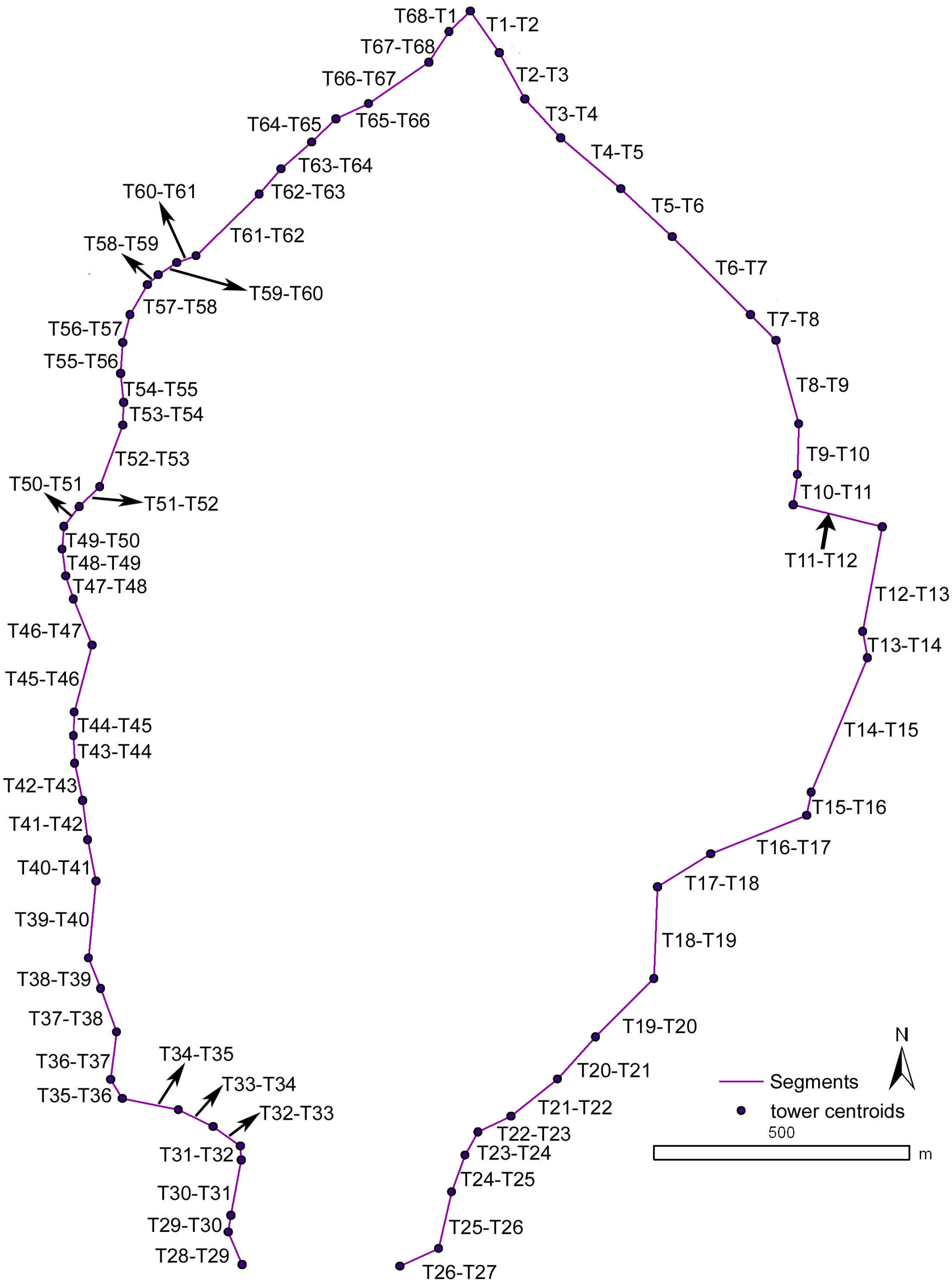



Figure 3.37. Segments between towers of Kerkenes.

The elevation and area values of the towers were calculated in ArcGIS 9.x program and results were shown in Table 3.3.

To understand the distribution of the towers and their placement along the city wall basic mathematic formula were applied. Measuring the distance between the centroids of the towers gave the direct distance (which is not the real distance because it does not account for slope). To find out the real distance and elevation differences between towers in addition to slope a formula is applied (Figures 3.38 and 3.39).

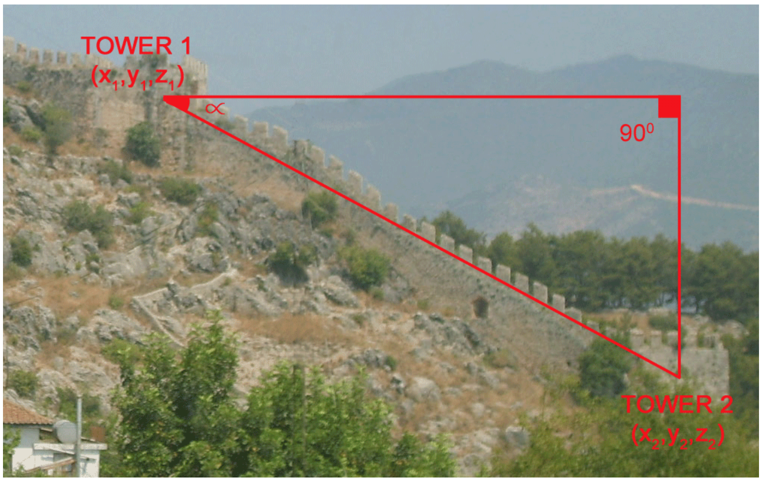



Figure 3.38. Towers of the Alanya Kalesi. (Photographed by Nurdan Atalan).

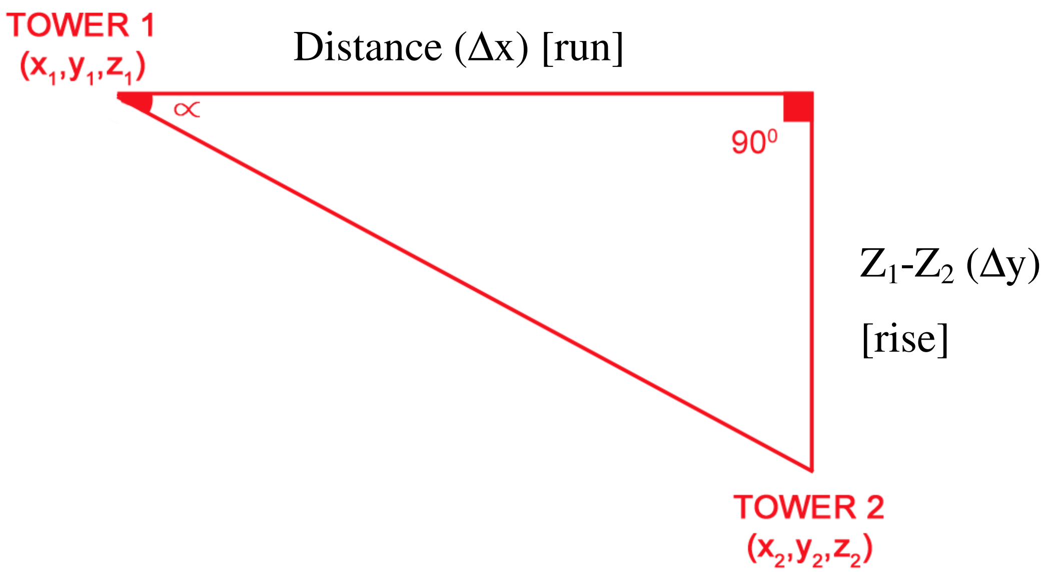



Figure 3.39. Triangle explains slope formula.

The formula[1] used in this study is given below:

*Slope or gradient is the measurement of the steepness, incline or grade of a straight line. It is the ratio of the "rise" divided by the "run" between two points on a line*

When Δ is the change or the difference and m is slope.

$$\mathrm{m} = \frac{\Delta y}{\Delta x} = \frac{y2 - y1}{x2 - x1}$$

$$\mathrm{m} = \frac{rise}{run}$$

*Rise means how many units you move up or down from point to point. (y)*

*Run means how far left or right you move from point to point. (x)*

*θ=Degree of slope*

*The angle θ a line makes with the positive x axis is closely related to the slope m via the tangent function*

*m=tan θ and θ=arctan m*

Formula implemented in the tower analysis so as to obtain the slope values between two towers is:

$$\text{Slope=}\,\mathrm{m} = \frac{\Delta y}{\Delta x} = \frac{Elevation\_difference\_between\_two\_towers}{Dis\tan ce\_between\_two\_towers}$$

Calculated arctan (m) in radyan and turned into degree.

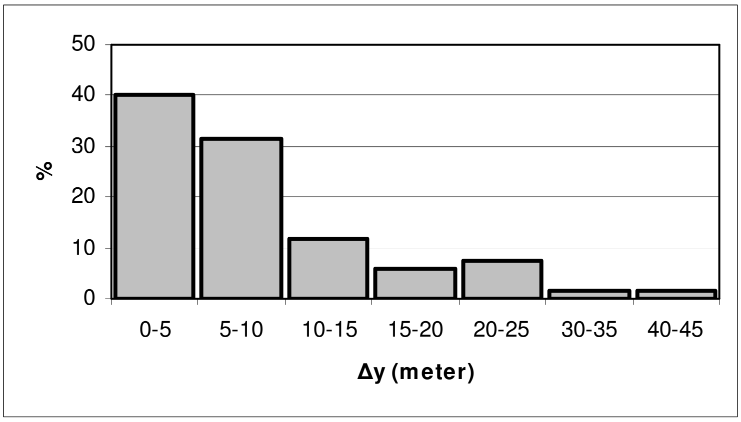
Histograms are created for Δy, Δx and for slope (Figures 3.40 to 3.42).

The elevation difference between two towers is minimum 1 meter maximum 45 meters. Usually between 1-10 meters (Figure 3.40).

The total length of the city wall which is measured from the central points of the towers is 6288,34 meters. To find the average number of towers along the city wall; the length of the city wall divided to the total number of the towers that is 68.

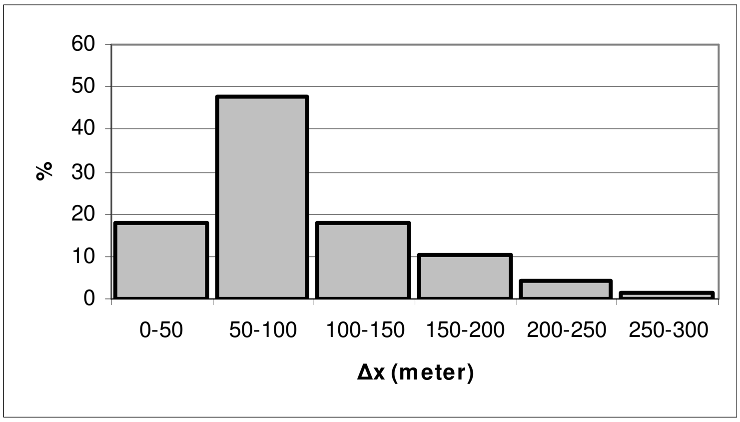
$$\text{Average number of towers} = \frac{Total\_length\_of\_the\_city\_wall}{Total\_number\_of\_the\_towers} = \frac{6288{,}34}{68} = 92$$

[1] General information for slope taken from http://en.wikipedia.org/wiki/slope and http://www.wtamu.edu/academic/anns/mps/math/mathlab/int_algebra/int_alg_tut15_slope.htm



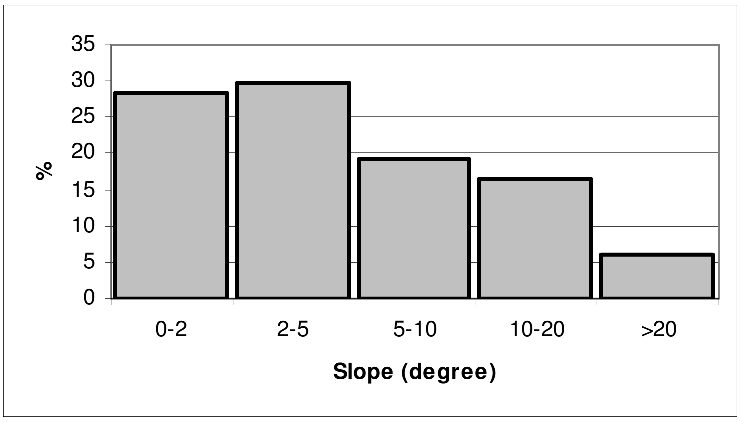

| | |
|---|---|
| Min | 0,29 |
| Max | 44,75 |
| Mean | 8,45 |
| Std.Dev. | 8,14 |

Figure 3.40. Histogram shows the elevation differences between towers.




| | |
|---|---|
| Min | 26,71 |
| Max | 285,47 |
| Mean | 93,85 |
| Std.Dev. | 52,46 |

Figure 3.41. Histogram shows distances between towers.




| | |
|---|---|
| Min | 0,12 |
| Max | 28,51 |
| Mean | 6,38 |
| Std.Dev. | 6,39 |

Figure 3.42. Histogram shows the slope between towers.

$$\text{Average number of towers along the eastern section} = \frac{Length\_of\_the\_east\_section}{towers\_number\_on\_the\_east\_section} = \frac{3278{,}56}{27} = 121{,}43$$

$$\text{Average number of towers along the western section} = \frac{Length\_of\_the\_west\_section}{towers\_number\_on\_the\_west\_section} = \frac{3009{,}78}{41} = 73{,}41$$

Table 3.4 represents Δx, Δy, slope and angle measurements.

Table 3.4. Slope and angle values of the tower segments

| Name of the segment | Elevation difference between two towers (meter) (**Δy**) ($Z_1$-$Z_2$) | Distance between two towers (**Δx**) (meter) | Slope (m)(degree) | Angle (degree) |
|---|---|---|---|---|
| T1-T2 | 1,31 | 98,78 | 0,76 | 0 |
| T2-T3 | 5,56 | 103,58 | 3,07 | 6 |
| T3-T4 | 6,84 | 103,69 | 3,77 | 13 |
| T4-T5 | 23,63 | 153,83 | 8,73 | 7 |
| T5-T6 | 24,59 | 138,40 | 10,07 | 3 |
| T6-T7 | 17,75 | 216,22 | 4,69 | 2 |
| T7-T8 | 13,89 | 71,10 | 11,05 | 1 |
| T8-T9 | 4,75 | 169,13 | 1,61 | 30 |
| T9-T10 | 6,09 | 99,45 | 3,51 | 17 |
| T10-T11 | 6,83 | 59,70 | 6,52 | 84 |
| T11-T12 | 10,70 | 179,53 | 3,41 | 86 |
| T12-T13 | 2,78 | 208,05 | 0,77 | 86 |
| T13-T14 | 20,70 | 52,80 | 21,41 | 21 |
| T14-T15 | 8,33 | 285,48 | 1,67 | 33 |
| T15-T16 | 4,03 | 46,91 | 4,91 | 11 |
| T16-T17 | 5,76 | 202,35 | 1,63 | 56 |
| T17-T18 | 9,72 | 122,34 | 4,54 | 10 |
| T18-T19 | 7,13 | 179,56 | 2,27 | 56 |
| T19-T20 | 2,97 | 161,26 | 1,05 | 43 |
| T20-T21 | 5,10 | 111,90 | 2,61 | 3 |
| T21-T22 | 5,22 | 116,57 | 2,56 | 9 |
| T22-T23 | 0,35 | 71,61 | 0,28 | 13 |
| T23-T24 | 12,34 | 52,01 | 13,34 | 36 |
| T24-T25 | 21,62 | 77,04 | 15,67 | 8 |
| T25-T26 | 31,85 | 113,69 | 15,65 | 8 |
| T26-T27 | 1,77 | 83,59 | 1,21 | 53 |
| T28-T29 | 3,63 | 68,90 | 3,02 | 31 |
| T29-T30 | 3,07 | 32,86 | 5,34 | 2 |
| T30-T31 | 4,80 | 110,55 | 2,48 | 14 |

Table 3.4. Continued

| Name of the segment | Elevation difference between two towers (meter) (**Δy**) ($Z_1$-$Z_2$) | Distance between two towers (**Δx**) (meter) | Slope (m)(degree) | Angle (degree) |
|---|---|---|---|---|
| T31-T32 | 9,54 | 26,71 | 19,65 | 51 |
| T32-T33 | 0,44 | 65,93 | 0,39 | 10 |
| T33-T34 | 1,06 | 74,95 | 0,81 | 14 |
| T34-T35 | 2,25 | 112,44 | 1,15 | 48 |
| T35-T36 | 9,48 | 43,71 | 12,24 | 38 |
| T36-T37 | 0,79 | 93,46 | 0,48 | 27 |
| T37-T38 | 5,09 | 91,04 | 3,20 | 2 |
| T38-T39 | 20,47 | 63,70 | 17,81 | 27 |
| T39-T40 | 11,78 | 152,09 | 4,43 | 16 |
| T40-T41 | 44,75 | 82,38 | 28,51 | 3 |
| T41-T42 | 15,42 | 77,69 | 11,23 | 4 |
| T42-T43 | 8,84 | 74,84 | 6,74 | 8 |
| T43-T44 | 3,55 | 54,28 | 3,74 | 6 |
| T44-T45 | 2,25 | 45,25 | 2,84 | 12 |
| T45-T46 | 3,34 | 135,69 | 1,41 | 36 |
| T46-T47 | 14,59 | 97,85 | 8,48 | 3 |
| T47-T48 | 15,69 | 47,00 | 18,46 | 11 |
| T48-T49 | 5,41 | 53,06 | 5,82 | 12 |
| T49-T50 | 1,64 | 44,71 | 2,11 | 32 |
| T50-T51 | 1,07 | 49,14 | 1,25 | 9 |
| T51-T52 | 1,65 | 56,40 | 1,67 | 25 |
| T52-T53 | 3,89 | 128,51 | 1,73 | 19 |
| T53-T54 | 16,98 | 44,79 | 20,76 | 7 |
| T54-T55 | 7,39 | 57,17 | 7,36 | 10 |
| T55-T56 | 0,85 | 60,28 | 0,81 | 12 |
| T56-T57 | 4,64 | 56,83 | 4,66 | 15 |
| T57-T58 | 7,83 | 67,66 | 6,60 | 17 |
| T58-T59 | 10,56 | 28,10 | 20,60 | 10 |
| T59-T60 | 2,25 | 43,27 | 2,98 | 14 |
| T60-T61 | 5,66 | 40,93 | 7,87 | 25 |
| T61-T62 | 1,34 | 172,99 | 0,44 | 5 |
| T62-T63 | 14,78 | 64,60 | 12,89 | 8 |
| T63-T64 | 12,31 | 80,52 | 8,69 | 3 |
| T64-T65 | 9,11 | 65,54 | 7,91 | 20 |
| T65-T66 | 6,44 | 70,77 | 5,20 | 10 |
| T66-T67 | 0,30 | 142,88 | 0,12 | 22 |
| T67-T68 | 6,37 | 72,57 | 5,02 | 12 |
| T68-T1 | 3,89 | 57,71 | 3,86 | 0 |

Histogram for Δx (Figure 3.41) shows the distances between towers. The distances between towers are between minimum 27, maximum 285 meters. Considering all the towers were equally spaced along the city wall then one tower is expected every 92 m. The towers were not equally spaced in the city wall. The towers are much closer on the western section of the wall than the eastern section. Average number of towers along the eastern section is 121 meters, but 73 meters along the western section.

The angle between the towers is measured in AutoCad software (Figure 3.43). The angle of the segment T1-T2 is accepted as zero. The line from T2 is extended and the angle between this line and the segment T2-T3 are measured (Table 3.4). The angles between the towers are acute that is between 0-90 degrees. Most of the angles are between 0-20 degrees (Figure 3.44).

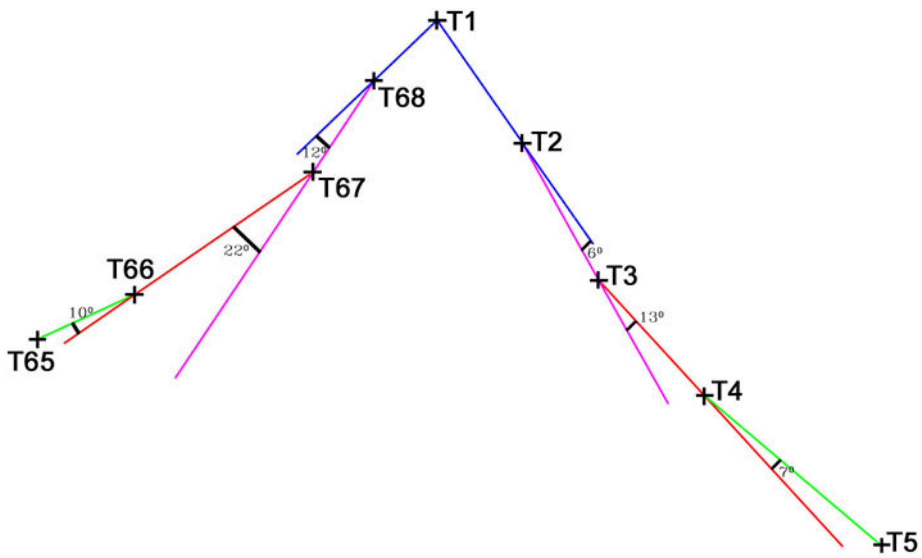
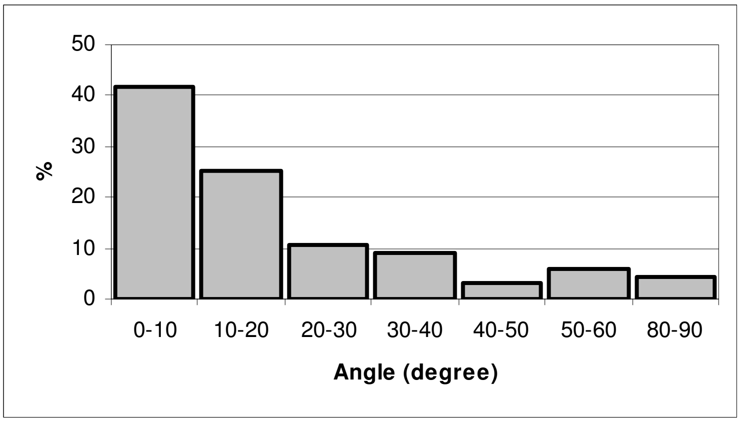



Figure 3.43. Angle between towers at Kerkenes.




| | |
|---|---|
| Min | 0 |
| Max | 86 |
| Mean | 20,07 |
| Std.Dev. | 20,25 |

Figure 3.44. Histogram shows the angle between towers.

#### 3.2.1.3. Gates

The application of a specific analysis for the gates posed a problem as understanding the external and internal effects of the gates becomes crucial. Farming and grazing areas and the trade routes are important external factors for economic and social activities.

This study could help in answering some of the questions to clarify the function and position of the gates and their relation with topography.

In this section brief information on the gates at Kerkenes is given with specific analysis.

Summers (1994) identified seven original city gates (Figure 3.15) and suggests this was the total number for the gates as the wall is clearly visible for most of its length. Later additions such as breeches, small gates and openings can also be observed along the course of the wall (Summers and Summers 1996: 104).

The seven original gates are: (Figures 1.3 and 3.15)

Karabaş (North) Gate

North-East Gate

East-North-East Gate

East Gate

Cappadocia (Southeast) Gate

Gözbaba (Southwest) Gate

West Gate

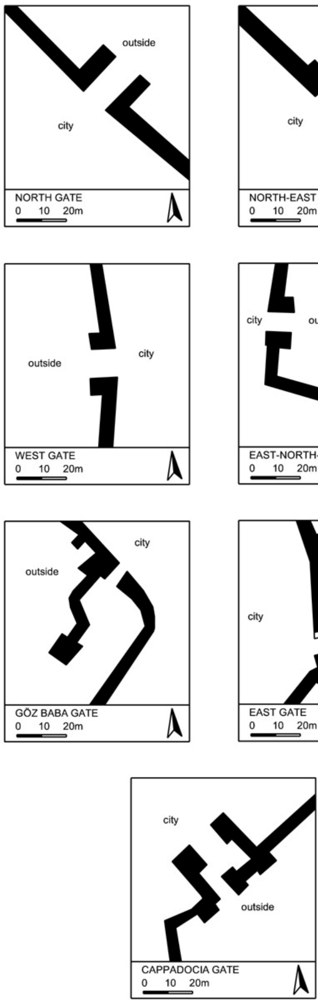
As explained in the 3.2.1.3 section, gates have been counted as one tower for the tower analysis along the city wall. However for individual gate analysis, each gate is assumed to have had two towers (although the Gözbaba and Cappadocia Gates had more and are of complex design while the perhaps has East Gate only one).

In contrast to Hittite Gates which usually follow a standard plan (Figure 3.45), each gate at Kerkenes would have been individually planned (Figure 3.46) to increase its function for particular situations (Summers and Summers 1996: 104).

Source: Tanju et al 2004
Figure 3.45. Aerial view of Hattuşaş shows gate.

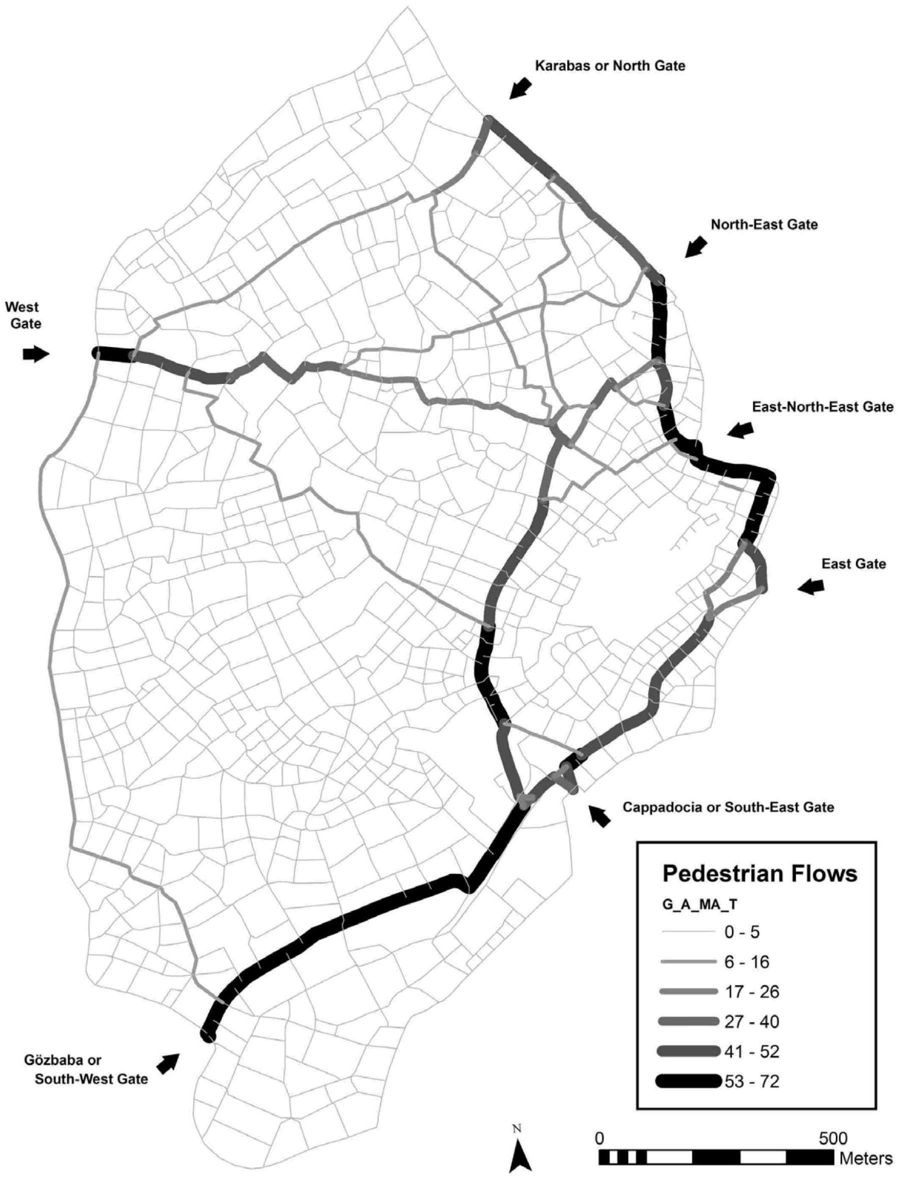
The function and importance of the gates vary and while some gates are specifically used by the inhabitants in everyday life activities such as taking cattle to pasture, the others which are particularly reserved for important personages are aptly designed.

According to Branting's (Branting 2004) GIS-T study the city compounds and gates at Kerkenes, the traffic between urban blocks was widely spread but restricted between the gates with smaller segments and routes. (Branting 2004: 121) The Simulation of the traffic between the gates shows that most of the traffic flowed from the Gözbaba Gate through the Palace Compound (Figures 3.47 and 3.48) (Branting 2004: 130) The simulations show that high traffic volumes were around the Palace Complex, Büyük Göl and the gates. It also reveals their public character (Branting 2004: 131). Branting sorted and grouped the city compounds according to their place and closeness of the gates. People used the gates in transit and the proximity or remoteness of the gates to their dwellings was not an issue. Branting's study investigates the relation between the gates and the residential area in the city and calculates the percentage of the urban blocks within their related gate catchments (Table 3.5 and Figures 3.49 and 3.50). Accordingly certain gates have smaller catchments and others bigger. For example the East gate was the smallest one, although it is the only gate all along the west side which do not have large catchments. The Cappadocia and the Gözbaba Gates have the largest catchments (Figures 3.49 and 3.50) (Branting 2004: 135).



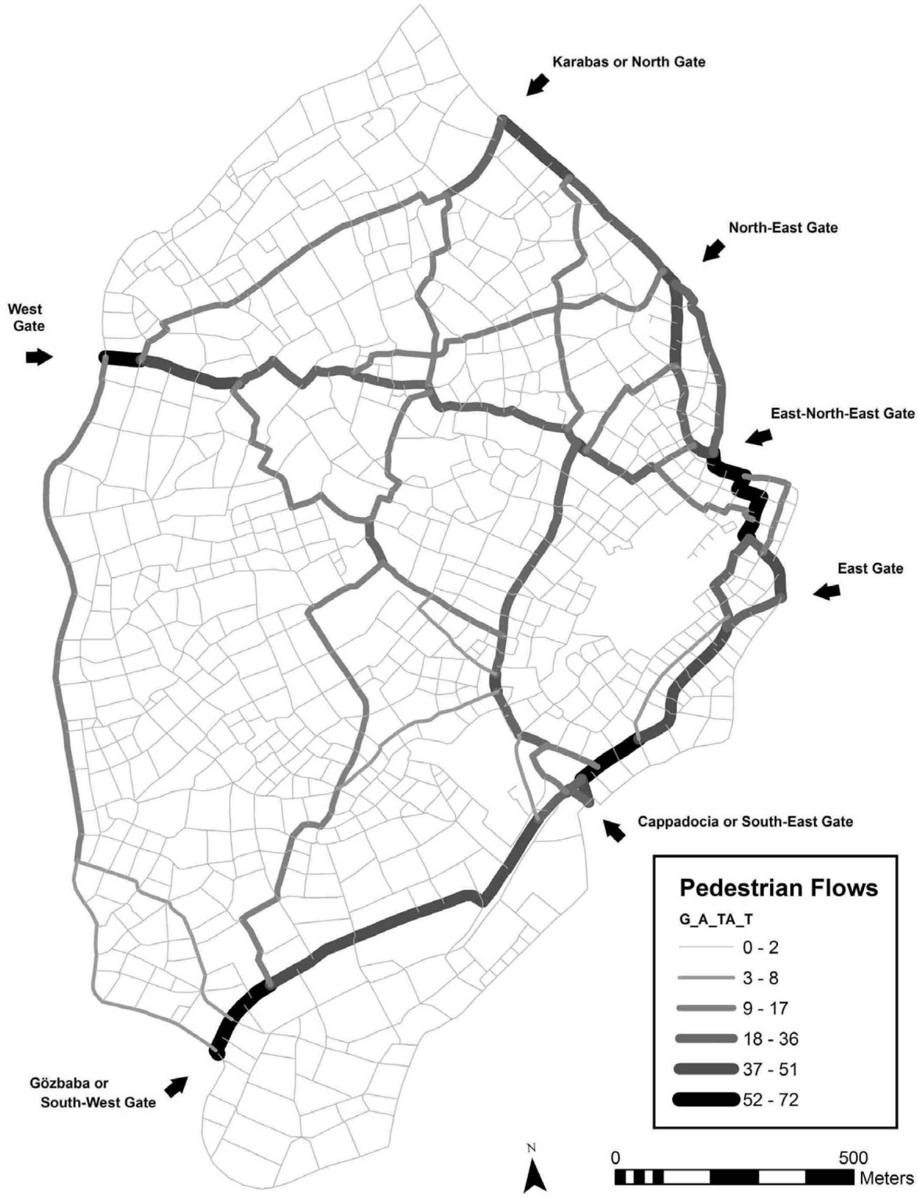

Source: The Kerkenes Project archive-drawn by Nilüfer Baturayoğlu and Ömür Harmanşah

Figure 3.46.Gate plans of Kerkenes.



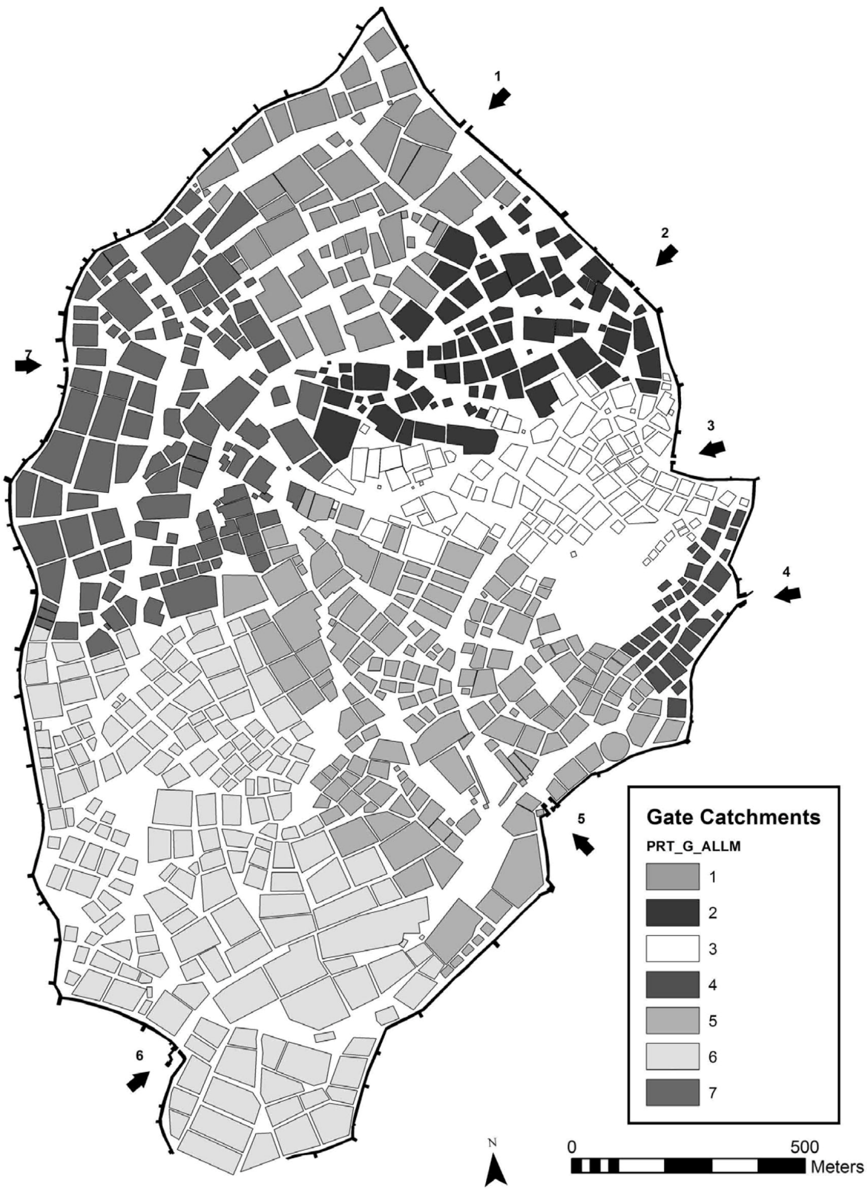

Source: Branting 2004: Figure 36

Figure 3.47.Simulation of the traffic volumes for pedestrians between the gates (energy minimizing).



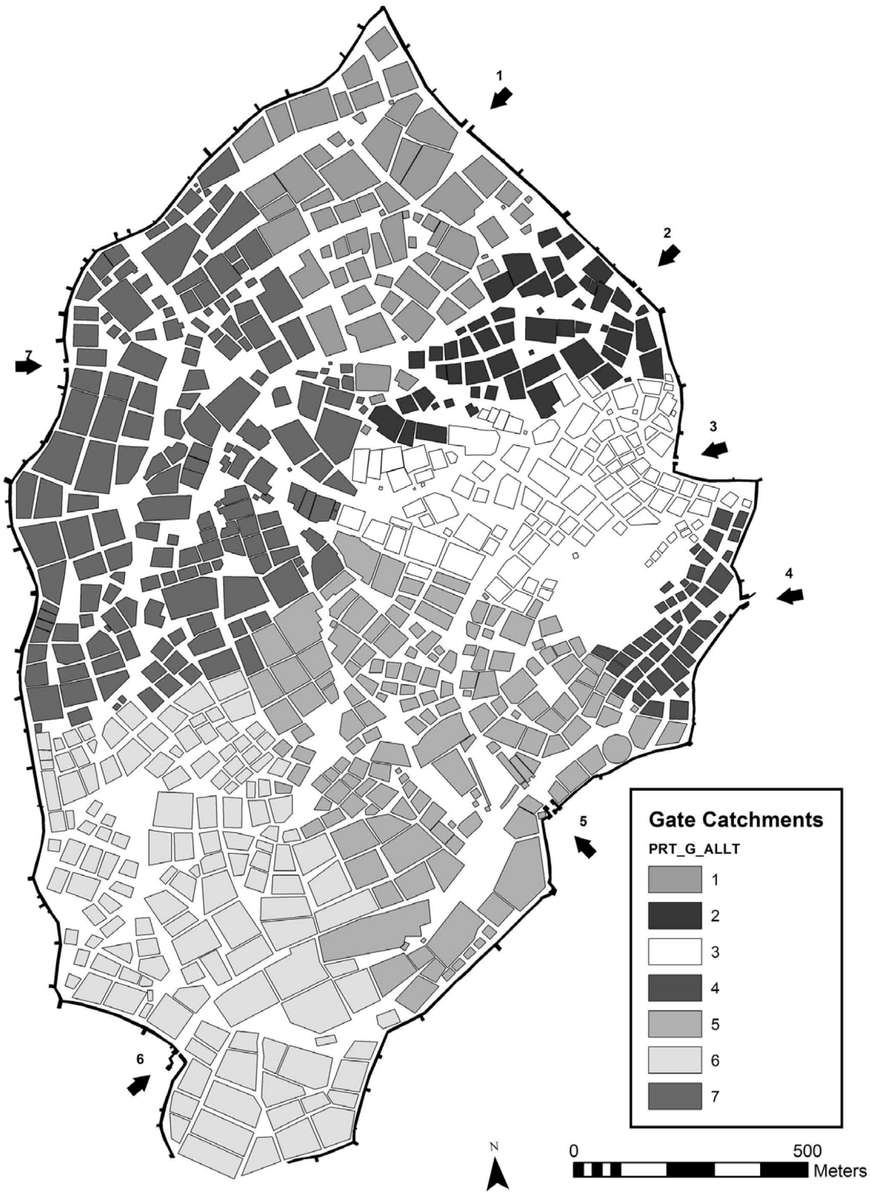

Source: Branting 2004: Figure 37

Figure 3.48.Simulation of the traffic volumes for pedestrians between the gates (time minimizing).




Source: Branting 2004: Figure 42

Figure 3.49.Compounds in each Gate catchment (energy minimizing).




Source: Branting 2004: Figure 43

Figure 3.50.Compounds in each Gate cathcment (time minimizing).

Table 3.5. Percentage of Total Urban Blocks in each Gate Catchment Area.
Source: Branting 2004. Table 4

| Gate | % of Total Blocks (Energy Based) | % of Total Blocks (Time Based) |
|---|---|---|
| 1. The Karabaş or The North Gate | 8 | 9 |
| 2. The North-East Gate | 11 | 7 |
| 3. The East-North-East Gate | 13 | 14 |
| 4. The East Gate | 4 | 5 |
| 5. The Cappadocia or The South East Gate | 24 | 22 |
| 6. The Gözbaba or The SouthWest Gate | 24 | 19 |
| 7. The West Gate | 16 | 24 |

**The Karabaş (North) Gate:** It is located on the northern part of the city wall and leads towards North-East. The width of the entrance is 8 meters. The entrance of this gate is wider than other gates.

**The North-East Gate:** The gate positioned on the northeast of the city wall has access for traffic coming from the north and west probably via the large mound at Kuşaklı. It also gives access to the Karabaş which is an extramural temple near Kerkenes. This gate has a direct link to the main residential area of the city and the Southern Gate (Summers and Summers 1996: 107).

**The East-North-East Gate:** This Gate is located on the North of the Kale between the North-East Gate and the East Gate. The entrance of this gate is 7 meters wide. It leads to North or slightly East of North.

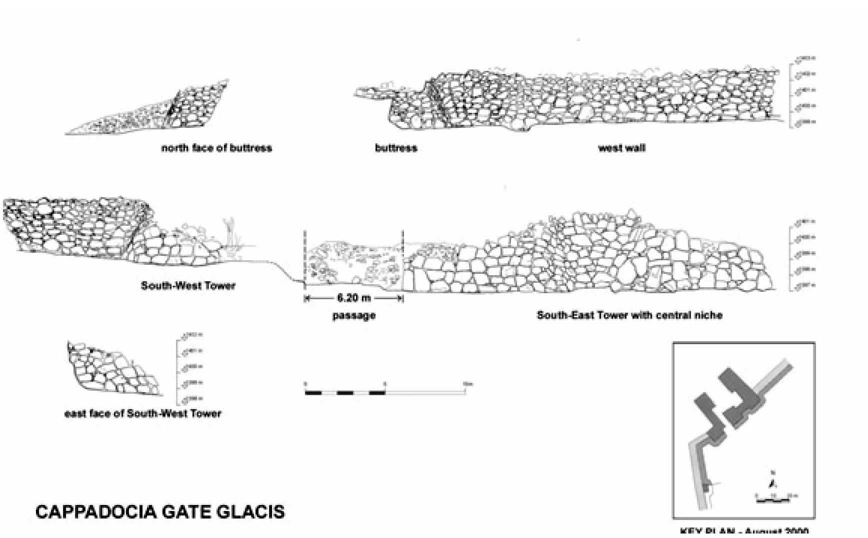
**The East Gate:** A road on a gentle slope leads to the East Gate from the Şahmuratlı village. Modern bulldozers changed the appearance of the eastern approach while carving the original route. Visitors coming to the East gate follow the street and pass the Cappadocia Gate to reach the Palace Complex. Other fanciful appellations of this gate are “Hamadan” or “Ecbatana” Gate (Summers and Summers 1996:107).

**The Cappadocia (Southeast) Gate:** Excavations and clearance at the Cappadocia Gate revealed the towers of the Gate (Figure 3.51). The plan of the

Cappadocia Gate is drawn by using recent data (Figure 3.52) and 3D reconstruction of the Gate becomes possible (Figure 3.53).

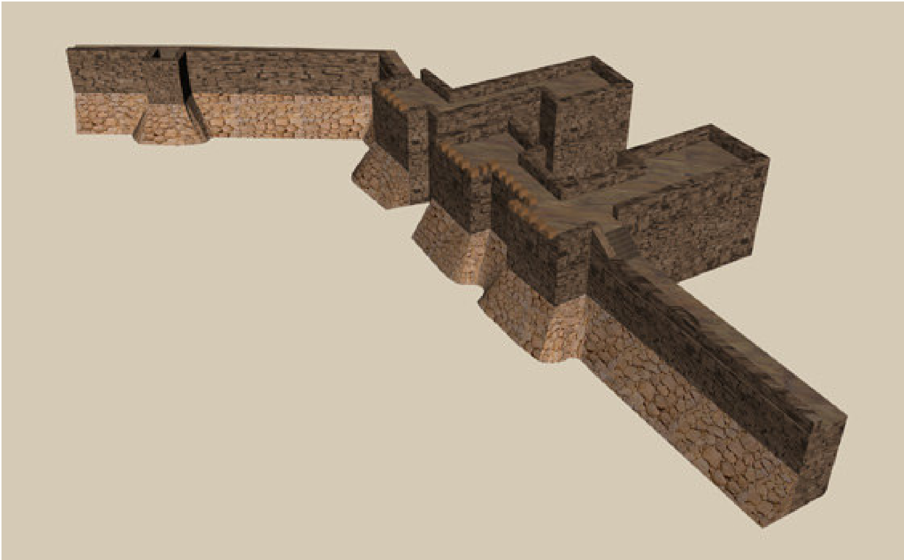
Source: Summers et al. 2000: Figure 9a

Figure 3.51. The Cappadocia Gate and the Kale.




Source:
http://www.kerkenes.metu.edu.tr/kerk1/16imfiles/drwg/urbanarc/defence/00cgphgm.htm

Figure 3.52. Plan of the Cappadocia Gate.



Source: Summers et al. 2003: Figure 4

Figure 3.53. 3D reconstruction of the Cappadocia Gate.

The configuration of this gateway differs from the other gates. It has an internal passage and chamber towers at the innermost limit. Also the gate commands a beautiful view overlooking the northern part of Cappadocia and Erciyes Dağ (on a clear morning) (Figures 3.54 and 1.7). Therefore it must have been one of the important gates of the city as one of the roads winds through the plain up to the gate and leads to the most important area of the city. One major street joins the northeast gate coming along the steep side of the Kale, another important street joins the east gate and the stone façade of the Palace complex (Summers and Summers 1996: 105-106).

Source: The Kerkenes Project archive-01dpjv1614

Figure 3.54.View from the Cappadocia Gate.

**The Gözbaba (Southwest) Gate:** There is a heavily fortified gateway on the southwest of the city with complex outworks of which the appearance was changed by later tumuli and shepherd's shelters. The road connects this Gate to the Gözbaba Tumulus which is the largest tumulus of the area (Summers and Summers 1996: 107-108).

There are streets inside the city with large enclosures on either side of the Palace complex. One of the streets is aligned towards the east-west and west and does not end with the Gözbaba Gate because this gate is positioned slightly towards the North and leads to the Gözbaba Tumulus. This wide street which looks like is aligned to capture the view of the rising and setting sun, the palace and the tumulus which is left outside the boundaries of the city should have served a ceremonial function (Summers and Summers 1996: 107-108).

**The West Gate:** It is located on the western part of the city wall and width of the entrance is 6 meters.

In this study, to understand the placement of the gates, the city wall is divided according to the gates (Table 3.6) and the results are given below:

Table 3.6. Name of segments according to the gates.

| Segment Name | Description |
|---|---|
| Segment A | Between theWest and the Karabaş (North) Gate |
| Segment B | Between the Karabaş (North) and the North-East Gate |
| Segment C | Between the North-East and the East-North-East Gate |
| Segment D | Between the East-North-East and the East Gate |
| Segment E | Between the East and the Cappadocia (Southeast) Gate |
| Segment F | Between the Cappadocia (Southeast) and the Gözbaba (Southwest) Gate |
| Segment G | Between the Gözbaba (Southwest) and the West Gate |

Table 3.7 shows the number of the towers on each segment and the length of the segments. 75 towers and the length of the city wall 6784,823086 meters considered in this part of the thesis because Gate Towers are included the towers and the Kiremitlik area is drawn to connect the between the Cappadocia and the Gözbaba Gates.

If the gates were equally spaced along the city wall then there would have been a gate at every 969, 26 meters.

$$\text{Average number of gates} = \frac{Length\_of\_the\_city\_wall}{Number\_of\_the\_Gates} = \frac{6784{,}823086}{7} = 969{,}26$$

Table 3.7 and Figure 3.55 show the gates that are not equally spaced along the city wall.

Table 3.7. Distance and the number of the towers between gates.

| Segments | Number of Towers | Length (meter) |
|---|---|---|
| *A* | 19 | 1427,626749 |
| *B* | 4 | 510,8194306 |
| *C* | 5 | 414,0402318 |
| *D* | 4 | 469,0359112 |
| *E* | 5 | 702,6317512 |
| *F* | 13 | 1518,686221 |
| *G* | 25 | 1741,982791 |
| **Total** | **75** | **6784,823086** |

The total number of towers on each segment depends on the length of the segment. The longest segment is G, (between the Gözbaba and the West Gate) and has 25 towers and the shortest segment is C, (between the North-East and the East-North-East Gate) has 5 towers.

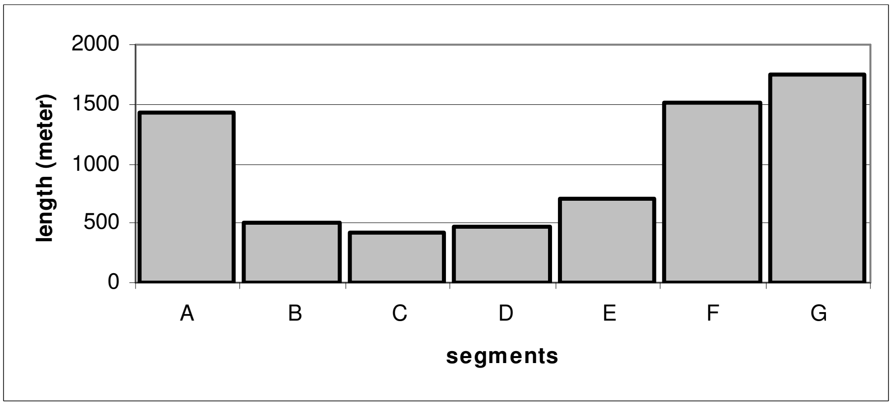



Figure 3.55. Histogram shows the distance between Gates.

Table 3.8 shows the area and the elevation values of the gate towers. The elevation difference between two gate towers (Δy) and the distance between two towers (Δx) are given in Tables 3.9 and 3.10

Maximum elevation difference between two gate towers is 5,84 meters that is the East Gate towers (Tables 3.9 and 3.10)

Table 3.8. Area and the elevation values of the gate towers

| Gate_name | Gate Tower | X | Y | Elevation | Area |
|---|---|---|---|---|---|
| The Gözbaba Gate | GGT1 | 548,76 | 446,80 | 1447,42 m | 91,51 m² |
| The Gözbaba Gate | GGT2 | 562,57 | 481,04 | 1450,75 m | 120,15 m² |
| The Cappadocia Gate | CGT1 | 1359,47 | 995,57 | 1402,44 m | 206,82 m² |
| The Cappadocia Gate | CGT2 | 1377,61 | 1006,13 | 1402,40 m | 288,95 m² |
| The East Gate | EGT1 | 1780,18 | 1437,47 | 1377,50 m | 181,67 m² |
| The East Gate | EGT2 | 1780,39 | 1456,69 | 1371,66 m | 104,71 m² |
| The East-North-East Gate | ENEGT1 | 1632,65 | 1741,54 | 1361,48 m | 66,90 m² |
| The East-North-East Gate | ENEGT2 | 1633,40 | 1755,95 | 1362,11 m | 67,88 m² |
| The West Gate | WGT1 | 329,07 | 1943,30 | 1275,52 m | 95,01 m² |
| TheWest Gate | WGT2 | 328,83 | 1962,38 | 1275,82 m | 81,59 m² |
| The North-East Gate | NEGT1 | 1554,49 | 2114,19 | 1365,26 m | 77,69 m² |
| The North-East Gate | NEGT2 | 1542,99 | 2126,00 | 1365,89 m | 122,43 m² |
| The North Gate | NGT1 | 1194,31 | 2459,23 | 1301,23 m | 113,83 m² |
| The North Gate | NGT2 | 1180,18 | 2471,15 | 1297,98 m | 137,79 m² |

Table 3.9 Elevation and distance differences between two towers

| Gate Tower | Elevation difference between two gate towers (meter) (**Δy**) ($Z_1$-$Z_2$) | Distance between two gate towers (**Δx**) (meter) | Width of the entrance of the Gate |
|---|---|---|---|
| GGT1-GGT2 | 3,33 m | 36,92 m | 4 m |
| CGT1-CGT2 | 0,04 m | 21,53 m | 6 m |
| EGT1-EGT2 | 5,84 m | 19,22 m | 6 m |
| ENEGT1-ENEGT2 | 0,63 m | 14,43 m | 7 m |
| WGT1-WGT2 | 0,30 m | 19,08 m | 6 m |
| NEGT1-NEGT2 | 0,63 m | 16,49 m | 6 m |
| NGT1-NGT2 | 3,26 m | 18,48 m | 8m |

Table 3.10 Descriptive Statistics of table 3.9

| | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|
| **Elevation difference between two Gate Towers (meter) ($\Delta$y) ($Z_1$-$Z_2$)** | 0,04 | 5,84 | 2,00 | 2,18 |
| **Distance between two towers ($\Delta$x) (meter)** | 14,43 | 36,92 | 20,88 | 7,42 |

To understand the location and uneven distributions of the gates on the city wall visibility (viewshed) analysis applied for each gates and visible areas are shown in Figures 3.56 to 3.62. Southwest and west side of the city does not have visibility from the gates.

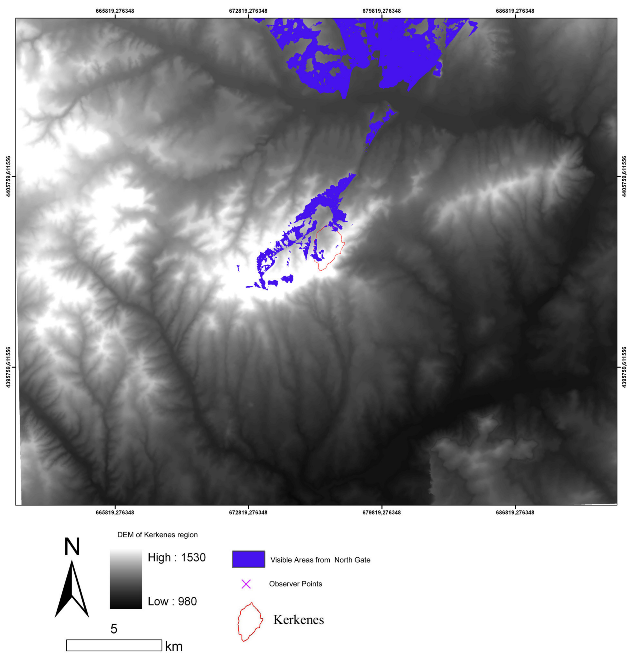



Figure 3.56. Visible areas from the North Gate.

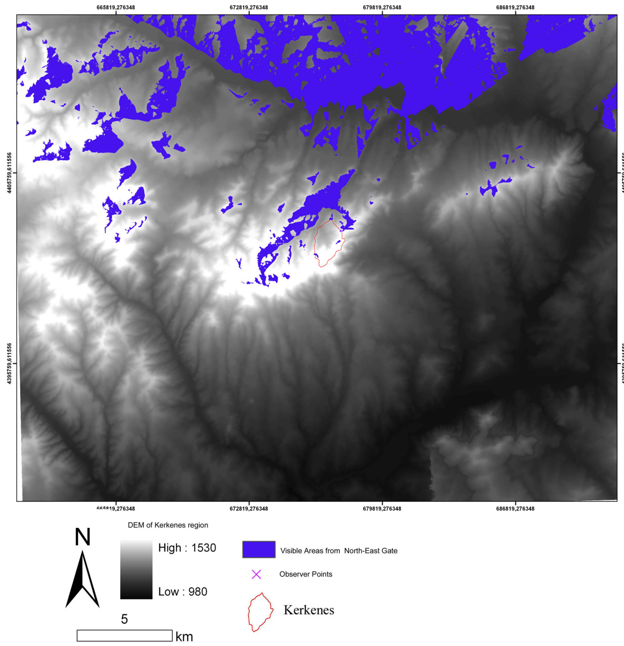



Figure 3.57. Visible areas from the North-East Gate.

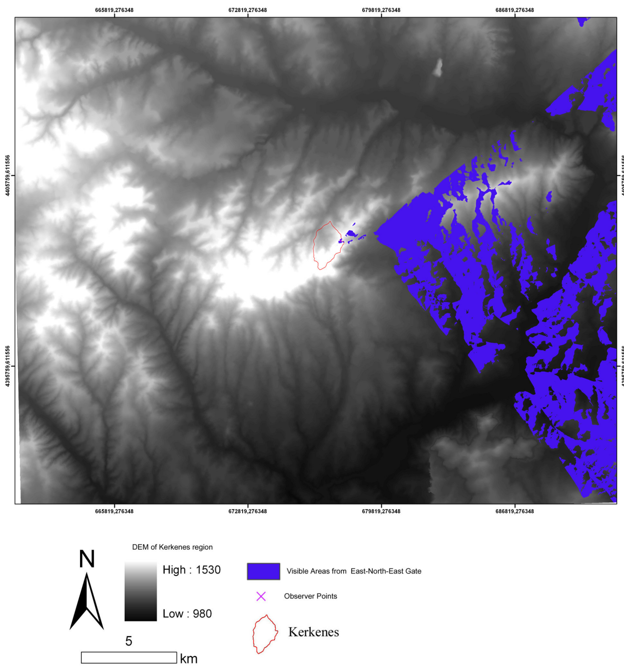



Figure 3.58. Visible areas from the East-North-East Gate.

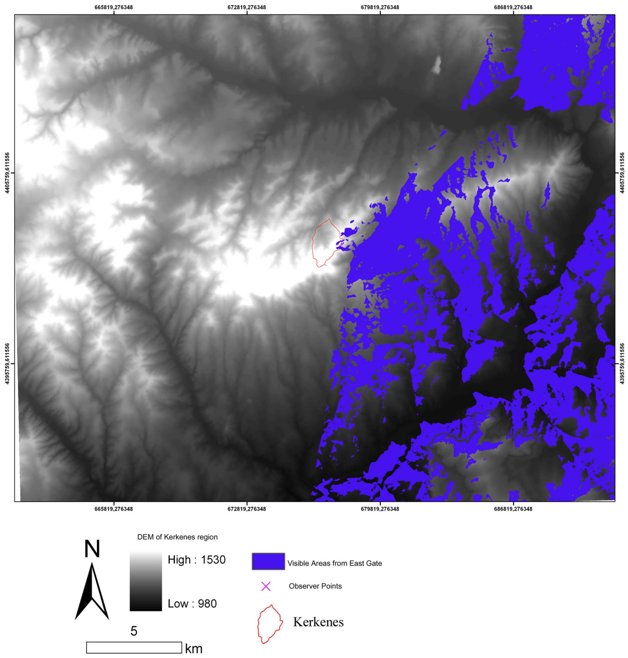



Figure 3.59. Visible areas from the East Gate.

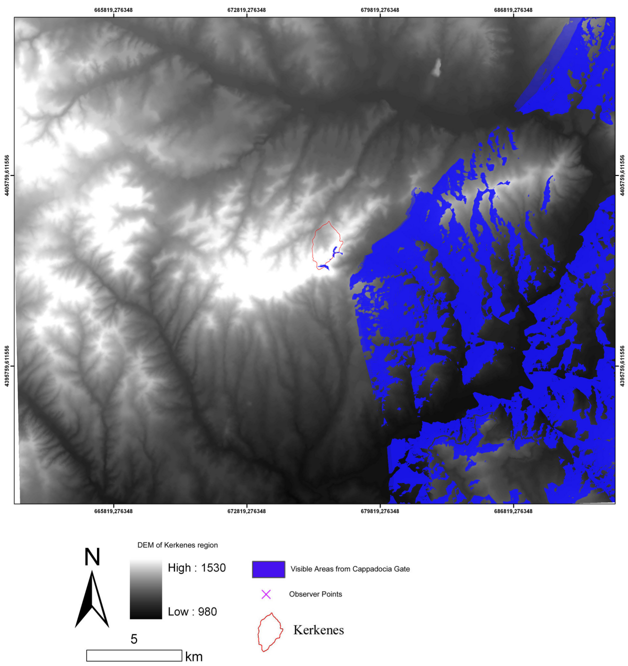



Figure 3.60. Visible areas from the Cappadocia Gate.

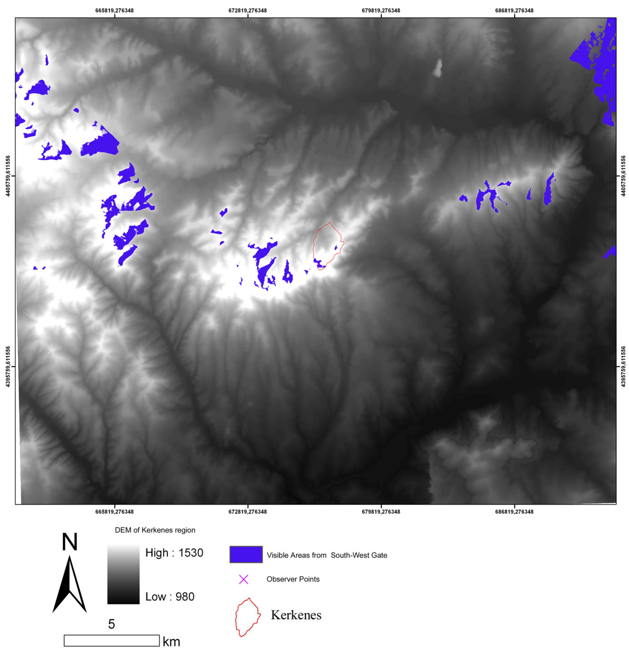



Figure 3.61. Visible areas from the South-West Gate.

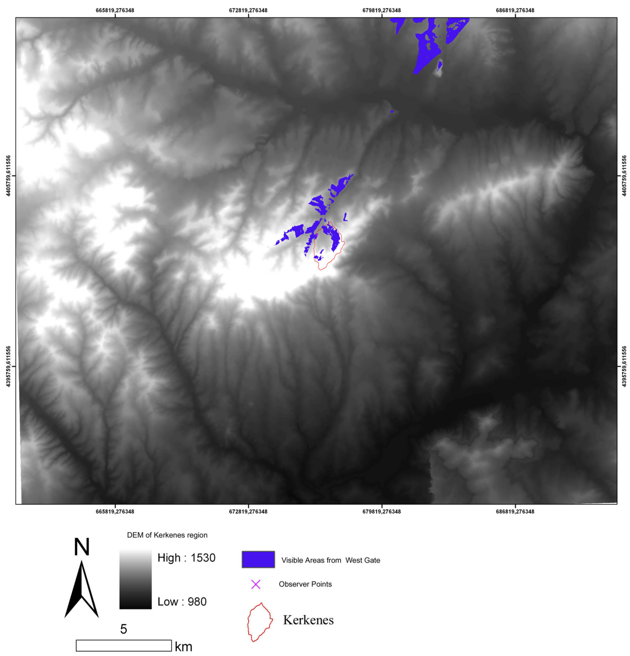



Figure 3.62. Visible areas from the West Gate.

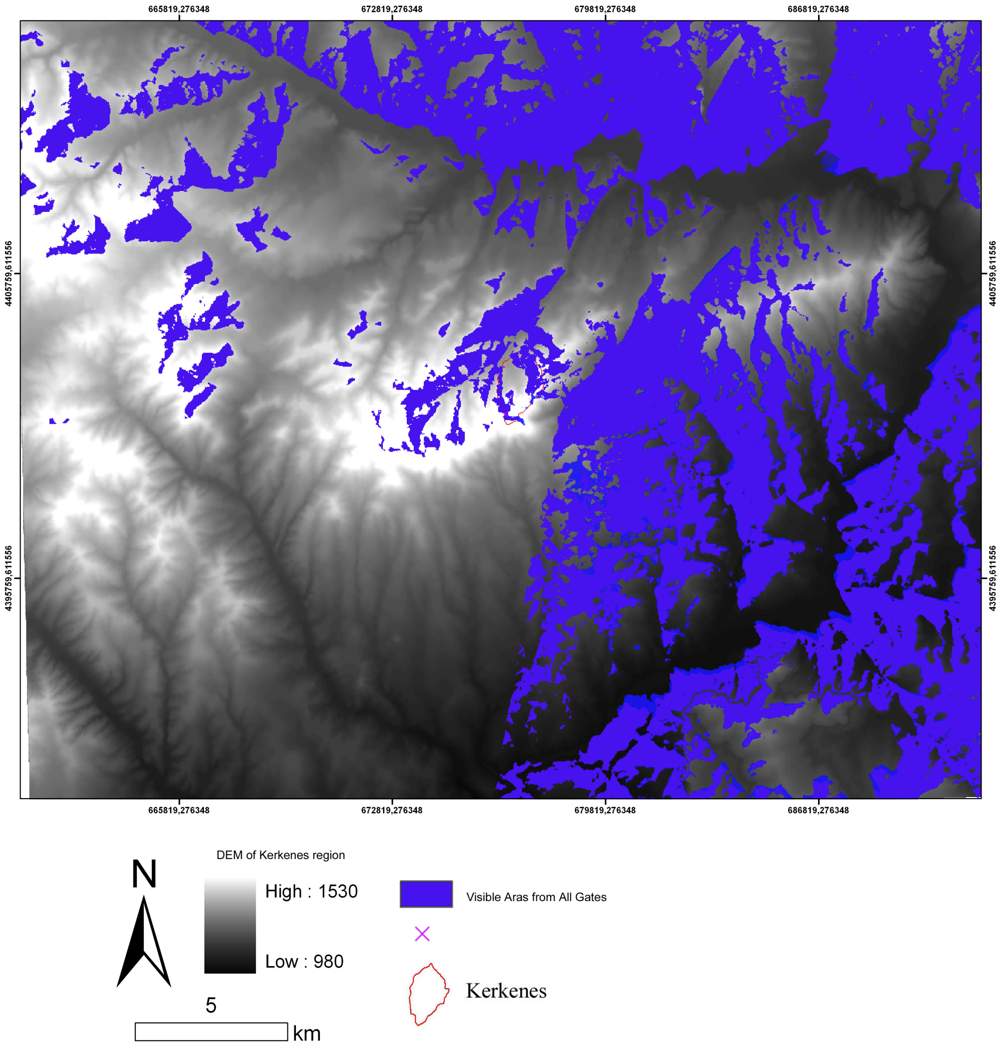



Figure 3.63. Visible areas from all Gates.

# CHAPTER 4
## INTERPRETATION OF THE RESULTS

One of the important factors effecting decision in the choice of a particular site is environmental conditions. These conditions also influence the distribution of a settlement over a particular landscape. Most of the human activities that take place in a site are associated with the context of a landscape and the availability of the resources. For example, settlement areas are generally chosen for their proximity to water resources or workshops near the quarries and locations for campsites and butcheries are usually related with the migration routes of the animals or water resources (Rapp and Hill 1998: 53).

The context of a landscape provides important information on the utility of an area within the boundaries of a city. Most of the time establishment of a settlement is related to the function and treatment of an area. Therefore the location of a site and the activities which take place are directly effected by landscape setting from regional environmental conditions to micro environmental context (Rapp and Hill 1998: 53).

People built fortifications for the purposes of security, to prevent assailants or wild animals from intruding into their living spaces. Therefore locations that are difficult to reach are the best places for defence and have the advantage of observing the foe from a vantage point. For that matter when planning their fortifications people chose naturally defensible sites such as hilltops. The aim was to defend the site but at the same time escape easily in case the attackers manage to penetrate the fort. As well as defining boundaries the city wall also represents the status and independence of a community.

People felt the need to build defences from the early times in Anatolia. The construction, design and building techniques of a settlement depend on social and political issues. When political situations demanded less protection, an agglomeration of houses as seen in the Neolithic settlement of Çatalhöyük (7./6.

Millenium B.C.). On the other hand the city wall in Hacılar in the second half of the $6^{th}$ Millenium B.C. was comparatively improved but still lacking gates (Naumann 1998: 328-329).

There were apparently almost no towers in the city wall in Alişar in Central Anatolia during the first half of the $2^{nd}$ Millenium B.C. The city walls in Boğazköy and Mersin had towers which were arranged in a specific order in the Hittite Kingdom ($15^{th}$ -$13^{th}$ century B.C.). The Egyptian paintings give an idea about the height of the towers which is a distinctive feature of the Hittite architecture. This type of tower construction was probably developed by the Hittites. The best example which shows the ordered arrangement of the towers in a city wall is in Boğazköy (Hattuşaş) (Naumann 1998:333).

The city walls were sometimes set up to protect natural resources such as streams, lakes or springs depending on the topography.

The primary need for the existence of a settlement is a supply of potable water the quality of which is important for domestic use (Rapp and Hill 1998: 131).

A water resource is that the source of water which is useful or potentially useful. Consequently a water resource is also as important as the quality of the water for the settlements. There are three types of water resources:

a) Surface water
b) Subsurface water
c) Ground water

As water flows and dissolves into the granite or precipitated over the gentle slope, people build fountains to contain the subsurface water. Morphology of the drainage basin is important for the surface water. Ground water simply means water flowing under the ground and people open wells to obtain it (Interview with Mehmet Ekmekçi[1]).

Consequently the need for defence, protection, water resources and independence would have urged the people to construct the wall at Kerkenes.

At Kerkenes, the city wall runs along the topographic divide which controls the water system in the city (Figure 3.18) and constitutes catchment areas for obtaining water. There are five catchment areas in the city. Catchment area 1 is the largest. The stream flows outside the city through a channel at the Water Gate of the city wall (Figure 3.27).

However in other catchment areas, the city wall was built against the direction of the actual flow and stopped it with respect to the amount of water. There should have been channels in the city wall to stabilize the structure against the flow or erosion. Figure 3.24 shows possible placements of the channels in the city wall. At Figure 3.24 the pink areas should have been especially designed such as the Water Gate.

People who lived at Kerkenes would have used surface and subsurface water from the artificial reservoirs. So far there are two known large artificial reservoirs (Interview with Mehmet Ekmekçi). The stone lined reservoirs or settling pools constitute the most important components of a centrally organized system for water control and distribution (Summers and Summers 1996: 106).

One of the reservoirs is Büyük Göl and collects water from the Catchment Area 1.The other is near the Palace Complex opposite the Cappadocia Gate and called At Göl or Sülük Göl[2] (Figures 1.3, 3.21, 3.24 and 3.25). The dimensions of the Sülük Göl are 32 x 56 meters. A small sounding shows the depth of the reservoir as 3 meters of which 1 meter is full of mud and the rest of the space is filled with water. These values determine the overall capacity of the reservoir as 5376 $m^3$ (Summers and Summers 1999:125). The reservoirs or pools were constructed using stone (Summers and Summers 1999:125 and Summers et al. 2001:7). The stone walls of the reservoirs might have an additional function as filtering the water before it gets into the reservoir.

The function of these reservoirs is still not clear. There are two assumptions; one is that they might have been used for domestic purposes or to obtain drinking water. The first assumption coincides with the present use of water for domestic purposes.

At present the reservoirs are not covered. However for the second assumption it is difficult to visualize the condition of the reservoirs during the life span of the city. In case the top of the reservoirs were left open there was the probability of

[1] Assoc. Prof. Dr. Mehmet Ekmekçi, Hacettepe University, Department of Hydrogeology

microorganisms polluting drinking water. Therefore the reservoirs should have been covered with some sort of material (wood or straw) which would have been disappeared by weathering or fire.

Also climatic conditions have an effect on the supply of water which could lead to substantial decrease in the amount during summer months when the reservoirs almost dry out. Therefore additional water reservoirs such as tanks or cisterns would probably have been built in the city to accumulate water for the dry season and also to prevent of pollution.

According to Summers there are a series of stone lined cisterns both outside and inside the city wall near the Water Gate. The outside cistern was open and probably collected water for animals which grazed outside the city. The inner cistern was built from stone and probably had a roof. There was another cistern which was outside the city wall at the Northeast part of the city (Summers and Summers 1994: 23).

If there were two or three cisterns at the northeast and northwest sections of the city then people occupying other parts could not have had access to water. Therefore there should have been more cisterns or very sophisticated water distribution throughout the city which needs to be discovered.

At present, modern springs are being used for drinking water by the shepherds at the site, but these also dry in summer.

There is only one well in the city which is called Uyuz Kuyusu and it is located at the western part of the site.

City walls were often fortified by gates and towers[3]. A gate tower is a structure built next to, or on top of a city gate for effective defence. A wall tower connects the curtains and by protruding outwards have the function of covering the curtains during attack.

The towers have two functions. One is observing the enemy from long distance which plays an important role in defence and the other is to reinforce the fortification.

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[2] Because sick people come from considerable distances for the medicinal leeches that live in the reservoir.

[3] General information for city wall used http://en.wikipedia.org/wiki/Defensive_wall and http://www.vkrp.org/studies/historical/iron-age-military/info/gates.asp

A gate provides access for the troops and citizens yet it is the most vulnerable section of the city wall. During peace time a gate should function efficiently for everyday requirements. It must be wide enough for people, animals and vehicles to pass comfortably. It was also the focus of attack during a siege or war. Therefore the potential weakness of a gate should be compensated by constructing a massive structure which should be considered as the strongest section of the city wall. These massive complexes would have had multiple doors and flanking towers and chambers between the doors (Figures 3.45 and 3.46).

There are many methods and materials for constructing walls. The stone seems to be the widely chosen building material as it is more durable than wood or mudbrick. So it stands as one of the most important material used in the constructions. Coarse-grained igneous and high-grade metamorphic rocks were used as stone for monumental buildings for more than five millennia. On occasions the stones were quarried at long distance from the settlements and transported. Granite has its advantages as there are jointing patterns on its surface which facilitates its extraction and makes it easily workable (Rapp, Jr. and Hill 1998: 139). Granite was one of the preferred building stones throughout antiquity. For example, Egyptians used the Aswan granites for building Giza pyramids. (Garrison 2003: 180)

At Kerkenes the granite was the raw material for all kinds of constructions. The effort and time spent on the construction process are minimized by taking advantage of local geomorphology such as bedrocks which should have been the case for the city wall at Kerkenes. Bedrock, in some situations, create natural heights for the city walls. It can be seen in the Hittite period at Hattuşaş (Figures 4.1 and 4.2) and in later periods at fortifications such as the Ankara Kalesi (Figure 4.3), the Mamure Kalesi (Figures 4.4 and 4.5), the Softa Kalesi (Figure 4.6). Even a medium sized city wall becomes invulnerable with the inclusion of geomorphological characteristics which can be seen at Kerkenes on the southeastern section of the city wall.

One of the highest places in the region was chosen for Kerkenes. There is a particular elevation for this area which is between 1250-1500 meters. But the elevation value for the surrounding area is 980-1520 meters. The area was chosen for visibility and the two highest places which are the Kale and the Kiremitlik were included in the city. Figure 4.7 shows the elevation map of Kerkenes and the surrounding area and places higher than 1250 meters are calculated. The placement of Kerkenes is also convenient for the visibility of the eastern part.

Source: Tanju et al 2004
Figure 4.1. Aerial view of Hattuşaş shows defence system.

Source: Tanju et al 2004
Figure 4.2. Aerial view of Hattuşaş shows defence system.

Source: Sülüner 2005: Figure53
Figure 4.3. “Ankara Kalesi”, Ankara

Figure 4.4. “Mamure Kalesi”, Anamur, Mersin
(Photographed by Nurdan Atalan)

Figure 4.5. “Mamure Kalesi”, Anamur, Mersin
(Photographed by Nurdan Atalan)

Figure 4.6. “Softa Kalesi”, Anamur, Mersin
(Photographed by Nurdan Atalan)

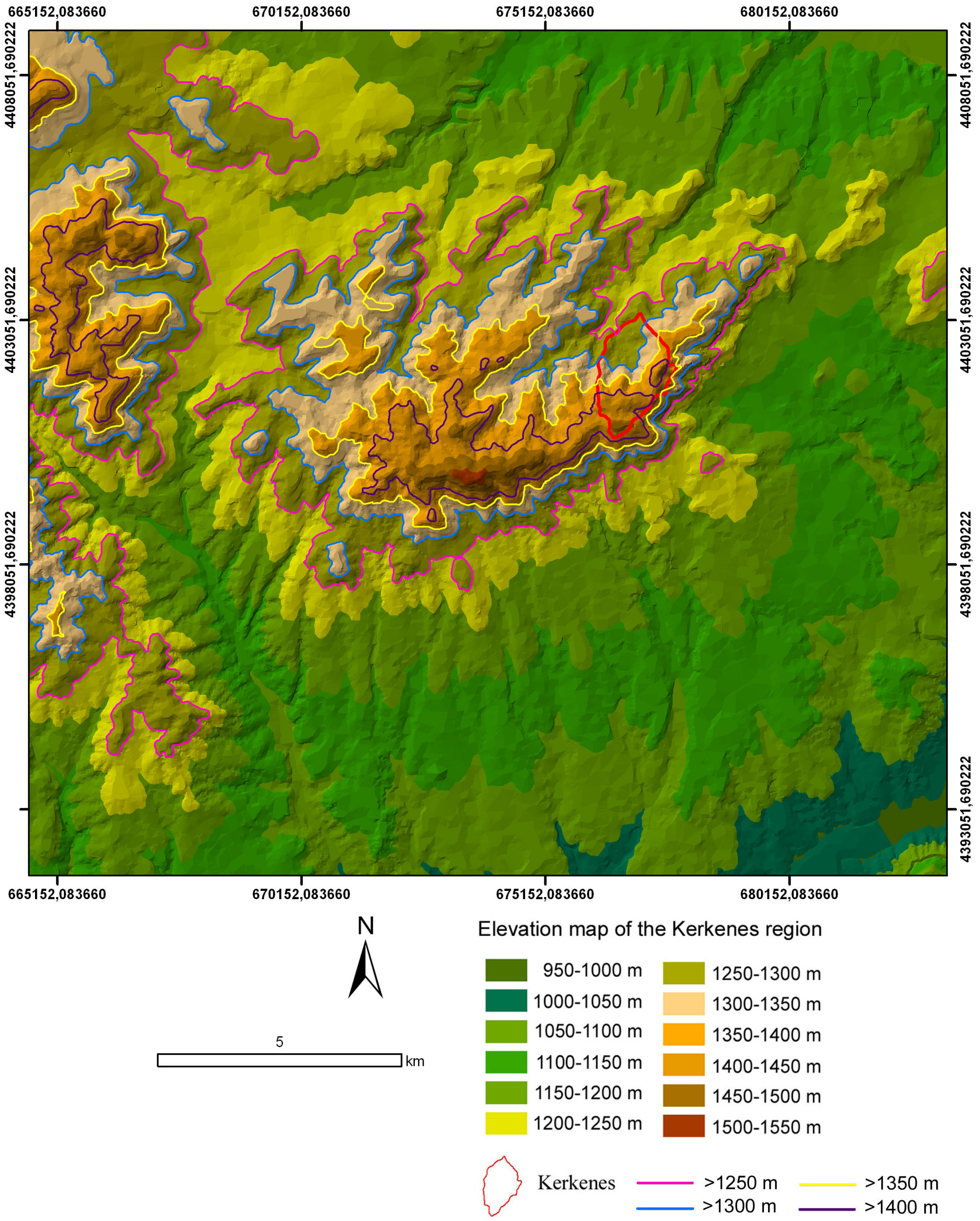


Figure 4.7. Elevation map of the Kerkenes region

Grazing and farming areas are also important for the inhabitants. Today the villagers around Kerkenes still come to the ancient city to graze their cattle and sheep. At present there are farming areas around the city. It is clear from the geophysical maps that there was no space for farming and grazing inside the city. Therefore people living in the city would have gone outside the city wall and use the gates for their daily activities.

Slope can be an answer for the agricultural strategies. Terraces can be found on steep slope areas and farming areas at gentle slopes (Bevan and Conolly 2002: 126).

According to the slope analysis most of the gentle slope areas are on the east side of the city and the west side of the city has steep slope. If people had gone to the west of the city they would have found streams and steep slope hills. Sometimes it could have been difficult to take the cattle to fields. Also nowadays the nearest farming areas are used by modern farmers which lie between the East Gate and Şahmuratlı village.

Since there is no fully preserved tower at Kerkenes, the city defences are analyzed from the remains of the towers. According to the results of the tower analyses are;

The towers remains are not the same size. This can be explained in two ways; some towers are wider than the others or some towers higher than others. It is hard to estimate the real height of the towers, because the stones of the city wall were used by the shepherds to build modern enclosures so that calculating the amount of the stones from the remains will be difficult. On the other hand excavations can reveal the width of the towers. The excavations at the Cappadocia Gate is useful in understanding the Gates and gate towers, however to explain the function and the shape of the towers some towers can be chosen for excavation so that the evidence can be use as a guide for the other towers.

According to the survey at the city wall[4], the towers are rectangular.

[4]In 1996 detailed measurements of the city wall were taken by Total Station (Summers et al. 1998: 627).

# CHAPTER 5
## DISCUSSION

The Kerkenes Project contains lots of data sets in different coordinate systems. The conversion of the data sets and their analysis are the main problems of the Kerkenes Project as data are still being collected in local coordinate system. Most of the data are gathered from other sources such as Quickbird satellite image and topographic maps are in the UTM WGS 84 coordinate system.

An issue in this research was the coordinate system for the combination of data sets. The data used in this study was in different coordinate systems and have different resolutions. Very accurate and detailed GPS data of Kerkenes in the UTM WGS84 coordinate system does not overlay with the 1:25000 topographic maps of the Kerkenes region which has the same coordinate system but different accuracy. The vector data in Kerkenes local coordinate system was another problem for overlaying maps in order to understand the city wall.

Also, in chapter 3, GPS Data in UTM WGS84 coordinate system is used for topographic data analysis. The conversion of the GPS data from UTM to Kerkenes local coordinate system was done by Scott Branting in 2002, but there is no constant error between elevation values (Interview with Scott Branting[5]). Therefore the UTM version of the GPS data is preferred because it provide more accurate elevation histograms with which to compare the result for the Kerkenes region.

In chapter 3, the GPS data is used in Kerkenes local coordinate system for the settlement data analysis of the city wall, because all the vector data (plan of the city wall, towers and gates) was in the local coordinate system that was measured with total station in 1993. The data is not converted to the UTM coordinate system for this analysis. Conversion of the vector data from one coordinate system to another is difficult. Elevation errors are accepted as they are. Since, the elevation error is not

[5] Dr. Scott Branting, Associate Director of the Kerkenes Project and Director of the CAMEL Laboratory, Oriental Institute, Chicago.

constant (see p. 48) it is better to have all the data in one coordinate system and process them.

Other problems are caused by the hardware and software. At the outset of the research ArcGIS 8.x was loaned by İşlem Ltd. This version of the software was not capable of performing some of the spatial analysis. Later İşlem Ltd. upgraded it to the ArcGIS 9.x which was more efficient with newer tools.

Also processing the data in commercial GIS software creates bigger files when dealing with large amounts of data like 1.4 million points of GPS data. Those files consume the actual hard disc space and memory of the computer which slowsdown the computer. This problem can be solved by increasing the hardware capacity of the computer.

The digitized topographic map of the Kerkenes region is also susceptible to digitizing errors which needs to be corrected as manually digitized topographic maps may include human-made errors.

It was difficult to choose the appropriate method for the analysis of the city wall. Many of the methods which are employed in the analysis of the city wall which initially seemed feasible eventually resulted in dead ends or unreasonable spaces. The first attempt involved the division of the city wall by using a compass into directions such as North, Northeast etc. this was followed by making division according to the location of the gates. In this way sections are created for comparison. However this comparison proved to be unjustifiable as the analysis lacked evidence. It was virtually the creation of separate sections with nothing to compare.

As GIS was initially designed by geographers most of the contribution still comes from the technical sciences. The GIS analyses are still in the initial phase for archaeological applications (http://khalid.gourad.com/thesis/thesis.pdf). Predefined sets of ways and methods were settled for some of the analyses like hydrological analysis for the landscape and crime analysis. However archaeological applications do not follow a specific method. Research on archaeological sites should be encouraged to raise the standards for the archaeological applications of GIS which would then maximize the progress in methods of analysis in applications of GIS in this field.

# CHAPTER 6
## CONCLUSION

Different criteria are instrumental in the choice of sites for settlement such as potential water resources, suitable topography, materials that are locally available, farming and grazing areas, market places etc. These factors and their relationship with settlements both in ancient and modern times are difficult to understand. It is even more difficult to comprehend the incentive behind the choice of a particular site in ancient times.

The time gap can conceal long-established factors and functions that are left buried underground and become a mystery. Archaeology is a discipline that unravels this kind of mystery. Consequently archaeologists try to find answers lots of questions and understand various aspects of ancient settlements.

One of the Iron Age settlements in Central Anatolia is Kerkenes, which is considered to be unique for the characteristics of its city. Those characteristics are;

1. The size of the city and its walls of approximately 7 km.
2. Sudden destruction of the city by fire
3. One level of settlement

The archaeological research still continues with GIS survey and excavations at Kerkenes try to reveal the mystery of the Iron Age city.

In this study, the effect of topography on Kerkenes is investigated and the followings have been achieved.

**Topography:**

The GPS and total station survey data are used from the remote sensing data of Kerkenes with the 1:25000 scaled topographic maps of the Kerkenes region and the elevation, slope and aspect maps are produced with histograms. Results show that there is a particular elevation for this area which is between 1250-1500 meters. But the elevation value for the surrounding area is 980-1520 m. thus this analysis shows that Kerkenes is located in one of the highest areas in the region. The highest points that are the Kale and the Kiremitlik have a view range covering an area from the south end to the north end of Kerkenes.

The slope is very gentle in the northern part of Kerkenes but for the Kale there are steep slope areas. In the Kerkenes region most of the areas are gentle slopes but Kerkenes is in the steep slope area. Since Kerkenes was located on a hill top that can be reason for the steep slope.

The aspect analysis shows that the areas on Kerkenes usually face the Northwest and West but in the region areas are oriented towards the Northeast, East and Southeast. In this research the choice of the location can not be explained by aspect analysis of the site. However, further aspect analyses can give information about the Iron age city plan and building habits such as the direction of the sun light, wind for each house and public buildings (if any) at Kerkenes.

The topographic divide lines for Kerkenes are drawn by using 1:25000 topographic maps to compare the location of the city wall with the topographic divide. Most of the city wall runs along the topographical divide forming catchment areas for urban water collection.

The people who built the city wall wanted to include two uppermost points in that region inside the city which provided the inhabitants with the best view to observe the enemy and the surrounding area. When the city was built the wall included the Kale and the Kiremitlik for purposes of defence with the addition of the Cappadocia Gate as it is linked to one of the trade routes.

**Towers:**

Results of the analysis of the towers shows that the towers are not equally spaced along the city wall. The towers are more closely spaced on the western section of the city wall then the eastern section. The city wall on the western section has almost the same elevation values from the exterior and interior. On the other hand, steep slope starts just at end of the city wall on the eastern section. Elevation ranges dramatically change for the exterior and interior of the city wall in this section which explains the decrease in the number of the towers; the steep slope in this area provides a natural defence and adopts the function of the towers. However on the west side of the city wall the comparatively level nature of the terrain requires more towers for defence.

There is no evidence for the height and components of the walls, except some stones belonging to the original towers therefore calculations are made using remains of the towers. The results show that elevation differences between two towers generally vary between 1-10 meters; the slope is between 0-5 degrees and the angle is between 0-10 degrees. The towers would probably have been constructed in accordance with the topography. Therefore it is reasonable for the towers to be built on the same level. The analysis of the angles shows that the angles between the towers on the east side are larger than the angles on the west side. This is also related with the topographical divide which suggests that the position and number of the towers would have been affected by the divide.

Area calculations of the towers show that towers do not have the same size. The area of the larger tower is nearly 3000 m² and the area of the smallest is 16 m². The two largest towers are situated on the southeast section of the city wall. In this research the remains of the towers are measured and the size of the remains can be explained in two ways:

1. The height of the towers would have differed from each other. Higher towers could have been constructed in certain places.
2. The width of the towers would have been different. Some towers could have been wider than the others.

Also, the bedrock outcrops can affect the size and the location of the towers.

**Gates:**

The gates are distributed unevenly. There are 5 gates on the eastern section of the city wall; on the other hand there are only two gates on the western section. However there can be more gates on the western section. Future studies reveal the real number of the gates. Topographical analysis of the outside the city show that the eastern part of the city suitable for the trade routes because it has lower places and do not have steep slope areas. On the other hand western part of the city has steep slope areas that are not suitable for vehicles etc.

Another important factor influencing the number of the gates is their connection with the trade routes. The Cappadocia Gate and the East Gate would probably have been used as linking the city with the trade routes. Also the nature of the terrain in this section accommodates the easy transit of the vehicles. Because eastern part of Kerkenes is lower then western part of the site and do not have steep slope areas.

Visibility analysis applied to understand the uneven distribution of the gates. Also the results of the visibility analysis show that the Gates which are situated on the east side have a wider range of visibility then the gates on the west side.

**Data:**

The study shows that the GPS data do not show statistically significant differences then the 1:25000 scaled topographic maps in regional scale, especially analyzing the elevation and slope data. However GPS data gives much better results visually but collecting data with GPS is time, energy and money consuming. Therefore 1:25000 topographic maps would be sufficient in the application of aspect, slope and elevation analysis. However it is better to have a GPS Data set, for the intrasite analysis.

Consequently using remote sensing data with GIS is one of the best methods in the research of a site like Kerkenes for understanding the location of a city in relation with topography. It is convenient to have data sets for the application of GIS in a site like Kerkenes. However collecting the remote sensing data and their interpretations using GIS are not easy. The results of the remote sensing data and GIS should be correlated and combined with the data obtained from the excavations.

# CHAPTER 7
## RECOMMENDATIONS

Archaeology started with the collection of antiquities and people in search of valuable objects started digging archaeological sites. Consequently mapping and excavation techniques were improved with the introduction of theoretical studies which were followed by scientific surveys and excavations. However the destruction caused by digging disrupted the excavations which called for other solutions. Therefore the necessity of highly developed techniques resulted in the introduction of aerial photography, satellite, imagery, analysis of the archaeological sites by using remote sensing data and GIS. These techniques offer the archaeologist the opportunity not to destroy the site while trying to find answers for specific questions.

The use of GIS in archaeology is a very new concept in Turkey. There is a big potential as predictive modeling, reconstructing ancient sites using GIS in 3D and intra site analysis can be applied to archaeological sites in Turkey. However conducting data by remote sensing methods and using computer technology in archaeology and interpretation of the results are not easy for an archaeologist. Also these processes are time, energy and money consuming. On the other hand excavating a site is not easy for the same reasons. Nevertheless future studies that apply GIS in archaeological sites in Turkey will be helpful in elucidating the relationship between the settlements and landscapes.

This study can be taken as a sample for further analysis. Aspect data can be useful in the evaluation of constructions in a site yet their interpretations by using geophysical maps pose a problem. The water management system can be explained by the application of hydrology analysis on the site. The resources of raw material around Kerkenes can be studied and it can offer explanations for the gate placements. Further studies that focus on the ancient environments will be helpful in the discovery of some important aspects such as; farming and grazing areas.

And this study can be combined with other studies such as GIS-T study at Kerkenes and helps to solve other archaeological problems of Kerkenes.

Studies on the geophysical maps for the intra-site analysis will be useful for understanding the life span of a city.

The dating and historical context of a city is another issue which is not presented in this study. There is a need for subsequent excavations to collect more evidence for understanding the history of Kerkenes.

A study focusing on the building methods used in the city wall will help in the interpretations such as the number of the workers used during the construction of the fortifications.

Further GIS studies and excavations at Kerkenes, will elucidate other aspects not only for Kerkenes but also for the Iron Age sites in Anatolia.

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