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COMPUTER APPLICATIONS AND QUANTITATIVE METHODS IN ARCHAEOLOGY: THE CASE OF ANAZARBOS

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ABSTRACT

The study focus on the use of modern digital methods to obtain data about the social, cultural, physical formation and development and explain the city of Anazarbos (Turkey) formation in an analytical plan. The basic starting point of the study is how this formation takes place, how it is shaped and the method by which its comprehensibility can be analyzed. The space syntax method, which is an analytical method, was used to understand Anazarbos city formation. The areas of the city showing spatial integration and separation were identified and their relationship with each other was investiagted. It is shown that the city of Anazarbos was built on the measurable not random boundaries of human perception. It has been observed that commercial buildings on the highest axis of integration and necropolis structures are located in the areas where the separation is most integrated. The fact that the integration value range is on the cardo axle between 2.961 and 1.48 has led to the conclusion that it supports the holistic planning approach of the Roman period and that this understanding gained the power of Rome in Anatolian lands, thanks to taxes earned from trade. The axes of the integration values, which are in the range of 0.641 and 0.916, are evaluated as areas where urban needs are tried to be eliminated by means of particle applications. In this context, by analyzing the differences in the integration values of the city, important data about the formation of the city were obtained.

KEYWORDS: Magnetic survey, Spatial Network Analysis, Space Syntax, Anazarbos

1. INTRODUCTION

The fact that the excavation works take long years in archaeological cities delays reading the city in a holistic sense. While every object in archeology leads history, it is important to be able to look at the city in a holistic sense in urban science. In this context, with the geophysical measurement studies to be applied for the ancient cities whose excavations are still ongoing, the city maps can be created by determining the structure and street system under the ground. Thus, while the excavation continues, the city constructions can be analyzed on the newly created city map. At this point, the present study deals with the formation setup of the ancient city of Anazarbos, which was created by the geophysical measurement method, but is still at the beginning of the excavation process. In any way the formation of archaeological cities occurs as a result of social, cultural and physical formation and interaction.

The aim of this study is to explain the urban formation of the ancient city of Anazarbos, which is included in the World UNESCO World Heritage Temporary List, on an analytical plane. Anazarbos, is located in the Ovalik Cilicia region, which is part of the Anatolian lands. The city attracts attention with its 34-meter-wide, 2700-meter-long cardo axis, which is the first double-lane and colonnaded road known in the world. At the same time, the ancient city of Anazarbos is known as the birthplace of Dioskourides, known to have served in the army during the Roman era, known as the famous medical scholar and pharmacologist of history. The ancient city of Anazarbos appears to be on the road route that St. Paul followed in the 2nd and 3rd Mission trips in some maps. Jewish origin St. Paul is known as one of the 12 apostles in the establishment of Christianity. This event in history emphasizes the importance of the city (Fig. 1).

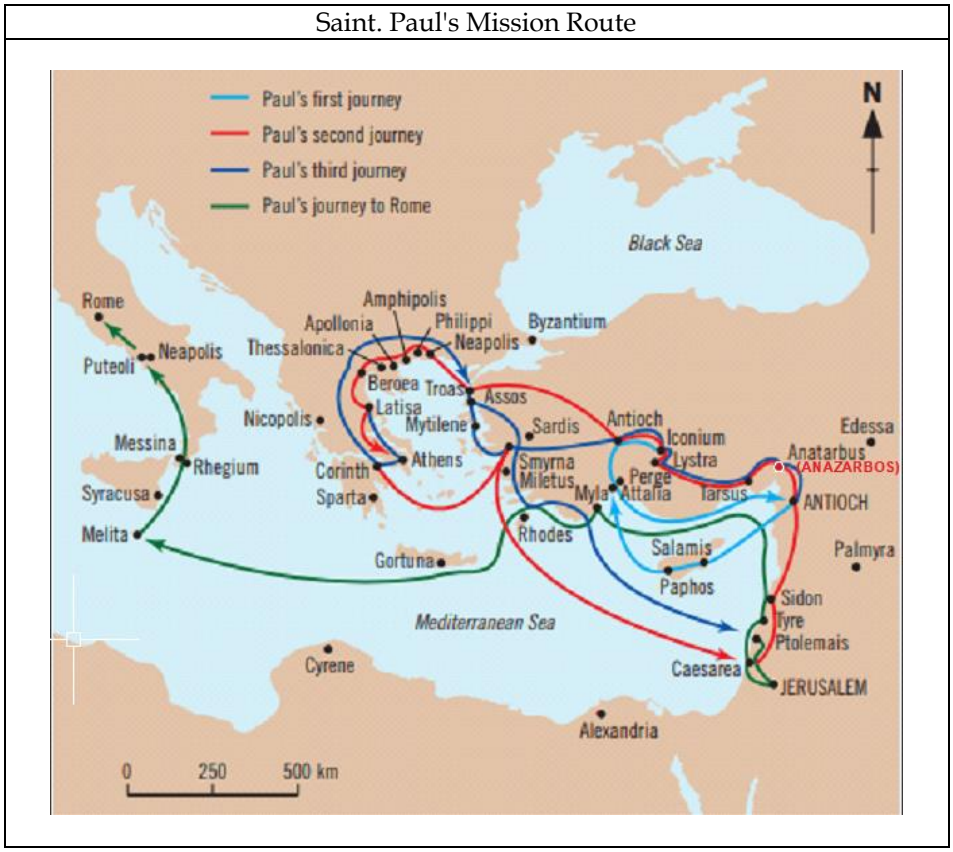


Figure 1. Saint Paul's Mission Journay Route (Hartney and Noble, 2008. The map is developed from map in Cambridge studies of religion)

Traditional research in the analysis of ancient cities has given particular emphasis to the study of the construction process and built environments as well as their development over time. Current approaches give evidence to the organisation and perception of space, in particular in small areas or fractions of ancient cities, trying to identify also the social interactions between the built space and its surrounding environment.

In the last few years this kind of approach has been widely applied in particular in extensively excavated contexts. Most recently, a few researches have used the application of this approach to data coming from different kinds of geospatial techniques

and non-destructive methods. The possibility offered by technological advances can increase not only the amount of information that is possible to obtain but also as a consequence, the further analysis that is possible to apply. Recent researches have tried to stress application of different kinds of spatial analysis, trying to enhance interpretation of still buried archaeological features. This technological and conceptual development has been possible thanks to a growing awareness of its possible benefits.

Here, we applied an approach which considers the entire Anazarbos urban complex as a whole and gives an active role to spatial characteristics of the city itself. Various aspects of the city planning were taken into consideration together with cultural (and partially social) components underlying urban design.

Over the past two decades, space syntax has been proposed as a new computational language to quantitively describe spatial patterns of modern cities (Hillier and Hanson 1984, Hillier 1996). The notion of syntax, derived from linguistics, refers to relationships between different spaces, or interactions between space and society. These principles support the belief that spatial layout or structure has great impact on human social activities. From its origin in urban research, space syntax proposes a language of space that is of interest for many research and application areas involved in the description and analysis of spatial patterns in the city. Through the structural analysis of an urban environment, urban planners can derive a better understanding of the evolution of urban areas, and gain more insights to help with the design of new urban layouts. Using space syntax principles, human displacement patterns in the city can be analyzed, mainly by considering the degree to which urban spaces are integrated and connected (Peponis et al., 1990).

Accordingly, when the studies in which the space syntax was applied were analyzed in a scale, it was seen that it could be grouped under the structure scale and the city scale (Fig. 2). The scale of the city is divided into three sub-groups, namely the historical city, the modern city and the archaeological city.

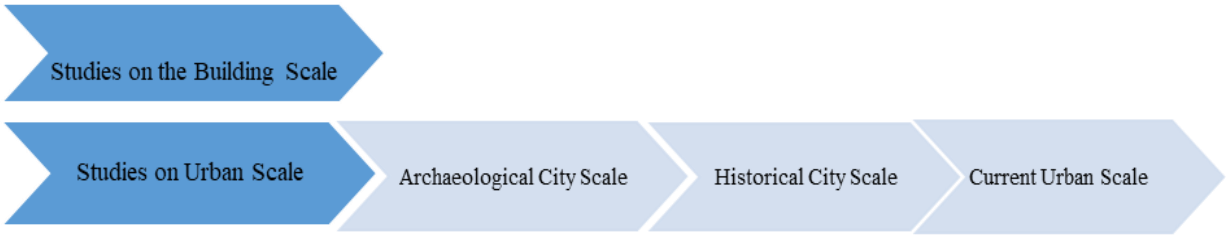


Figure 2. Scaling group of fields using the space syntax method

Although the method used in the study is included in the city scale group, it is also considered in a case study for an archaeological urban area. This study differs from other studies as a pioneering study in that the space syntax method is used less in urban archeological scale related to its social, economic and cognitive functions.

Accordingly, the starting point of the study was how the ancient city of Anazarbos, which was determined as the study area, was shaped by formation, how the spatial organization and its relations can be investigated by using a method, and how city readings from history can be put into an analytical framework.

The purpose of the study in line with all this information; It has been determined as the development of a model for the ancient city of Anazarbos that can place historical city readings to an analytical frame, and the mathematical interpretation of the socio-cultural and socio-economic meaning underlying the city formation with the space syntax method.

At the end of the study, the analytical data obtained with the method applied on the ancient city of Anazarbos was evaluated and the ancient city setup was explained with a mathematical interpretation. Thus, systematic data about the city of Anazarbos contributing to the readability of the city has been revealed. It is concluded that these data show that the city of Anazarbos does not develop randomly, and that spaces are built at the measurable boundaries of human perception. Considering that the excavation process of an archaeological city took many years, it was suggested that the line logic in Anazarbos city formation should be searched for an important structure or symbol of an historical event at the city's main street breaking points. The determination of structural historical markers, which are thought to have taken place at these points, is important. As the most integrated axis of the city constitutes the historical city core and the city's growth starting from this area, the determination of the city core constituted an important triangulation point in explaining the formation of the city.

2. ANCIENT ANAZARBOS CITY: FROM GEORADAR SURVEY DATA TO CLOSE RANGE ANALYSIS AND BEYOND

2.1. Anazarbos location and previous research

Anazarbos covering the eastern part of the city on Turkey's Mediterranean Coast Cukurova in the sub-region defined as the area in ancient Cilicia. The region is divided into two morphological regions as trakheia and pedias. The ancient city of Anazarbos is located within the borders of the region called Ovalik Cilicia, in Dilekkaya village of Adana province, Kozan district. Pile Cilician lands have rich cultural accumulation with the fact that dates back to the Neolithic period and is home to many cultures. Clicia Pedias has rich history that from Neolithic, Hittite, Persian period, Seleuk kingdom period, Hellenistic period, Roman, Byzantine, Seljuk period to reaching back to the Ottoman era and the Turkey today, and many more ancient cities are found in the Cilicia Pedias with Anazarbos (Fig. 3)

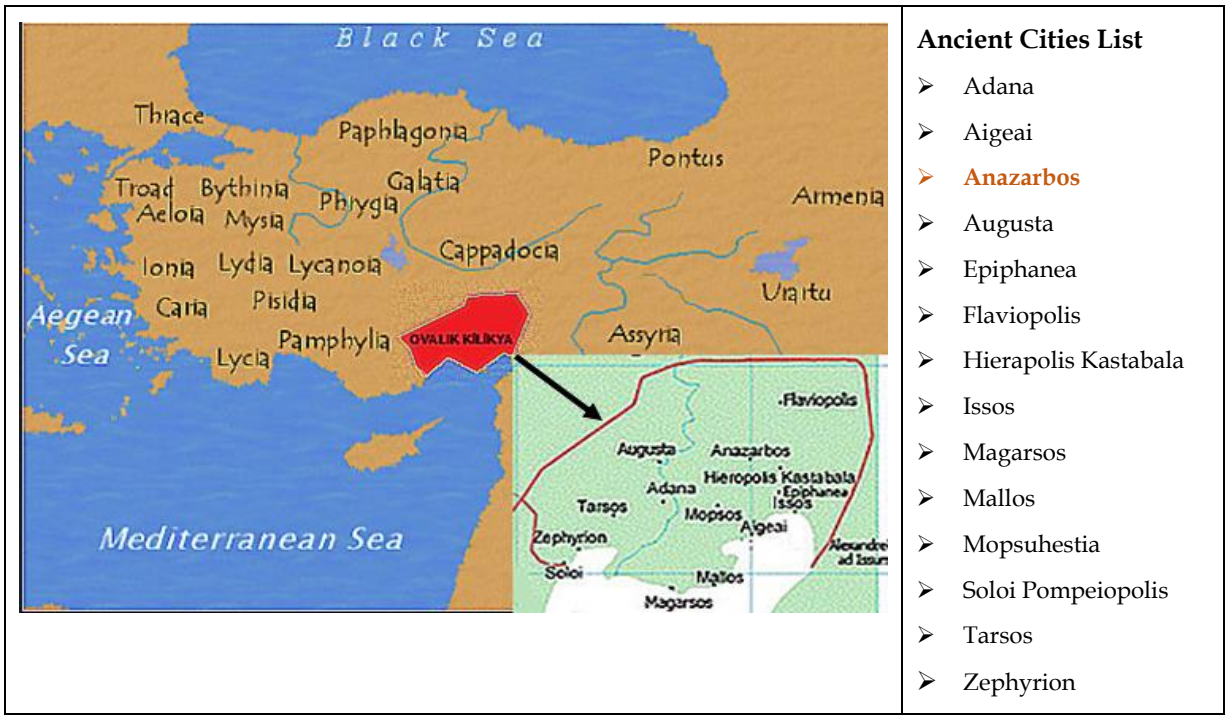


Figure 3. Ancient cities in the Cilicia pedias region

The oldest finds reached in Anazarbos emphasizes the late Hellenistic period. No artifacts from the pre-Hellenistic period were found in the studies conducted in the region (Sayar, 2000). The city was ruled by local dynasties during the Hellenistic period. It is known that it was ruled by Roman, Arab, Eastern Roman, Armenia and Mamluks in the following periods. It is known that there is competition between Anazarbos and Tarsos, which are the cities of Cilicia, with the Anazarbos people who organize Epinica and Olympic games against the festivals and games organized by Tarsos (Sayar, 1999). This rivalry between Anazarbos and Tarsos continued with the new state system of Cilicia, with two being the capital. Tarsus became the capital of Cilicia Prima, and Anazarbos became the capital of Cilicia Secunda. In addition, the ancient city was an economically important city due to its location on the trade routes of Syria and Kappodokia. In addition, the ancient city was famous for weaving in the 2nd century AD and the guild of weavers was established in the city (Jones, 1937). The fact that the famous Greek pharmacologist Dioskourides, who works in the Roman army and writes five volumes, *De Materia Mediceu*, is from Anazarbos, is also important for the contribution of the city to the history of world science. The fact that Anavarza St. Paul was on the road route he followed during the 2nd and 3rd Mission trips also means that his followers were at this point. In this sense, the city suggests that it is one of the leading cities followed in the spread of Christianity.

Artifacts such as rock tombs, monumental tombs, church ruins, aqueducts, theater, amphitheater, bath ruins, mosaic-based structures, city entrance gates, colonnaded streets, temples, stadiums have remained from the ancient city to the present day. It is known that Anazarbos was damaged by two major earthquakes that occurred in the Ovalik Cilicia

region and was rebuilt in the future. There was a major earthquake in the first half of the Julius Caesar period that was 1st century BC (Sayar 2000). It again suffered major earthquakes in 524 and 561 A.D (Ünal and Girginer 2007). The major earthquakes that continued in 1157, 1170, 1200, 1202 and 1269 AD caused destruction in the city. It is believed that most buildings could not reach the present day as a result of the fact that the stones belonging to the collapsed buildings due to the fact that many buildings were affected by these earthquakes and that the city was abandoned after the earthquake were used as building materials in nearby settlements.

2.2. Data Collection

Anazarbos was investigated with a multi-scale approach at different levels of resolution, from macro-scale to close-range analysis. Before acquiring new data, the first step of the research was dedicated to the digitisation of preexisting maps, aerial photographs and all other available forms of information.

An accurate study and analysis of the urban layout requires an extensive and detailed knowledge of the Anazarbos urban plan, which is not common without excavation and only with the use of remote sensing techniques or geophysical prospections. At the sam time, the detail of the Anazarbos magnetic map has given the opportunity to realise a theoretical urban layout and to attempt the study of urban interactions, access and visibility. The combination between satellite image interpretation and magnetic prospection at Anazarbos showed us such a detailed and complete image of the entire layout, which is not visible on
the ground, that it allowed the opportunity to study the urban plan as a whole.

We have also considered that the interpretation of remote sensing data (satellite imagery and geophysical maps) gives only an overview on the last state of occupation of the ancient city and does not give the possibility to argue anything about the evolution nor the development of the city and its urban plan. Therefore in our analysis the street network outlined belongs to the last phase of occupation, but it gives the possibility to make hypothesis about the original plan and urban layout.

The application of Space Syntax seemed to be the most logical step to gain further information on such detailed plans even if these techniques are usually applied to urban archaeology or on excavation data and in contexts with high levels of detail, such as Pompeii and Ostia (Stöger, 2011a, 2011b). It has been applied in different researches, most of the time incorporating only selected aspects of the more general technique. With this approach is intended that has the benefit for archaeological application to encourage the integration of network analysis within a wider and complementary perspective. The use of Space Syntax at Anazarbos is only part of the research, which takes into consideration different aspects of remote sensing and spatial techniques.

The application of Space Syntax tools to remote sensing data is therefore even less common and hazardous, but in recent years it has given the possibility to fully exploit the data and to identify key elements of ancient street network and the use and perception of the space. The first case is probably the application of GIS transportation network analysis made by Branting at the iron age site of Kerkenes Dag, prospected for an extension of 300 ha with geophysical survey (namely magnetometry and resistivity: Branting 2004). Other examples are the application made by Benech in Syria at Doura Europos and Tell Sheirat (Benech 2007 and 2010) and by Morrow at Tiwanaku, Bolivia (Morrow 2009). More recently we can find the attempts made on Roman Street network at Ampurias (Kaiser 2011), Ostia (Stöger 2011b) and Ammaia (Paliou and Corsi 2013).

The field work was carried out in 2004-2007 in cooperation between the University of Istanbul and DAI Istanbul carried out, the overall management and thus the representation vis-à-vis the Turkish authorities at M. H. Sayar lay; Richard Posamentir took on the planning and management of all work. Partial funding of the project (creation of an aerial or geophysical Prospection by the team of H. Stümpel, Institute for Geosciences at the University of Kiel), was carried out by the Fritz Thyssen Foundation. At last, this georadar image is given a clear general description of the Anazarbos city plan. Georadar image and current Google earth image is shown in Fig 4 (a, b).

At Anazarbos the space syntax analysis could give the added benefit to study the movements in past built environments and to encourage contemplation about human practices and social use of the space, not seen only as an unpopulated environment. Moreover the computational approach to the study of movement in archaeology can reveal the social context that lies beneath landscape and/or townscape: cultural markers assume extra significance as they influence movement and the perception of space, as it has been underlined by Lock et al, (2014).

a. **b.**

Figure 4. a) Map of the urban area of Anazarbos with underlying geophysical measurement images (geomagnetic prospection) (Birk & Stümpel in Posementir, 2011), b) current Google earth image (www. earthgoogle.com)

The lack of excavation data made these results particularly significant as they allow a detailed reconstruction of the settlement. This is even more important if we consider that no area of Anazarbos has been excavated for more than a small fraction of its total area. Results of all the remote sensing together (magnetic prospections and total station survey of all features visible on the surface) yielded a more complete understanding of the settlement as a whole, including its city walls, the street network, the disposition of blocks and, in some cases, also the internal organisation of almost each district (Fig 3).

Hence, in this combination of different surveying approaches (remote sensing, geophysical prospection, mapping, surface collections etc.) was the basis of our urban-spatial analysis. The following example shows how detailed images can be obtained with remote sensing (Fig 4 c).

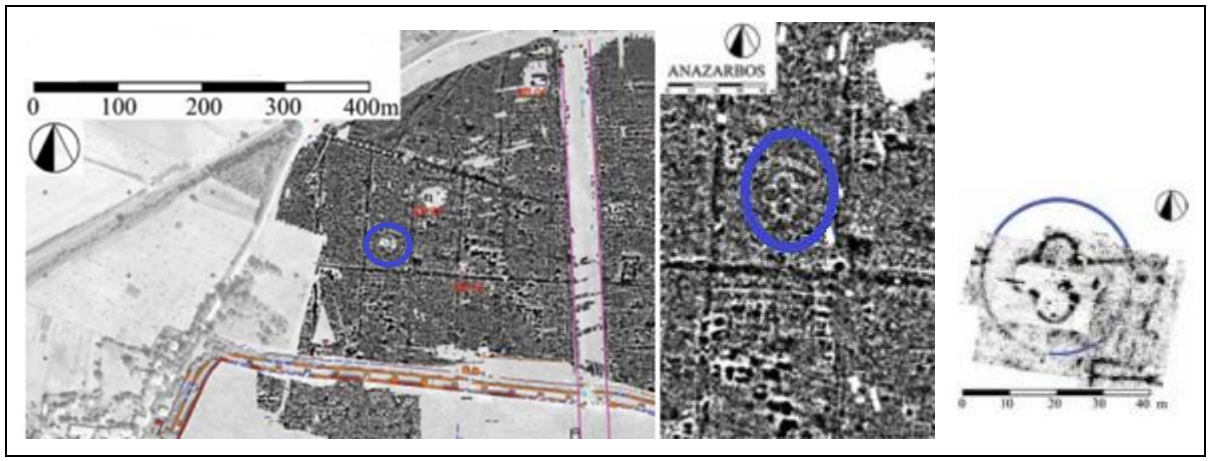


Figure 4. c) Detail of remote sensing work (geomagnetic survey) outside the circuit walls showing the orthogonal grid plan from Roman imperial times and a three- or four-leaved, light anomaly embedded within the antique insula system (Stümpel in Posamentir, 2011).

2.3. Application of Urban Network Analysis and Space Syntax

In the study, Anazarbos ancient city, the Space Syntax method, which allows numerical interpretation of the city formation, was used. In Table 1, the aims of Hillier and Hanson, the founders of the space syntax method, and the aims aimed by applying the space syntax method on ancient cities in this study.

Table 1. The objectives of the space syntax method and the those targeted by the application of the method in the study area.

The Aims of Hillier and Hanson to achieve with the Space Syntax method	Objectives of the study with the application of Space Syntax method on ancient cities
Hillier and Hanson (1984), known as the founders of the method, stated that they aim to reach the following information about the relation between space and space parts and space syntax method. • Locating the main axis of the system of the building and revealing the diversity of human spatial organizations within this framework, • To be able to group the basic functioning axis of the building, • To be able to determine how the main structures are related to each other in the building, • Determining how these structures come together to form more complex ones.	In this context, the constructions that Hillier and Hanson intended to apply on the structure were tried on ancient cities in this study. To understand the formation of an ancient city in more detail; • Locating the main axis of the ancient city and determining its relationship with urban elements, • To be able to distinguish the urban elements of ancient cities according to their functions, • Determination of the main functioning axis of the ancient city and how the city skeleton relates to each other.

Accordingly, the reading of the city formation was evaluated from an analytical point of view thanks to the data obtained by the method. Until the stage of the space syntax method is interpreted, the application steps of the operations performed on the city maps are shown schematically in Fig. 5.

It is necessary to create axial view axes by converting the picture format maps into dwg drawing format, and to save axial maps by saving these axes in shp format. Integration map is created by applying the space syntax method on the data obtained in shp format. Integration map can be made on the axial maps created and integration analysis can be evaluated.

In regards to the study of the street network, our approach consisted in the analysis of axial maps, with the aim of exploring how spatial configuration of the streets can favour or discourage human movement and interactions. Within the Space Syntax analysis, streets are not considered as independent features, but as a whole open space (Benech 2010: 405). The axial map can be considered as the basic analysis of the urban network in terms of axiality and connection and represents the longest lines that can be drawn from an arbitrary point inside the spatial configuration.

The mathematical logic of axial lines in the space syntax method is explained as follows. The initial idea of space syntax comes from an attempt to understand evolution and flow within the city: evolution by analyzing the way a built environment has developed as it has, flows by studying some social activities such as people displacements in the city. The axial line-based representation of an urban structure is the earliest approach of the space syntax (Hillier and Hanson, 1984). Axial lines are used to represent directions of uninterrupted movement and visibility, so they represent the longest visibility lines in two-dimentional urban spaces. Over the past two decades, this approach has been widely applied to solving various problems in urban systems such as prediction of pedestrian and vehicle flows, crime analysis and human way-finding process (Holanda, 1999). A set of axial lines, that mutually intersect and cover a whole free space, is called an axial map. According to Hillier'sinitial definition, an axial map constitutes the least number of longest axial lines (Hillier and Hanson, 1884).

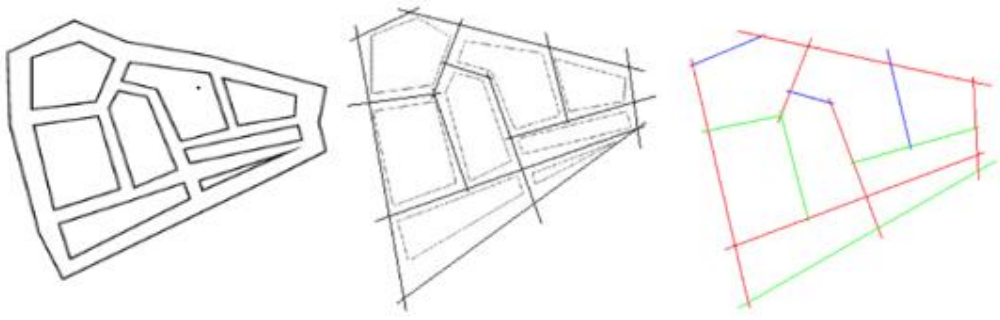
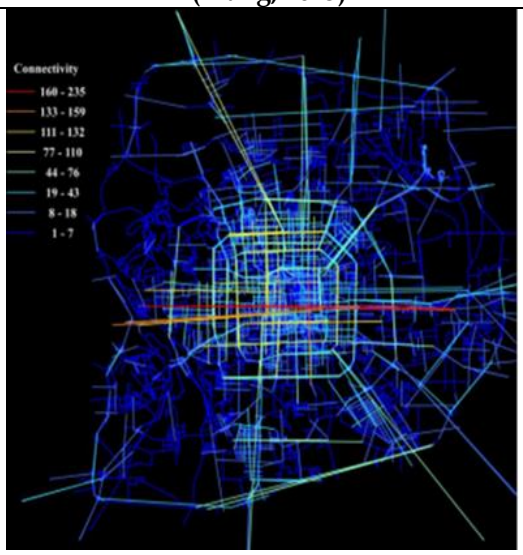


Figure 5. Schematic representation of the application steps of the operations on the city maps (Jiang, 1998) (a) A Fictive urban system, (b) its axial lines (dwg) and (c) axial map (shp)

In terms of how each line intersects other lines, various morphological parameters can be derived fort he analysis of an urban structure. These parameters include the connectivity, control value, local and global integration. The connectivity of an axial line masures the number of lines that directly intersect that given axial line. It also denotes the number of immediate neigbourhoods of an axial line. The control value of an axial line is given by the sum of inverse connectivity values of immediate neighborhoods of this axial line. Litarately the control value shows the degree to which each axial line controls its immediate neighbourhoods. On order to introduce the Notion of integration, let us first define the Notion of depth. The depth of an axial line is defined by the number of lines distant from a given number of steps to that axial line. While connectivity consider immediate neighbours, depth consider neighbourhoods.

Table 2 shows the Integration map of Beijing city. General interpretation of the integration map coded with colors is done as follows.

Table 2. Interpretation of the integration map.

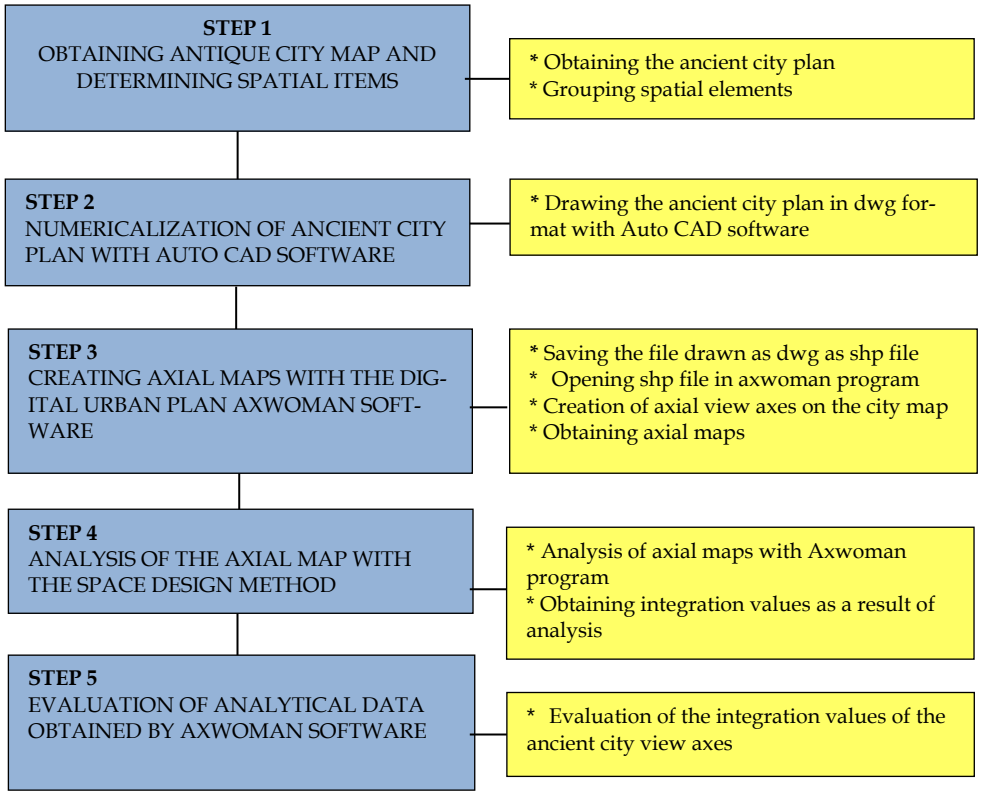
Interpretation of the map	**Sample Map-Beijing integration map display (Wang, 2013)**
➢ As a result of the analysis of the city construct, a map coded with colors is created from the most integrated view axes to the most isolated. ➢ Colors ranging from red to blue symbolize accessibility. red color indicates the areas with the highest accessibility, blue color shows the areas with the lowest accessibility. ➢ The presence of the movement on the city is determined with this map. ➢ Long lines mean perceiving building facades from a wide angle and short lines mean directing to the building from a narrow angle. ➢ This feature is a line logic and these lines or lines offer a perceptible environment to the user who looks at the city remotely. ➢ Secondary or lower perception structures can be located on short lines viewed from a narrow angle. ➢ The high integration value of a line means that its depth is low and the movement has an intense effect	

With this method used in the study, analysis of ancient cities and evaluation of maps created involves 5 stages. Flow chart for the application of the research method is given in Table 1.

The examination of the 5 basic steps with schematic representation, was made through analysis of the literature, and analysis and synthesis method based on the plans, decisions, interviews, observation and visual resources of the study areas.

During the city plans creation, satellite photographs were used. As a result of the observation, photography, detection, and documentation made in the field, the documents were transferred to the digital media with the Autocad software. The ancient city plan in the digital environment was transformed into axial maps by Axwoman software working with Arc-GIS based Arc-Map and the urban textures were analyzed by using the space syntax method. The findings of the study took shape, after the comparison, following proper interpretation and evaluation stages on the obtained analytical values.

Table 3. Flow Chart of application of research method



Each step in the schematic representation for the application of the method shown in Table 3 is given in some detail below:

1. Obtaining plans for determined ancient cities and determining their spatial elements: At this stage, the plans of the ancient city were reached by literature search. The literature has been studied in detail under the main branches of history of architecture, archeology and art history, and efforts have been made to identify urban elements within the scope of city plans

2. Digitization of ancient city plans via AutoCAD software: At this stage, ancient city plans were digitized with AutoCAD software and plans with the same character and content were created.

3. Creation of axial maps of city plans prepared in AutoCAD format: At this stage, the autocad drawings of the city plans were transferred to the axwoman software and axial lines of sight for the streets of the city were determined. All of these lines formed the axial map that belongs to that city. By digitizing the ancient city plans, the longest line that can be drawn to all areas outside the buildings to analyze the urban pattern is drawn by folding the most areas it can pass through.

These lines drawn by intersecting each other form axial lines. These lines define the eye level that potentially reaches the farthest view of the person moving in urban space. The lines drawn are, in other words, a form of symbolization (behavior) in which axial lines of vision, fields of motion and potential fields of view coincide.

4. Analysis of axial maps by spatial syntax method: At this stage, the axial line of sight lines forming the axial maps were analyzed through the axwoman software program. As a result of the analyzes, analytical data were obtained. With this value (global integration value), the hierarchy of the streets in the settlement can be defined from the most open areas to the least used areas. With this value being low, the most frequently passed streets and areas are defined as "integrated" and the less passed as "isolated".

5. Evaluation of analytical data obtained through Axwoman software: Analytical data of an ancient city was evaluated at this stage and city constructions were determined. With the analysis, a new map coded with the colors from the most integrated view axes to the most isolated was created. The most integrated streets are considered as the common public areas of a settlement, offering the potential to bring all people together, with the possibility of the most people going through to another place. Since the direction and road to be reached in a street with a high integrity value can be easily found, these streets have been evaluated as the most readable places of the settlement in terms of space syntax analysis. Insulated streets, on the other hand, are foreseen as roads used to go to a place on that street depending

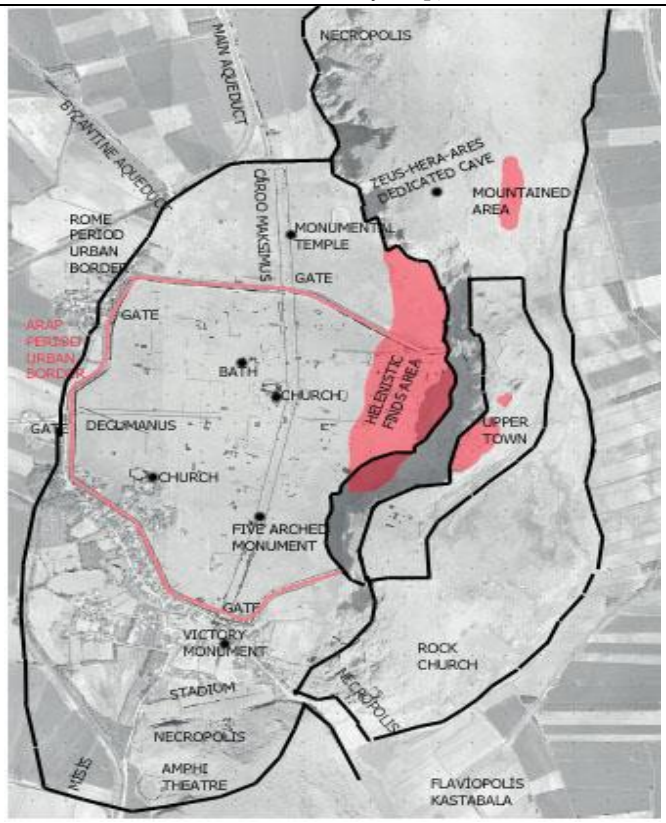
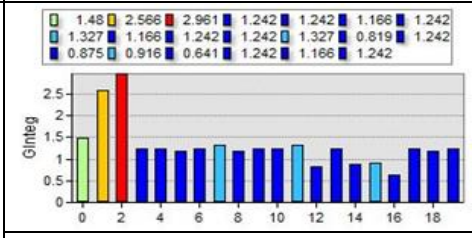
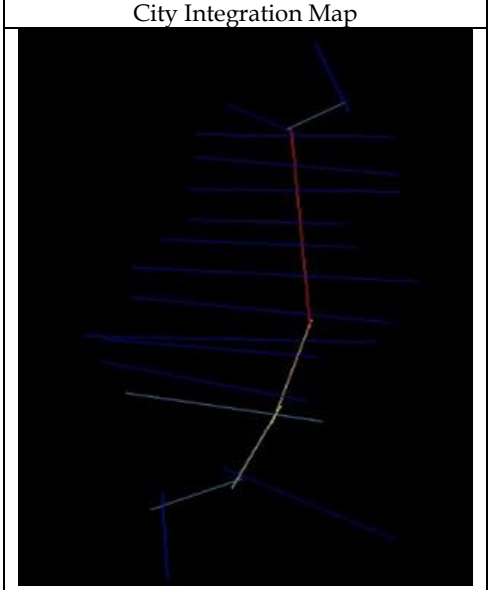
on a purpose. In spatial syntax analysis, integrity and isolation came to the forefront in the study as two basic concepts that allow the interpretation of the relationship between the formal characteristics of a settlement and its socio-cultural environment.

3. A CASE STUDY

The integration value has an important place in the analysis of urban mobility. As a result of the analysis, it is seen that the frequency of use of the outer spaces of ancient cities is revealed and the urban network can be explained by the current mobility relationship. In this regard, the integration maps analysis results of the global integration values (Rn) give information about the existing integrated or differentiated regions in the settlement. In the analysis study, a total of 20 lines were examined; the lines were the lowest 0.61 and the highest were 2.961. The low line value is dark blue and the highest line value is red according to the values on the map. It is seen that the integration value of the lines providing the connections of the city in the south-north direction is high. Towards the city walls where accessibility decreases, it is seen that the integration values are low especially in the lines providing east and west connections of the city center. It was seen that the integration value range between 2.961 and 1.48 on the main axis supports the holistic planning studies of the Roman period. The axes of the integration values, which are in the range of 0.641 and 0.916, have emerged as areas where urban needs are tried to be eliminated by means of particle analysis applications [1]. It was observed that the integration axes from commercial buildings to public buildings ranged between 1.48 and 1.116. A total of 16 lines with an integration value greater than 1.00 are observed.

When the ceramic remains from the Hellenistic period found in the outskirts of the mountainous area of Anazarbos ancient city and in the remains of the buildings obtained as a result of superficial excavations were entered into the city plan, the plan in Table 4 was obtained. The maps were interpreted by comparing these city plan findings with the integration values calculated on the integration map created on the city plan. In line with these findings, determinations regarding urban constructions were made. Table 4 contains the integration map of Anazarbos city, integration value and Anazarbos city map.

Table 4. Anazarbos ancient city integration analysis and Space Syntax analysis results.

ANAZARBOS ANCIENT CITY INTEGRATION ANALYSIS AND SPACE DESIGN ANALYSIS RESULTS	
Urban Plan (Anazarbos ancient city Hellenistic find area and Roman period city borders (created on the basis of Posamentir city map)	Integration Chart
	
	City Integration Map
	

When the integration analysis analytical data (Table 4) of the ancient city of Anazarbos analyzed in the study, the city's literature and observation data were evaluated together, the following basic determinations were reached.

- After reaching the city from the entrance gate in the south direction, there is a break in the main road axis (cardo maximus) twice. The response of this break in line logic is explained by the fact that a short line of sight is planned, since an important structure is emphasized on the short line of sight. In other words, it is concluded that an important structure should be sought at these points where breakage occurs. As a result of the research carried out for this purpose, the presence of an arched entry(door) was determined at this breaking point. However, this structure has not reached today. At the point of the second break, the presence of the church is known. The foundation remains of this building can be seen in situ.
- The most integrated axis of the city is the colonnaded street that turns north after decumanus. There are important public buildings on this street. It is thought that the first settlement in the lower city was formed in this area. Hellenistic surface ceramic finds also support this argument.
- It is seen that the width of the street with columns on the most integrated axis (the northern part of the city) is larger than the width of the southern street of the city. The idea that the main traffic density has increased after the first construction of the northern street axis, which is thought to have been made earlier; we can explain the width of this street axis as it is wider than the south of the city. It can be concluded that the northern part, which has a large street width, has been expanded due to the need as a result of being used more frequently by city users. It is also understood from the changes in the size of the insula that the parcels on the side of the street have been shrunk by including this street, which was expanded in the advanced period.
- There are commercial areas with various workshops/store on the second and third most integrated axle (southern part of the city).
- According to the line logic, it was evaluated that there could be an important public structure (agora?) in the intersection of the first and second most integrated axes.
- The fourth most integrated axis of the ancient city is the street right after the south gate of the city (ala gate), coming from Misis and reaching the city in front of the stadium. The meaning of this in line logic, the decrease of integration as it moves away from the city center shows that the city borders expanded in the south in Roman period.
- The fifth most integrated axis is located on the road to Misis passing through the theater and necropolis from the entrance of Takın (Ala Kapı). This road is also more integrated than the axis that leads to the ancient city of Flaviopolis and Hierapolis Kastabala, passing through the rock cut (Ali Kesiği) opened by a human hand. The meaning of this value is evaluated as the road to Misis was used in a period before the road to Kastabala.
- The integration value of Cardo maximus street was higher than the integration value of decumanus maximus street, suggesting that the ancient city of Anazarbos had developed in the north-south direction. While the first cities in history have developed in the east-west direction, Anazarbos ancient city has developed in the north-south direction.
- In the ancient city of Anazarbos, there are monumental tombs and necropolises in the most isolated areas, that is, the least in integration.
- The north-south columnar street, the most integrated axis of the ancient city of Anazarbos, divides the city into two. The presence of shops on this street emphasizes the importance of trade in the city.
- It is seen that the street (decumanus maximus), which divides Anazarbos into two regions as east and west, is built with columns. The low integration value of this axis indicates that this street was added after the cardo maximus axis. The fact that this axis dividing the city into two is not the same as the insula dimensions of the northern part and the insula dimensions of the southern part, indicates that these two regions have developed in different periods. It is thought that the first development area of the city started in the upper city skirts and in the northern region, and in the later periods the southern region of the city was built.
- Cities are a form of physical expression of communities. The idea and thoughtful structures of the communities form the foundations of the city. It is determined how the city users should behave in the city as the thoughts of the administrative structure and the decisions they take are shaped by shaping the city. Urban formation can bring living people together as well as decompose them. The segregation seen in cities organized by the kingdom administration style is observed to have anxiety to integrate and bring together by changing the Roman formation. The main axis (cardo maximus) in the basic formation logic of the city of the Roman period was formed as the backbone and the highest integration value of this axis was considered as the representation of the holistic Roman Imperial understanding. It can be said that the rhythmic

colonaded road on this axis is a symbol of the military power of the empire.

- It has been observed that similar actions are divided into similar sections in order to make the city legible and take place in the cognitive map of the user. With this formation, it is seen that the citizens of Rome or the city users of Rome perceive themselves as a part of the empire. Although users of different ethnic backgrounds lived in the Roman Empire territory, the holistic identity and standards in the city formation symbolized the unity and power of the empire, while the urban resident contributed to the unity of the union. In the evaluation made on the forehead, it can be said that the most emphasized element of these formational similarities are the cardo, the main street of the city, and the shops on the right and left of the street. It can be thought that other buildings function as public spaces.

4. CONCLUSION

The space syntax method involves a set of techniques for observing how urbal network planning and archaeological data of space relate to functional patterns, such as movement, land use, area differentiation, migration patterns, and even social wellbeing and malaise. The application of remote sensing and spatial syntax analysis techniques on the ancient city of Anazarbos are supported by archaeological data helped to understand the city's shaping and development principles. As a result of the analyses made, the following points were obtained:

a) Cardo-decumanus axes, which are the backbones, are defined in the spatial setup of the city of Anazarbos with the analysis results.

b) The areas where the integrated axis is the highest are determined as the area where the public areas are located on the cardo axis in the northern part of the decumanus axis.

c) The growth areas of the city have changed with the spatial development and a line extending from the south to the north has been formed on the cardo axis, which forms the main backbone. This development is supported by the values of integration.

d) The development of the city progressed from the north to the south on the cardo axis, and from the east to the west on the decumanus line.

The fact that the theater and stadium structures located in the southern part of the city are outside the main entrance gate of the city can be explained by the fact that these structures were built after the construction date of the gate. The segregation of these structures can be explained by the low integration value of the region.

The applied method used in the study can be used as an auxiliary tool in other similar ancient city studies, and may contribute to the field of archeology in terms of the management of the excavation sites for ancient cities. From the information obtained, the most integrated axes, streets and avenues can be reached and thanks to these data, which points of that city are used more frequently and therefore the regions of the places used by the community can be determined. It can be expected that it will support science in terms of forming stronger assumptions in line with the frequency of use (the most integrated space) data for the structures that are not yet clear for what purpose they were used in the ancient city and which are known to be underground.

The method used in the example of ancient Anazarbos can be evaluated to strengthen the connection between ancient and modern cities. Thus, it is predicted that ancient cities can benefit the modern city in terms of tourism. The new pedestrian and vehicle connections can be established in this direction that will contribute to the evaluation of fire access roads to protect ancient cities from fire and to create new access networks.

In addition, due to the limited number of studies in the field of urban archeology, it is thought that the study method will contribute to different comprehensive studies in this field. Within the framework of the findings and recommendations obtained as a result of the examination, research and observations made, it is predicted that regional analysis of other ancient cities and determination of their structures and comparing their similarities and differences in these regions, could play a positive contribution to the analytical evaluation of the historical process.

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[1] The transition to a space affects its occupancy, and vice versa. The easiest way to include occupancy is to iteratively base the value solely on movement and use of the summation values of minimum angular path (MAP). But since the overall angular separation is merely the 'difficulty' of moving along the MAP, the two quantities can simply be combined. The method may be similar to particle splitting in quantum mechanics, as a path turns to minimize its 'particle' mass density, until it reaches zero after a certain amount of angular change. The reduced density flow can then be used from all the different MAPs that lead to it to measure the amount of 'particle' ending at a certain spot. (see: Turner 2000, 16).