AN EVALUATION OF SPACE SYNTAX METHODS IN ARCHAEOLOGICAL CONTEXT: CASE OF MILETUS

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ABSTRACT

AN EVALUATION OF SPACE SYNTAX METHODS IN ARCHAEOLOGICAL CONTEXT: CASE OF MILETUS

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The Miletus street network has been subject to studies since the initial excavations that took place in the late 19th century. In light of recent geophysical research since the 90s, the street network has been defined more accurately to allow further research on the urban layout and helped uncover structures that are not visible to the naked eye. This thesis uses axial and segment analysis tools to analyze the Roman street network of Miletus to examine access and movement patterns to evaluate space syntax methods on the case of Miletus. For the analysis, the Roman street network - spatial arrangement of urban space- of Miletus is extracted using recently published research primarily including geophysical studies, archaeological surveys, and excavation data. This study aims to evaluate the potential of space syntax methods on the Roman network of Miletus as a case study. A secondary aim can be defined as understanding the accessibility and movement patterns of Roman Miletus street network and demonstrating the possible limitations of Space Syntax methods on Miletus case.

Keywords: Space Syntax, Miletus Street Network, Roman Street Network

ÖZ

MEKAN DİZİMSEL ANALİZ YÖNTEMLERİNİN ARKEOLOJİ ALANINDA KULLANILMASINA DAİR BİR DEĞERLENDİRİLME: MİLET

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Milet şehir planı, 19. Yüzyılın sonunda yapılmış olan ilk kazılardan günümüze kadar çeşitli araştırmalara konu olmuştur. 90'lardan bu yana yapılan jeofizik çalışmaları, Milet sokak ağının daha doğru ve hassas bir şekilde tanımlanmasına ve toprak altında olması nedeniyle henüz tespit edilememiş kalıntıların ve sokak ağının anlaşılmasına yardımcı olmuştur. Bu tezde, mekan dizim araştırmaları ile geliştirilmiş aksiyal ve segment analizi araçları, Milet'teki Roma sokak ağı için erişim ve hareket örüntülerini değerlendirmek ve yorumlamak amacıyla kullanılmaktadır. Analiz için, Roma dönemi Milet sokak ağı -şehir planının mekansal/uzamsal düzeni- jeofizik çalışmaları, ve kazı raporlarını da içeren güncel yayınlar ve araştırmalar kullanılarak düzenlenmiş ve mekan dizimsel analiz yöntemleri ile analiz edilmiştir. Bu tez Roma dönemi Milet sokak ağının mekan dizimsel analiz yöntemleri bağlamındaki potansiyelini ortaya koymayı, Milet için erişilebilirlik ve hareket örüntülerinin anlaşılması ve yorumlanmasını ve Milet şehir planı örneği üzerinde mekan dizimsel analiz metodlarının sınırlandırıcı faktörlerini göstermeyi amaçlamaktadır.

Anahtar Kelimeler: Mekan dizimsel analiz, Milet sokak ağı, Roma sokak ağı

to my mother, F. B. Orhon

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CHAPTER 1

INTRODUCTION

Space syntax methods have been used widely in historical and archaeological research to explain urban context-related questions since their introduction in the late 1970s. The main argument of space syntax is that the relationship between space and its inhabitants can be rationalized by the use of syntactic methods. Space syntax research aims to define spatial systems within their measurable units and generate functional analyses to explain their relations with the inhabitants. Space syntax methods have been widely used in archaeological contexts to analyze urban and architectural spaces.

The Miletus Street network has been subject to studies since the initial excavations that took place in the late 1890s. The street plan has been revised and reconstructed several times. Considering the recent geophysical research since the 90s, the street network is defined more accurately to allow further research on the urban layout and helped uncover structures that are not visible to the naked eye.

In this thesis, the street network of Roman Miletus will be analyzed using axial and segment analysis tools of space syntax to examine the access and movement patterns in the urban space. The extraction of spatial layout of the urban street network is a necessity for executing such an analysis. This thesis uses results from the data from a collection of published plans, research, archaeological survey, excavations, and geophysical surveys to extract the spatial layout of Roman Miletus for the periods following the reconstructions and modifications of Hellenistic buildings between 1st and 3rd centuries A. D..

This thesis seeks answers to the following questions after modeling the spatial organization of Roman Miletus:

a. Can the street network of Roman Miletus be analyzed by executing axial and segment analysis on the Roman Miletus urban layout?

b. Can the axial and segment analysis of the Miletus street network provide information about accessibility and movement patterns on Roman Miletus street network?

c. What are the limiting factors for the axial and segment analysis applications on Miletus case?

This thesis consists of six chapters. In the first chapter, the motivations and objectives of the study are briefly discussed. The second chapter summarizes the space syntax research and its history and fundamental concepts. The third chapter is an outline of archaeological space syntax applications and related research. The fourth chapter gives a historical outline of Miletus city, its excavation history, and the development of the city plan of Miletus. The fifth chapter presents the nature of used data, depthmap software, the results of axial and segment analysis for the Roman street network of Miletus, and interpretations for the resulting accessibility and movement patterns. The fifth chapter evaluates the executed analysis, its limitations on the Miletus case and possible effects of these limitations on the results.

CHAPTER 2

SPACE SYNTAX RESEARCH AND RELATED METHODOLOGY

In the 1970s and 1980s, the humanities and the social sciences witnessed the influence of linguistic approaches initially introduced by Saussure who was concerned with the underlying structure of language. In his definition, structure referred to the grammar and rules that regulated the surface phenomena which consists of gestures and phonology. The approach was later modified to fit social and cultural phenomena by Levi Strauss and Roland Barthes. This understanding, which is concerned with the governing rules between different mediums, provided a basis for the introduction of new analysis methods into science that led to the combination of different scientific disciplines under a structuralist perspective (Preucel & Mrozowski, 2010, p. 20-21).

Another reflection of the structuralist approach can be observed in the theories of Bourdieu and Giddens which are influenced by Durkheim, Marx, and Weber. These theories are concerned with the link between social structure and individual agency. While Bourdieu emphasizes the habitus definition which he uses for the combination of forces that influence individuals, Giddens focuses on the role of human agency in the construction and reconstruction of social structure (Camic & Gross, 1998, 454). De Certeau's (1984) conception of tactics focus on the combination of memory and practice of the individual as a factor within the structure that modifies habitus (Fladd, 2017, p. 129). It is necessary to indicate the recursive relationship between the social structure and the individual in these approaches.

On archaeology, Lewis Binford's criticisms of the preceding approaches for omitting functional contexts of artifacts, cultural transformation, and structural and functional characteristics while explaining relations of archaeological complexes, was followed by the introduction of systems theory that identified the appropriate scale of analysis

as the interactions involving the exchange of matter and energy between organisms and their environment.

Spatial modeling and quantitative analysis turned into a central element of the methodology in archaeology after the introduction of newly introduced sciences such as evolutionary ecology and human geography in the 1950s. While these methods were being recognized by researchers, computer simulation and related methods became a frequently used tool as a form of quantitative analysis. Locational analysis and simulation started to have greater significance as tools of predictive modeling to explain trade, exchange, the spread of agriculture, population, and cultural resource management after the 1980s (Preucel & Mrozowski, 2010, 20-21).

In the same time frame, Bill Hillier and Julienne Hanson introduced the space-syntax method as an attempt to produce a theory for architectural analysis in the mid-1970s to create a method that provided an autonomous description of structures/sites, the ability to account for a wide range of variability in site type and layout, and the allowance for varying relationships between spatial and social order.

This approach relies on a semiotic understanding of space which forms a morphic language that consists of components such as an open space (the carrier), a growth process, and a syntax that represents the relations between units that determine the function of that space. In this morphic language, the relations between units are emphasized rather than individual structures. The permeability and boundaries are the main elements of the analysis which together expose a graphic representation of spatial pattern (Fladd, 2017, p. 128).

It can be fairly said that space syntax research is an attempt to incorporate structural linguistics, Durkheim's sociology, and systems theory in a single method to explain built structures and their relations with the inhabitants. Durkheim's approach to social structure has a prominent significance in the development of space syntax research.

Durkheim advocated for the idea that the main outcome of the studies conducted in humanities was to comprehend societal dynamics and define divergent social mechanisms within the inner structure of societies (Trigger, 2008, p. 320). He did not accept the culture-historical approach which claims that social mechanisms and

culture-specific codes of behavior are linked social structures, and they can be perceived as a random and systemized constitution of coincidentally integrated features. Rather, Durkheim suggested that human groups actually form complex systems that are the results of intertwined sets of units like the parts of a living organism or as the items of a syntax tree of a sentence in a human language. Therefore, the study of human societies was expressed as an analogous science of "societal morphologies" whose aims are similar to that of analogous physiology (Trigger, 2008, p. 321). Furthermore, because of these highly interrelated internal structures of human groups and societies, Durkheim claimed that an alteration cannot take place in only a particular section of a social mechanism; on the contrary, a change in a segment of the social system would cause alteration in other parts of the system in varying proportions.

Based on the interconnectedness approach of Durkheim, in settlement archaeology, separate archaeological sites are no longer being examined independently from their contextual properties. Moreover, they are no longer understood as demonstrative of a specific area or culture. In opposition, archaeological sites are regarded as constituting networks and links, where single archaeological sites have contributed to the totality of the system at various and supplementary levels. An increasing number of archaeologists conceive patterns related to the built environment as a significant resource to interpret demographic fashions as well as governmental, social, and canonical organizations of societies. Domestic spaces, for example, display familial structures, and settlements reflect space distributions that affect the social structure, trade routes, administrative organizations, and religious behaviors of the communities. Settlement archaeology is the field that is most strongly linked to the objectives of Durkheimian understanding of society as it rejects ecological determinism and concentrates on deducing social ritual patterns based on the relationship between space and humans (Trigger, 2008, p. 320-322).

Upon defying the connection between the similar morphological structure of human groups and the reciprocal effect of space on human social life and interaction, in their book *The Social Logic of Space* by Bill Hillier and Julienne Hanson (1984) integrated the main components of Durkheim's social anthropology with the theoretical understructure of Space Syntax. They addressed Durkheim both before and after

publishing the book. Similar to the relationship between the space syntax theory and Durkheim, Hillier and Hanson also gave references from several other sociological academics, the majority of whose works were in line with the Durkheimian tradition. Considering the level of overlap between the two fields, Durkheimian sociology, and settlement archaeology, it can be fairly said space syntax is the method that is significantly accounting for Durkheim's socio-morphological theory that can be implemented using archaeological data and measurement (Liebst & Griffiths, 2019, p. 215).

Durkheim defined the term 'social morphology' as an examination of the physiology of human groups, which is a comparative term for the study of "morphemes" and "lexical" items described in the structural generative syntax theory of Chomsky. Furthermore, social morphology is also compared to the biological understanding of morphology -which associates morphology with the structure of living organisms comprised of individual interdependent 'tissues' and 'organs'. Within this framework of resemblance among generative syntax in linguistics, biological comparison, and space syntax of settlement archaeology, Durkheim expresses another key element of his sociological inquiry. "Social physiology" is simply defined as the investigation of the social functions that are internal to the anatomy, or syntax, of the communities (Liebst and Griffiths, 2019, p. 217).

The constitution of humans and non-human things –which are linked in and space in nature- enables the generation of a complex social structure whose entirety owns discrepant features from its individual components. This kind of understanding of social structure is reminiscent of both the "constituency" of syntax theory of linguistics –because the syntactic tree generated through merging varying lexical items and phrases posits a different final structure from its constituents- and space syntax theory of archaeology.

Therefore, although the concept of society has its morphological foundations, it also has its own political, social, religious, and administrative functions and properties that are both culture and context-bound. Even though various types of social interaction derive from separate intertwined morphological mechanisms, the moment they form a structure they become a individual uniform entity.

While the different forms of collective activity also have their own substratum and while they derive from it in the last instance, once they exist, they become, in turn, creative sources of action, they have effectiveness by themselves, and they react on the very causes on which they depend. Durkheim, most fully elaborated the empirical implications of this morphology-physiology nexus in his early masterpiece, The Division of Labour in Society – which is also the Durkheimian text to which space syntax theory gives most weight (see e.g. Hillier & Hanson 1984; Hanson 1999; Hillier & Netto 2002).

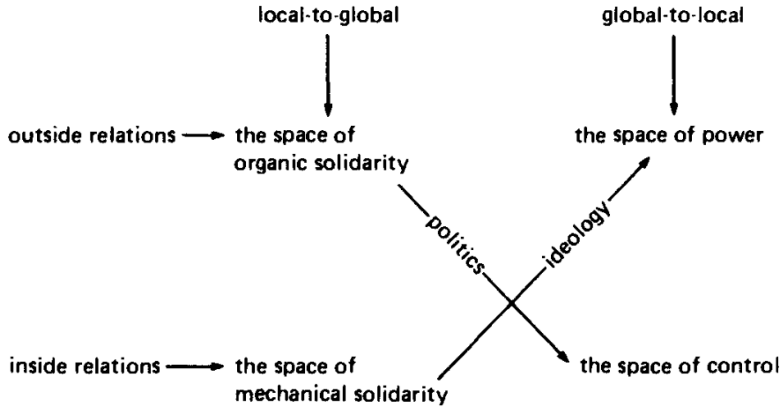


Figure 1: Socio-spatial relations (Hillier & Hanson, 1984, p. 22)

Durkheim identified the source of different solidarities by the spatial variables –the size and density of populations. Hillier & Hanson (1984) define the theory of space as a "missing component" in the Durkheimian approach. By this motivation, space syntax research aims to "form the elements for spatial analysis for social formations". This led to the development of "the elementary cell" to identify the simplest considerable socio-spatial structure (Hillier & Hanson, 1984, p.18).

In developing their "sociology of the elementary cell", Hillier and Hanson (1984, pp.18,19) define the cell as a spatial difference that makes a social difference through the establishment of a sociological distinction between an "inside" and "outside" – we may think of the elementary cell as a simple ground-floor dwelling with a single room and doorway that connects it to the exterior.

Of particular relevance for the resolution of Durkheim's ambivalence, Hillier and Hanson's meditations on the elementary cell imply an assignment of agency to morphological space. The spatial difference between inside and outside makes a social

difference because of how the structure of the elementary cells generates and regulates patterns of human movement and social co-presence. As it is highlighted, the spatial morphology has a direct relation – rather than a merely symbolic one – to social life, since it provides the material preconditions for the pattern of movement, encounters, and avoidance which are the material realization – as well as sometimes the generator – of social relations. (Hillier & Hanson, 1984, p. 19)

This argument transcends Durkheim's ambivalence: spatial morphologies affect society because of the agential impact of real space on dynamic densities.

When space syntax theory uses the term spatial/network agency, it simply refers to the independent influence that spatial networks have on movement density patterns (Hillier, 2005, p. 475). For space syntax theory, this is a testable claim that may be assessed with space-morphological methods. By comparison, Durkheim offered few methodological guidelines for how morphological space should be empirically examined.

While he could only speculate on how movement and dynamic densities are shaped by spatial "passage-lines", it is the singular achievement of space syntax methodology to operationalize these passage-lines with topological network representations (or, to use the technical term, "axial-lines graphs"; Hillier & Hanson, 1984, p. 96). This approach to capturing the networked nature of real space marked advancement in the primarily descriptive typology of "generative" and "conservative" spatial-morphological systems that had characterized the previous phase of space syntax research (Hillier et al., 1976). Specifically, this new method enabled precise syntactic description at the scale of individual streets, for example quantifying how central or segregated a given street was, relative to others in the same urban system; thereby yielding numeric descriptions that could be mapped onto other forms of social data (Hillier & Raford, 2010, p. 13)

An essential component of space syntax is access analysis which is used for the creation of a graphic representation of the architectural space which relies on the patterns formed by architecture. This graphic representation consists of nodes that indicate spaces and lines of access that combine these nodes. The relationships between the spaces are presented in the form of justified graphs (j-graphs) which align

spaces based on their depth from an exterior node. J-graphs provides a comprehensible and uncomplicated encapsulation of the subject space. Also, spatial qualities like symmetry, asymmetry, distribution, or non-distribution are represented. These relationships can then be linked to forms of social organization. Symmetry can be linked to integration while asymmetry implies segregation, and the distributed system can be linked to diffused social control while the non-distributed system indicates central control (Fladd, 2017, p. 128).

To summarize, the space syntax research program defines built environments -whether buildings or urban spaces- as a product of an effort to arrange spaces for functions and suggests that it is possible to read the society (the social function of spaces) through the way the built environments shape and order space (Hillier & Hanson, The Social Logic of Space 1984). In the space syntax approach, the social function of a space is defined by the place's publicity or privacy. With this proposition in mind, space syntax was introduced in the late 1970s as a method for analysis of the built environment. Its ability to consistently model and visualize the correlation of alterations between space and its inhabitants provided the space syntax methods a base in research communities in architecture, urban planning, historical research, archaeology, and fields that are related to the organization of space.

After its introduction, space syntax methods have been improved further with the help of technological advances and more integration of computer sciences into every aspect of design and scientific research. *Social Logic of Space* by Hillier and Hanson explains the space syntax approach as a method to represent spatial order in an observable and measurable sense. The primary concern is the problem of quantification which brings forward the problem of measurement.
This chapter explains space syntax under six titles;

- Structural Linguistics and Chomsky's Generative Syntax
- Development of Space Syntax methods
- An Outline of the Space Syntax Model and Aims,
- Archaeological perspectives on Space Syntax

2.1. Structural Linguistics and Chomsky's Generative Grammar

Structural linguistics assumes that sentences are formed by structural components that form hidden hierarchical patterns. This assumption has found a large base in the scientific community since its introduction and has been adapted to various disciplines including cognitive science, computer science, neurolinguistics, psychology, sociology, and social sciences.

Inspired by Ferdinand de Saussure's works, structural linguistics have been developed further between the 1930s and 1950s through research pioneered by Leonardo Bloomfield (Language, 1933), Rulon S. Wells (Immediate constituents, 1947), Zellig Harris (Methods in Structural Linguistics, 1951). The most recognized approach that is followed by these is Noam Chomsky's generative grammar which emerges as a reaction to Harris's structural analysis that mainly relies on phonetic components that form the structure of grammar (Lasnik & Lohndal, 2013, p. 26). Chomsky's initial proposal relies on the definition of the human mind as a computational system and complex operations for manipulating these basic phrase structures Chomsky utilizes concepts of mathematics and logic to develop his methods of linguistic analysis (Lasnik & Lohndal, 2013, p. 26).

The main difference between Chomsky's approach from the former structuralist reasoning stems from the focused aspects. While Chomsky concentrates on the recursiveness of a system, the former structuralist approaches in general focus on morphophonemics, phonemics, paradigmatic inventory, and such finite levels of a language. Chomsky, on the other hand, aims to focus on syntax, which he addresses as the source of problems related to linguistic creativity, and has been neglected in the former approaches. Derived from mathematical logic, Chomsky's approach relies on an axiomatic-deductive method. For this, he is inspired by Emil Post's "…Recursively enumerable sets of positive integers and their decision problems…" ("recursive function theory" in short terms) (Lasnik & Lohndal, 2013, p. 26-27).

Chomsky's earliest work Systems of Syntactic Structure (1952), focused on explicit and comprehensive answers for the structurally embedded nature of language; and he posited a computational system in the human brain that operates over basic phrase structure patterns of languages (phrase structure rules) as well as more complex

operations which manipulate these basic phrase structures (transformations). In light of this framework, Chomsky's computational theory partook within the *Transformational Generative Grammar* (Lasnik & Lohndal, 2013, pp. 26-29).

Later during the 1960s, his research focus shifted, and Chomsky called the previously developed theory "the standard theory". According to him, a theory of language must have the capacity to produce available grammar for all existing human languages. Theories put forward in the 1950s and 1960s made an infinite number of grammars available; thus, there was a severe explanatory problem to relieve adequacy (Lasnik & Lohndal, 2013, pp. 26-28).

Through the late 1960s and 1970s, theorists proposed further explanations and constraints regarding the "possible human grammar". These endeavors were motivated by the considerations of explanatory adequacy along with general considerations of simplicity and effortlessness. All of these culminated in the Principles and Parameters framework; more importantly, the Government and Binding approach proposed by Noam Chomsky led to a wide range of cross-linguistic research to be able to account for a comparative syntax and to help define theoretical definitions by using comparative data (Lasnik & Lohndal, 2013, pp. 26-28).

In the early 1980s, non-transformational theories such as *Lexical Functional Grammar* (Kaplan and Bresnan, 1982), *Generalized Phrase Structure Grammar* (Gazdar et al., 1985), and *Tree Adjoining Grammar* (Joshi et al. 1975; Joshi 1985) were also developed (Lasnik & Lohndal, 2013, pp. 26-28).

2.1.1 Syntactic Structures and Aspects

Since Harris's approach (one sentence transform into the other) was not sufficient in the sense of providing a systematic explanation for more abstract structures of the language; Chomsky dealt with *The Logical Structure of Linguistic Theory* (1955/1975) and Syntactic Structures to be able to relate abstract structures to abstract structures ((Lasnik & Lohndal, 2013, p. 26).

In Chomsky's understanding, infinity and structure were two of the fundamental features of human languages and they could be analyzed within the framework of a context-free phrase-structure (PS) grammar. Phrase structure is comprised of non-

terminal nodes (symbols) that could be expressed by sets of terminal nodes (symbols) which are the main components of PS (Lasnik & Lohndal, 2013, p. 26-30; Dawson & Phelan, 2016, p. 228-232).

Linguistically, terminal and non-terminal symbols are regarded as lexical items that can stand alone meaningfully, and they are used to define the formal rules of grammar. On the other hand, non-terminal nodes can be exchanged with sets of terminal nodes based on these defined formal rules of grammar, which are also known as "phrase structure rules" or "production rules" (Lasnik & Lohndal, 2013; Fukui, 2008). Specifying the PS in nodal or symbolic representation enables restating the given phrase structure by exchanging the symbolic terms with the sub-terms in a way that resembles the writing of a mathematical phrase (Dawson & Phelan, 2016 p. 228-232). In the previous versions of the phrase structure approach, it is proposed that individual lexical items should be situated in a solid structure. This situation converted the phrasal structure into a context-bound one; however, this is not a favorable predicament when analyzing the linguistic architecture of the phrase. The stated problem was intended to be resolved by improving the current mechanism with sub-categorization properties that divides the analytical foundations from the context of the phrase- which was described as the "Standard Theory" (Lasnik & Lohndal, 2013, p. 26-30).

After the development of the standard theory within the domain of the generative syntax of linguistics, the above-given insufficiencies of PS formation rules became the subject of depreciation. These criticisms facilitate the progress of the development of the "X Theory" of linguistics as an improved version of the Standard theory to overcome the criticized shortcomings such as the inadequacy to symbolize the transformation or production of unjustifiable structures.

Later, during the late 80s, "X Theory" was converted into what is known as the "Minimalist Program" by Chomsky (Lasnik & Lohndal, 2013, p. 26-30; Dawson & Phelan, 2016; Fromkin et. al., 2011). The concepts of dominance, constituency, merge, etc, stemmed from these frameworks and are examined in the following pages.

As mentioned by Lasnik & Lohndal (2013) "Phrase Structure grammars capture constituent structure by introducing non-terminal (unpronounced) symbols. By this, each symbol can be connected with (defined in terms of) the symbol(s) it rewrites so

that they can be traced back to the units of the structure. After joining the symbols derivations can be represented in the standard form of a tree" (Lasnik & Lohndal, 2013).

Below is an example of a tree structure built as suggested.

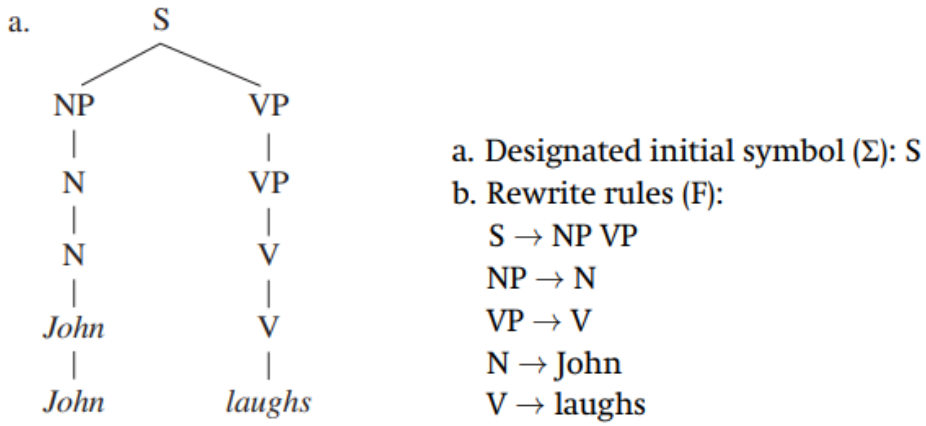


Figure 2: Standard form of a tree structure. S: Sentence, N: Noun, V: Verb, NP: Noun phrase, VP: Verb Phrase (Lasnik and Lohndal, 2013)

2.2 Development of Space Syntax Research

The definition of space -to quantitatively analyze the interspatial relations, and its relations with its inhabitants- was challenging right from the start because of the limitations of language itself particularly the insufficiencies of prepositions to define the spatial relationships (Hillier & Hanson, 1984, pp. 1-2). In order to address this "definition problem," researchers in the field of space syntax turned to structural linguistics, which offered a framework for representing observable phenomena in a mathematically abstract way. The goal of the space syntax research program is to develop a set of terms that can be used to define, process, and explain spatial systems without the limitations of language.

In order to address this "definition problem," researchers in the field of space syntax turned to structural linguistics, which offered a framework for representing observable phenomena in a mathematically abstract way. The goal of the space syntax research program is to develop a set of terms that can be used to define, process, and explain spatial systems without the limitations of language.

The Social Logic of Space (1984) focused not only on analytical techniques and considerations; but also underpinned the notion of how ostensibly complex built

environments as “global structures” derive from discrete yet `local rules and systems` (Thaler, 2020, pp. 297-298). Thaler expresses that the idea developed into the term “generative syntaxes” was mainly investigated as a prominent topic in the advancement of space syntax research and can be classified widely as a structuralist perspective in the field. Followed by *The Social Logic of Space* by Hillier and Hanson (1984) which introduces the recursive relationship between the built environment and its inhabitants, the more recent publications such as *Space is the Machine* by Hillier (1996) and *Decoding Homes and Houses* by Hanson (1998) tend to adopt a post-structuralist approach that emphasizes the temporal, social dimensions with the recursive relationships proposed formerly. Thaler explains this shift with the flexibility of space syntax methods within different theoretical frameworks and its ability to align with a phenomenological perspective. However, in archaeology space syntax methods are used as a practical tool.

2.2.1 Basic Principles of Space Syntax Methodology

In the space syntax research, each spatial unit (which is expressed in terms of convex space, axial space, isovist space, etc.) is represented with a dot or a node (as in the generative syntax theory of Chomsky where each lexical item is represented with a node that constituted a meaningful phrase structure by merging among themselves). To represent the interrelation between these spaces visually with a topological graph, every node or dot is linked with straight lines where a door connects two rooms (Figure 4b) As the data content of such a graph will not be subordinated to the relative positioning of the dots or nodes to one another any longer because the correspondent- or relative- relationships will be demonstrated by the straight lines as the representative of the edges, it will allow the rearrangement of the graph. This rearranged form which is commonly used is called a justified graph or j-graph in short (Figure 4c) (Thaler, 2020, pp. 298-300).

As mentioned, the space syntax methodology refers to spatial systems as an arrangement of interrelated basic spatial units and aims to analyze the connection between these units to define the spatial systems. Since the introduction of Space Syntax research in 1976, it is possible to observe three basic conceptions have been

developed; convex space, axial space, and isovist space for the spatial units to be defined in terms of.

Based on these definitions of "syntactic units" and their constituencies with the related map representations, the quantitative characteristics of the syntactic relationships are identified. To examine these quantitative characteristics independently from the physical measures, syntactic steps and depth values are used.

The inhabitant-visitor and inhabitant-inhabitant relations are represented in the syntactic representation by deducing the system into access and permeability, related control and integration values, and their variants. Statistical representations of these are numeric factors such as asymmetry and ringiness, and their relative values are generated to be used for comparisons between spatial systems of varying sizes.

2.2.2 Configuration in Space Syntax

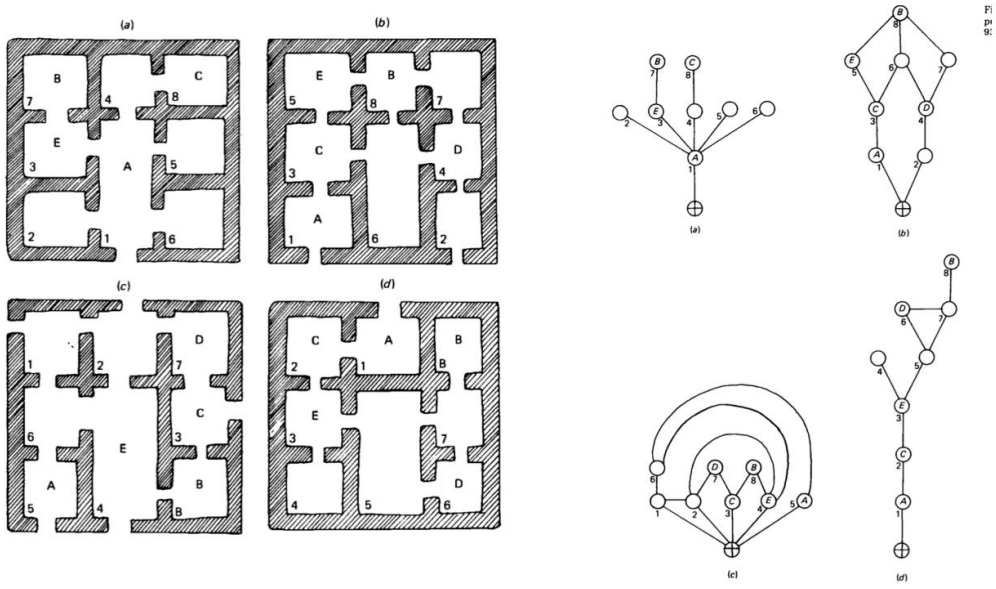


Figure 3: Syntactic variation in different fragmentation of the same space (Hillier & Hanson, 1984)

In Bafna (2003, p. 17) space is defined as a resource that society uses to organize itself. In this perspective, the inhabitation is configured/transformed into a continuous system of connected spatial units. According to Hillier & Hanson (1984, p. 9) spatial organization, in buildings, built environments, or public spaces, carries social ideas that represent themselves in the spatial configurations while transforming the human

society that occupies that spatial configuration. Socio-spatial relations occur in a cyclical manner: each modifies and restructures the other.

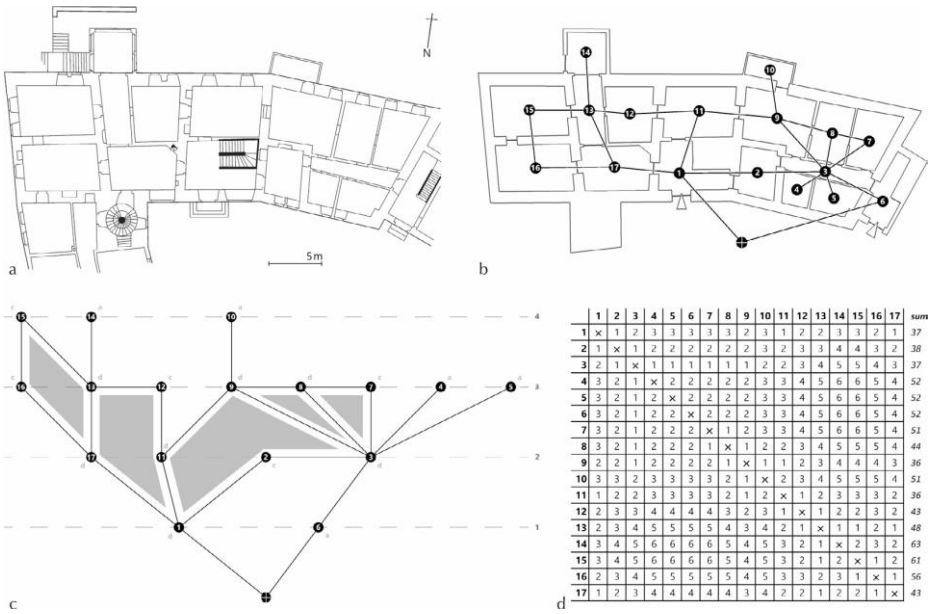
Bafna (2003, p. 23) exemplifies that, this recurring transformation is observed in the practice of setting boundaries to configure space in which the boundaries allow a certain amount of visibility and access between spatial units that directly modify society and spatial configuration by generating a movement pattern and probability of encounters within the population. This is expressed in spatial order by providing a higher rate of encounters between inhabitants and isolation to others (i.e visitors) or limiting the movement of visitors by providing control to particular spaces, as a result maintaining social organization members of a group to control traffic.

Space syntax employs graphic representations that rely on theoretically defined terms that identify and express social ideas. These terms aim to statistically state certain common measures of relationality in graphs. Space syntax theorizes these relationalities in terms of their potential to embody or transmit social ideas, and then transforms them into measurable diagrams of a spatial structure by linking them to geometric representations (Hillier & Vaughan, 2007, p. 207).

2.2.3 Justified Graphs

The justified graph is a visual representation of the logical relations between spatial units in a spatial system. Hillier's proposed spatial system can be defined as a series of obstacles that guide the movement along the fractions of the main space. The main space that carries these fractions is defined as the carrier space and defined as the root node of a syntactic diagram (Hillier & Hanson, 1984, p. 95). In the justified graph, the carrier space is represented with a further node at a place that is regarded as the root of the dendritic graph; the syntactic representation of the spatial units (Figure 4e). This root node will serve a similar function as the head noun or verb in the syntax tree of linguistics which allows projecting a further unit in the sentential context (Figure 5). Later, the nodes are adjusted in the form of horizontal lines based on their distance (step distance; depth) from the root node in terms of the minimum or the maximum number of edges/ doors they can be accessed through. This is called depth in the syntax tree (Hillier, 1999, pp. 71-73). It is useful to mention that the depth value in a syntactic system does not refer to any metric distance spatial units.

The j-graph allows the definition of some numerical values and indicators of certain spatial/environmental properties. For example, the effortlessness of the access from the outside – which is represented by the carrier/root node formerly- of a specific space (a room, a spatial unit, or an entire building) is exhibited in its "depth" or "mean depth" in numerical measures. The depth of the individual nodes can be labeled in the j-graph by appointing numbers to the horizontal lines of the pre-specified nodes. This operation will permit calculating the mean depth, the main quantitative indicator in measuring the accessibility of the building or a specific spatial unit from its periphery (Hillier & Hanson, 1984, p. 106).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	sum
1	×	1	2	3	3	3	3	3	2	3	1	2	2	3	3	2	1	37
2	1	×	1	2	2	2	2	2	2	3	2	3	3	4	4	3	2	38
3	2	1	×	1	1	1	1	1	1	2	2	3	4	5	5	4	3	37
4	3	2	1	×	2	2	2	2	2	3	3	4	5	6	6	5	4	52
5	3	2	1	2	×	2	2	2	2	3	3	4	5	6	6	5	4	52
6	3	2	1	2	2	×	2	2	2	3	3	4	5	6	6	5	4	52
7	3	2	1	2	2	2	×	1	2	3	3	4	5	6	6	5	4	51
8	3	2	1	2	2	2	1	×	1	2	2	3	4	5	5	5	4	44
9	2	2	1	2	2	2	2	1	×	1	1	2	3	4	4	4	3	36
10	3	3	2	3	3	3	3	2	1	×	2	3	4	5	5	5	4	51
11	1	2	2	3	3	3	3	2	1	2	×	1	2	3	3	3	2	36
12	2	3	3	4	4	4	4	3	2	3	1	×	1	2	2	3	2	43
13	2	3	4	5	5	5	5	4	3	4	2	1	×	1	1	2	1	48
14	3	4	5	6	6	6	6	5	4	5	3	2	1	×	2	3	2	63
15	3	4	5	6	6	6	6	5	4	5	3	2	1	2	×	1	2	61
16	2	3	4	5	5	5	5	5	4	5	3	3	2	3	1	×	1	56
17	1	2	3	4	4	4	4	4	3	4	2	2	1	2	2	1	×	43

Figure 4a-d: Extraction of the syntactic diagram and manual calculation of depth values (Thaler, 2020, 299)

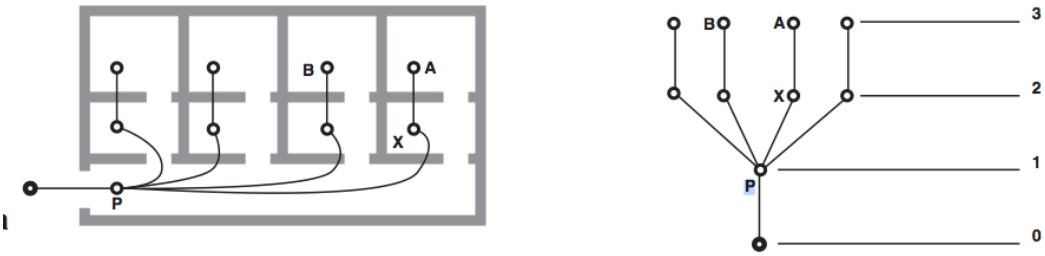


Figure 4e-f: Graph is justified with respect to "P". The respective depths of the individual spatial units from point P are shown (Bafna, 2003, p. 22).

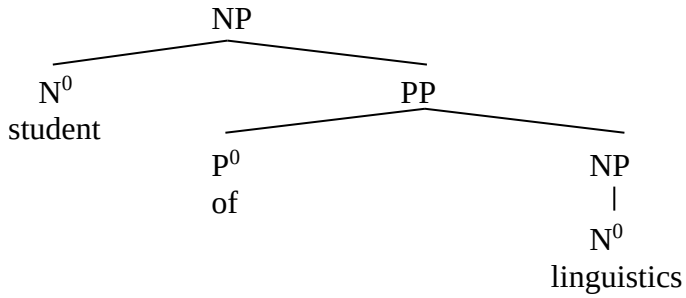


Figure 5: Syntactic structure represented in abstract tree form (Fromkin & Hyams, 2011)

The justified graph can be reconstructed to enable a given space to be located at the bottom –a position also called "root" or "carrier space"-. A "syntactic step" refers to the direct connection between a space and its immediate neighbors, -as in the immediate neighborhood of generative syntax theory by Chomsky (explained earlier in this chapter)- or between overlapping isovists (Klarqvist, 1993, p.11). The spaces that are found one syntactic step away from the root/ carrier space are placed on the first level, all spaces that are found two syntactic steps away from the root/carrier space are placed on the second level, and so on.

By implementing this technique, justified graphs provide a visual description of the total depth of a formation perceived –seen– from one of the spaces out of all the given spatial units. In a dendritically shaped justified graph – which has most of the nodes many levels away from the root space– the mean depth will be higher, and thus will be defined as "deep". On the other hand, a justified graph that has many nodes near the root node will have a lower mean depth; therefore will be labeled as "shallow" (Figure 6).

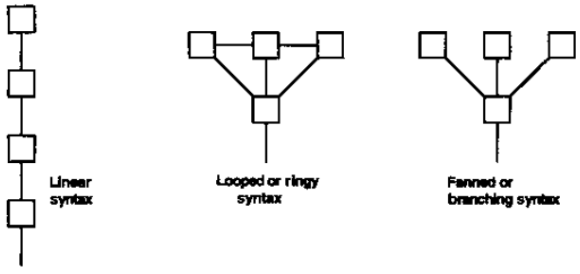


Figure 6: Representation examples for places of shallow and deep spatial organization in the syntactic tree (Dovey, 1999, p. 21). The effect of rings in the depth can be observed.

2.2.4 Basic Types of Spaces

As for the internal relationship and settlement of the spatial unit, route selection choices can be scrutinized first by defining the number of individually identifiable rings in the justified graph and the syntactic-dendritic system. While rings are the preliminary indicators of the internal relations in the structure, each room/ node/ spatial unit can also be labeled by both in terms of its connectivity (refers to the number of immediate neighbors of a specific spatial unit (Hillier & Hanson, 1984, p. 109) and immediate links with the other rooms/ nodes/ spatial units which are principally named as a-, b-, c-, d-, type spaces (Al Sayed et al., 2014, p. 14).

"a-" type of spaces demonstrate only a single edge (for example rooms that are called "dead end") and are accessible only through a single door and therefore highly controlled by other spaces within the structure. On the other hand, in contrast to the a-type spaces in the syntactic structure, b-type spaces compose the roots or the stems of the branches themselves. Mostly they are –at least- two-edged both physically and syntactically as they own local control over their environment to a certain degree although they have little to do with global control due to their limited linking system. Such a global control or contribution is a more common characteristic of c-type spaces which are defined as two or more edged nodes which comprise a part –more specifically a single piece- of a ring. Lastly, d-type spaces constitute both a part and a link between two or more rings resulting in being the main control and connection points in a spatial unit or a spatial system (Figure 7a).

The positioning of a, b, c, and d types of spaces within the local and global settings of the whole network can determine the overall spatial depth in a layout (Al-Sayed et al., 2014, pp.12-15).

A local increase in the number of a-type of spaces and a global increase in d-type spaces would consequently minimize spatial depth, creating an integrated system, while a global increase of b-type spaces and a local increase in c-type spaces are likely to lead to a maximized depth, resulting in a segregated system (Figure 7b-7c).

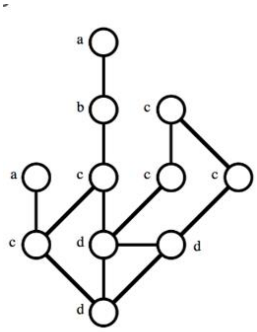


Figure 7a: Node types and ringiness: a-b-c-d types of nodes (Hillier, 1999, p. 249)

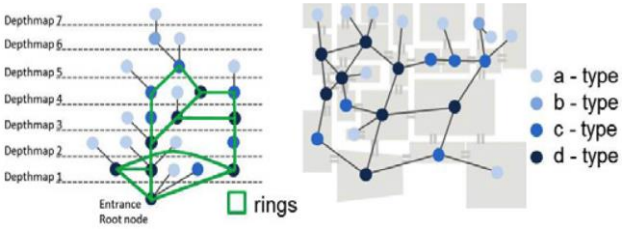


Figure 7b-7c: Node types and ringiness (Al Sayed et al., 2014, p. 14)

2.3 Basic Numerical Terminology

Such a categorization of spaces not only permits the notion of "connectedness" as a local property but also enables defining the "centrality" of a given space in comparison to its relationship with other spaces in a settlement or built environment as a global property. Global quality was later referred to as "integration" as a more broad term - upon doing sums- due to its importance in the analyses conducted through space syntax methodology (Figure 8a, 8b).

2.3.1 Relative Asymmetry (Integration)

According to the idea of integration, the spatial unit that is most easily reached from all other spatial units or rooms is the one that is integrated the most into the whole structure.

Figure 8a: Axial map of global integration of Hamedan (Hillier, 1999, p. 173)

Figure 8b: Axial map of local integration of Hamedan (Hillier, 1999, pp.172)

The most integrated space will be marked by the lowest sum, and the least integrated space will be marked by the highest sum of path lengths based on the path matrix sums done manually without a computer (Figure 4d). Based on the sums made by the path matrix average / the mean path length (mean distance, MD) can also be calculated. This calculation can be applied to every space in the system independent of the number of spaces in the structure. Later from the number of given spaces in a system, Hillier and Hanson stemmed a novel numerical measurement of "integration" which is referred to as "relative asymmetry" indicated by the following statistical expression:

$$RA = \frac{2 \times (MD - 1)}{k - 2}$$

This particular measure intends to compare and contrast various given points based on their theoretical depth and shallowness (Hillier & Hanson, 1984, p. 108; Thaler, 2020, p. 300). More specifically, the word asymmetry expresses itself by using 0 and 1 values which signifies the non-congruity of the actual and theoretically calculated possible depth. Whereas higher asymmetry denotes a less integrated space; relative asymmetry produces higher values for less integrated units while giving lower values for the well-integrated units. One important contribution of doing sums is also implied with the word "relative" because the terms asymmetry and integration are measured and evaluated considering the size of the system as relative asymmetry examines a room or a unit in relation to the whole building is found in.

Represented by Relative Asymmetry (RA) in statistical calculations: the designation RA compares how deep the system is from a particular point with how deep or shallow it theoretically could be. This is a theoretical way of normalizing mean depth. It is a global measure since it refers to the integration value of a system (Hillier & Hanson, 1984, pp. 108-109).

2.3.2 Choice Value

Similar to integration, the term "choice" is simply defined as the "set of shortest paths between any pairs of nodes within a structure" (Thaler, 2020, p. 305). In his glossary, Klarqvist 1993, p.12) defines "global choice" as a dynamic measure of the flow that occurs within the spatial units of the environment. Therefore, if a spatial unit is linking –or connecting- the other spaces of the same structure, with many large numbers of

paths, then the given space has a higher level of flow through it and it also has a strong choice value (Klarqvist, 1993). The term "betweenness" was also used as an alternative terminology (Al Sayed et al., 2014, pp. 114, 117; Turner, 2007, p. 540; Thaler, 2020, pp. 349).

2.3.3 Connectivity and Control Values

There are other numerical indicators of space syntax such as connectivity – which is a local measure. Control is also a local measure that is computed first by attributing – for each spatial unit- the correspondent of its connectivity to each of its neighbors. Then, the values assigned to each space are summed up which eventually gives the degree of control a place owns for enabling access between its immediate neighbors and the other parts of the network (Hillier & Hanson, 1984, p. 109; Thaler, 2020, p. 304).

As the predominant form of gamma analysis (syntax analysis) derives from a technique where spaces are converted into cellular-like structures (known as "syntax tree" in linguistics) by using the nodes and edges as the base. In the following figure 9, three different doorway positions resulted in three various syntactic representations. In a linear syntactic structure, since there is only one path enabling access from one room to another, there is no room for choice. However, the "ringy" syntactic representation is the exact opposite of the linear structure as it connects rooms or spaces to one another in multiple possible ways. A fan or branching is the structure that regulates the access of a set of spaces from a given space. Therefore, the branching or the fan serves as a corridor or a hallway.

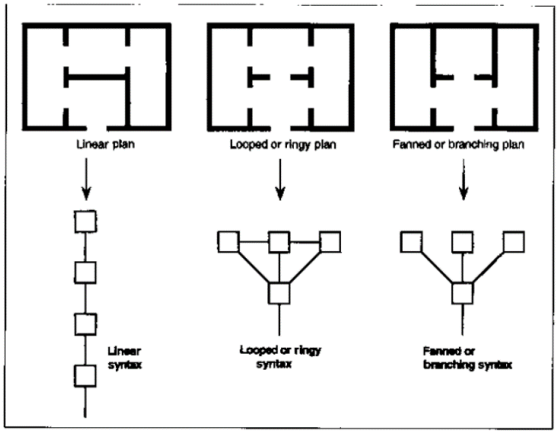


Figure 9: Varying connections in the same number of spatial units can result in different depths of the system (Hillier & Hanson, 1984)

2.3.4 Ringiness and Control

Another important aspect of gamma analysis is the level of "ringiness" and control. Thus, firstly "a ringy structure" will be characterized by its "multiple and lateral connections" which, thus, enable multiple alternative pathways passing through the ringy structure, and with its distributed control over the whole structure. It decides to what degree the spatial units in a given structure are interlinked through looping or ringy pathways in contrast to being governed through a syntactic system that is in a branched or linear structure. The linear –or the fanned- structure, on the other hand, is characterized by its control over the flow and inhabitant traffic in some specific places.

The level of "control" of a certain space is the extent to which access to other spaces –cells- can traverse it. Therefore, a foyer –or hall/ corridor/ entryway-, that stands as the only possible access to a set of places/ rooms is considered to have a high degree of control over daily life circulations. The linear structure described constructs a spatial exposition that owns high levels of control over all spaces or cells excluding only the cell that is the furthest from the root. The fanned structure enables access to many other sets of spaces from a single control space or level. On the contrary, the ringy structure –or the looped structure- proposes several possible pathways which in turn offer a loosely controlled circulation of life within the space, (Hillier & Hanson, pp. 102-104.

Space syntax formulates two fundamental kinds of social relations: the social relations between inhabitants of the space (power dynamics or social order), and the social relations between the inhabitants and visitors (Hillier & Hanson, 1984, p. 147). The domestic spaces that are segmented based on age and gender in the western cultural context can be provided as an example of the relationship between inhabitants. However, the domestic spaces also enable certain kinds of relationships between inhabitants and visitors in common places such as dining areas and family areas. On the other side, these spatial divisions are not easily interpretable as the higher level of dissection brings about raised the amount of crime rates such as sexual assault as well as domestic violence due to the isolation from social circles.

Another important element of space syntax theory is the level of depth to which the visitors are allowed to enter within the given structure (Hillier & Hanson, 1984, 165-

167). In general, the deeper spatial units of the structure were populated by the controllers –or inhabitants- while the shallower spaces were occupied by visitors. Thus, the power dynamics could be defined in the deeper cells of the linear structure. Such customary power centers evolved into a spatial exposition through which visitors were guided. Overall, inhabitant depth was an implication of status as well as the depth to which visitors were allowed to penetrate.

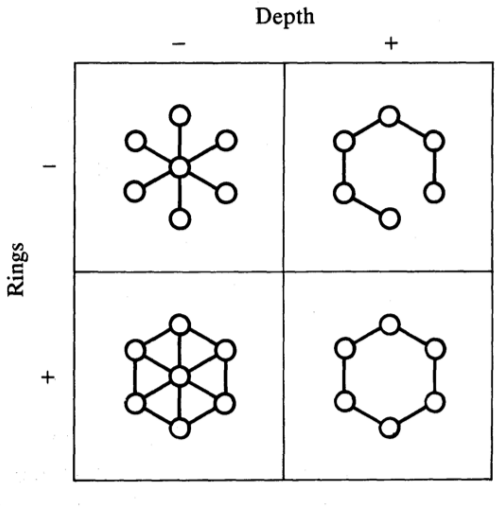


Figure 10: Correlation between ringiness and depth (Hillier et al., 1987, 363-385)

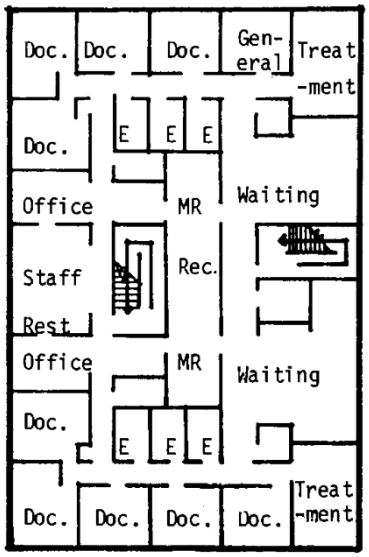


Figure 11: An example of a genotype plan for a health center (Hillier et al, 1984)

2.3.5 Genotypes

As spatial discourse has its roots in "representational critique", it has circumvented an extended social organization of architectural space such as social structures -or organizations- are invisible (Hillier & Hanson, 1984; Dovey, 1999). Thus, Hillier and Hanson intended to disclose those deeper socio-spatial organizations and structures, namely, the "genotypes" of architecture. Since genotypes are not considered formal types or archetypes of architecture, the definition of the term genotype has always been a subject of discussion in architecture. Rather than complying with the traditional or formal archetypes, they can be defined as sets of spatial fragments formed within the "syntactic rules of sequence and adjacency" (Hillier & Hanson, 1984; Dovey, 1999). Genotypes in archaeology are both conventionally and epistemologically ingrained. Therefore, spaces like factories, schools, working areas, libraries, and domestic areas, are reconstructed from a certain number of spatial structures, namely genotypes, each of which is connected to a particular social architecture in terms of knowledge and

construction. In their book "Social Logic of Space" Hillier and Hanson (1984, pp. 143-147) accounted for the term genotype within this framework.

Table 1 (Below): The remainder of the numerical terminology compiled from "Social Logic of Space" (Hillier & Hanson,1984; UCL Space Syntax (2022)).

Numerical Indicator	Syntactic description	Explanation	Indication
k	Number of cells	Number of nodes in syntactic representation of a space	the size of building or settlement in spatial sense
Depth	Step depth(distance) of selected node from the carrier space	Generalized term for if axial or convex segments were either many or few steps – thus deep and shallow- from the carrier or the buildings.	Refers to the number of other spaces that have to be passed through in orc to reach it from the carrier space. Depth refers to a numerical value within defined system of certain hierarchical level.
TD	Total Depth	Sum of depths between all the nodes in a j-graph	sum of step distances to be used to calculate mean depth. It is a numerical value to be interpreted in a mathematical statement to acquire meaningful data
MD	Mean Depth (Distance)	Arithmetic mean of the sum of depths	Mean depth of a system from the carrier. Indicates a statement for overall depth of single system
RA (Integration – a global value)	Relative Assymmetry	comparison how deep the system is from a particular point with how deep or shallow it theoretically could be	**Integration.** This is a theoretical way of normalising mean depth. It is a **glob measure** since it refers to the integration value of a system
E (Control – a local value)	Control measure	Control is a local measure, calculated by assigning, for each space, the reciprocal of its connectivity to each of its neighbours and then summing up the apportioned values for each space; it is taken to capture the degree toa which a space controls access from other parts of the network to its immediate neighbours. Measures how many spaces a space gives access to.	Each unit partitions one unit (of accessibility?) among its neighbours and getting acertain value back from them. Values below 1 are weak control val and above 1 are strong control values for a space. It is a local value since it refers to the control value of a space within its immediate neighbours.
RRA	Real Relative Assymmetry	Normalized RA values to compare systems of different sizes. (Compares the RA value of a particular space with the RA value for the root – the space at the bottom of a justified map – of a diamond-shaped system.)	This value is a formalization of Relative Assymmetry to be mathematically comparable within a number of spatial systems.
R	Ringiness	Ringiness measures the number of rings (or circuits of possible movement) in the system as a proportion of the maximum possible rings for that number of spaces. Increasing the ringiness of the system will increase the distributedness both of the complex as a whole and of those points within it affected by the rings.	Ringiness is identified by the number of possible islands formed by the nod of a spatial system. Defines the distributedness of a system. Distributednes means the properties purely generated by the arrangement of a number of equal, individual cells rather than, for example, by the superimposition of a single superordinate cell on those cells.
RR	Relative Ringiness	The relative ringiness of the complex will be the number of distinct rings over the maximum possible planar rings for that number of points in the complex. The relative ringiness of a point (RR of) in the complex will be the number of independent rings that pass through that point over the maximum that can pass through it	Distributedness of the structure from a certain space, the Relative Ringiness of that space is calculated. In other wo this RRindicates a nodespecific ringiness value in statistical sense.
D_x P_x	D value (for Diamond Shaped graph) P value (for Pyramid Shaped graph)	"Diamond shaped" signifies justified map in which there are k spaces at mean depth level, k/2 at one level above and below, k/4 at two levels above and below. Presents a symmetric structure when the j-map is (horizonally) divided from the MD levelIFor a syntax tree. Used in the calculation of RRA. D-value is the mathematical expression of how close a shape is close to the ideal diamond shaped structure thus symmetrical. "Pyramid shaped" signifies the assymmetric structure of syntactic tree contrary to the "Diamond shaped" term.	Related to assymmery that is calculated as Relative assymetry. D-value or P value aims to transform RA to fit RRA to compare spatial systems of differe sizes depending on the structure of syntacitic tree.

2.3.6 Convex Maps

Earlier it has been pointed out that the rooms of a given building are referred to as nodes while the doors are referred to as the corresponding edges; moreover, any set of meaningfully linked spatial units can be analyzed through configurational network analysis. However, space syntax analysis mainly deals with the "convex spaces" (Thaler, 2020, p. 301). A convex space is simply described by Thaler (2020) as "an area whose perimeter is not intersected by the connecting line of any pair of points within it". Similarly, a convex space is also defined by Klarqvist in his *A Space Syntax Glossary* as "…a space where no line between any two of its points crosses the perimeter…" (2013, p. 11).

Based on the definition of convex space, mathematically, "…a concave space, thus, has to be divided into the least possible number of convex spaces…" (Klarqvist, 2013, p. 11). Edges, on the other hand, are refined based on adjacency, or the correspondence of part of the border of two given spatial units (Thaler, 2020, p. 301). A convex map is meant to represent the least number of convex spaces which are in the position of

entirely occupying a layout and the existing connections between them. There is another special kind of convex map demonstrating the “permeable” associations between the external convex spaces and the building entrances they are adjacent to (Klarqvist, 1993, p.11).

2.3.7 Axial Maps

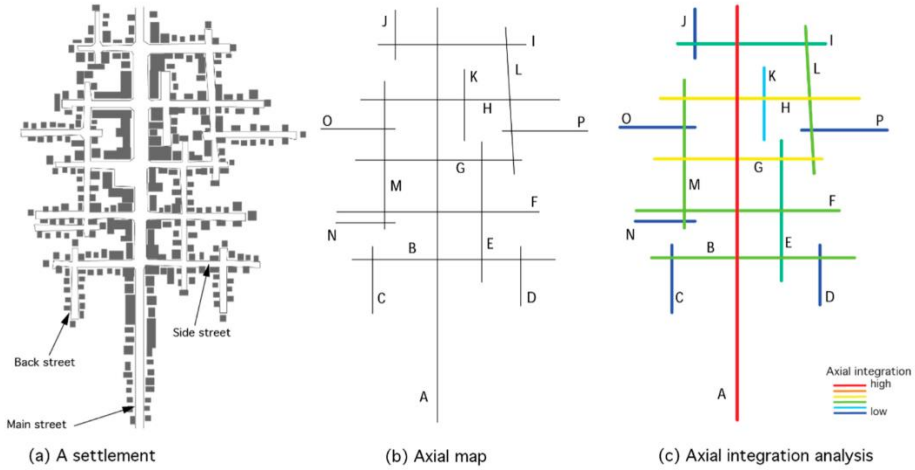


Figure 12: An example of an axial map (Yamu, 2021).

The set of “fewest and fattest” convex spatial units which takes up the whole accessible space within a built environment - which is the formal definition of a convex break-up - are crucial for clarifying another set of nodes and edges. These kinds of the set of edges and nodes are expressed as axial break-ups or axial maps (Thaler, 2020, p. 301). In the glossary of Klarqvist (1993, p. 11) an axial space or axial line is defined as “…a straight line…” ("sight line"), possible to follow on foot. According to Thaler’s description (2020, p. 301), these kinds of nodes and edges constitute the “…smallest set of longest lines of sight it covers…”. In other words, they reach all of the convex spaces in a given built environment moreover it replicates the rings within the given spatial unit (Figure 4b). If the axial lines are regarded as nodes of a network, then the intersections they form will compose the edges (Figure 4c). By the time the axial break-up map is formed and defined by following the above-described methods, other maps and matrices can also be formulated (such as a j-graph (Figure 4f), path matrix and numerical indicators of spatial properties can be calculated as done above for the convex spaces).

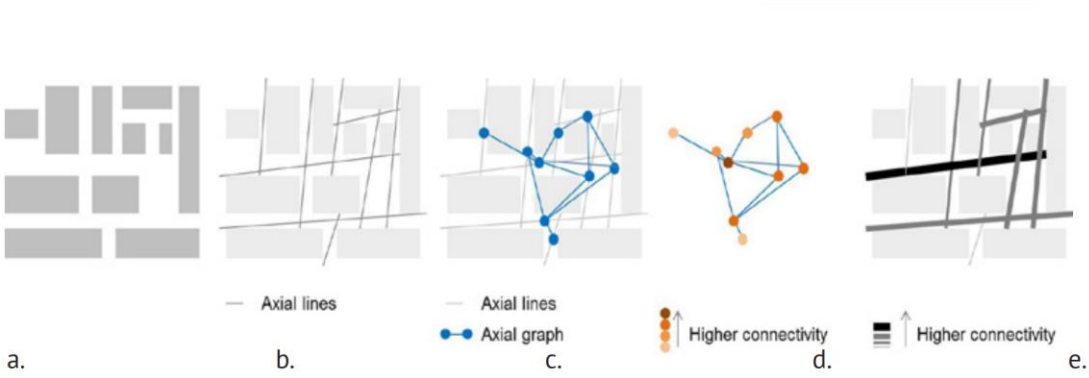


Figure 13: Extraction of axial lines in a spatial system (Al Sayed et al, 2014, pp. 15)

Formerly, there was a proposed connection between "…axiality and movement, into and through the system…" and "…convexity and the system's organization from the point of view of those who are already statically present in the system…" (Hillier & Hanson, 1984, p. 96; Al Sayed et al., 2014, p. 15; Thaler, 2020, p. 302).

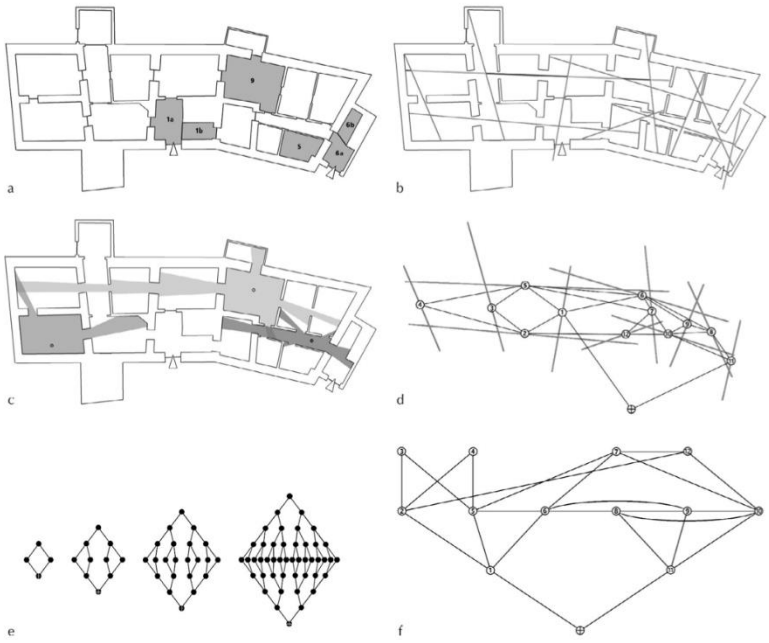


Figure 14: Symmetry exemplified in the syntactic representation of a system (Thaler, 2020, p. 155)

In reality, although the two views potentially suggest logical and meaningful outcomes both at the settlement level and building level; convex space analysis has a wider application area at the building level while the settlement level tends to deal more with the axial analysis. That might be one of the reasons why axial analysis methods and techniques witnessed further advancements in the space syntax community when the significance put on urban planning is considered (Thaler, 2020, p. 302).

2.3.8 Isovists and Visibility (VGA)

An isovist was introduced into the field by Michael Benedikt (1979) for the first time in the field of space syntax. Benedikt defined an isovist as "…the set of all points visible from a single vantage point in space considering an environment…". Isovist or viewshed can simply be described as a spatial unit in a built environment that is directly visible from a specific point (Figure 6a-b) (Al Sayed, 2014, p. 29). An isovist map is explained as "…a map depicting the areas that are visible from convex spaces or axial lines…" (Klarqvist, 1993, p. 11). The spatial/physical properties of the visibility field can be assigned to the point with its special geometrical characteristics (such as area and length of the perimeter, bound by a polygon, etc.). An isovist field is defined as a visual record of what can be seen in a 360-degree or 180-degree view from a given point (Hillier, 2001; Yamu, 2021). Furthermore, a graph can be formed by connecting the given point with the other points. This is not the only way to construct a graph; it can also be created by taking a specific area or spatial unit into consideration (such as a convex space) to demonstrate the visible range from a specific point. In addition to these two techniques, an isovist graph could also be produced by taking a façade as the defined point and then showing the space that is visible from the defined façade.

Another technique to draw isovists can be implemented through the examination of regular intervals indicating the user experience of spaces. Isovists employing the path layouts traced by the most or least used points of the origins to other certain destinations are broadly referred to as the "Minkowski Model" (Figure 15) (Al Sayed et al, 2014, p. 29).

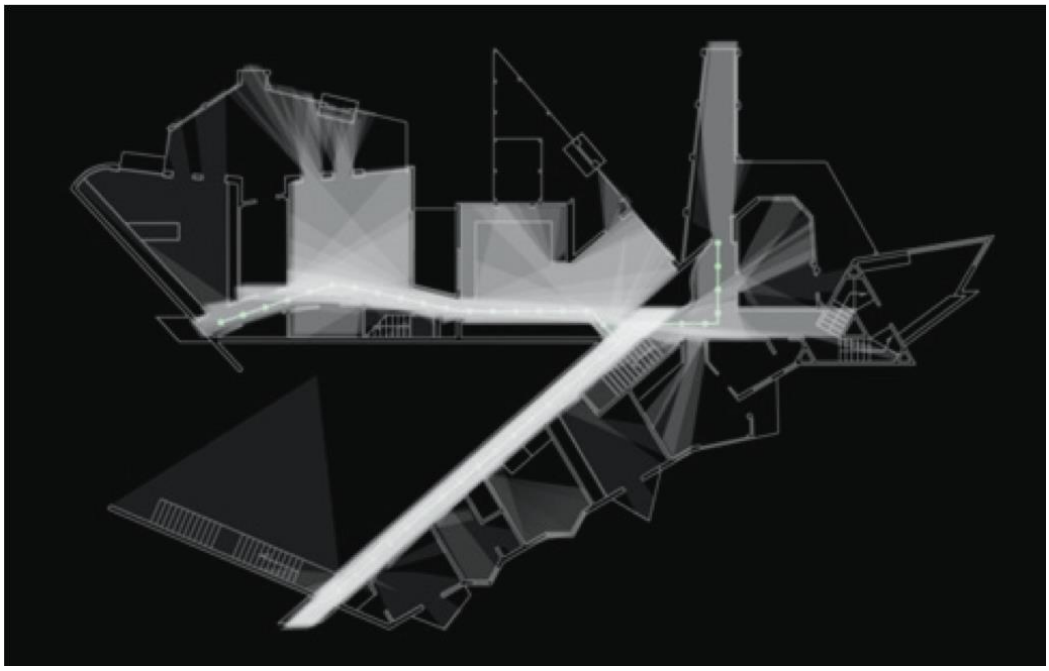


Figure 15: Representation of visible space in isovist map (Al-Sayed et al, 2014, p. 30)

2.4 An Outline of Space Syntax and Its Aims

In “Space Syntax” 1976 the intentions of the space syntax research is defined as “developing an effective model of the knowledge-field constituted by architectural and urban space patterns” that are explained with three provisions to employ:

- match between the model and the empirical evidence;
- the internal consistency of the model within its own limited syntactic terms;
- the possibility that man-made systems involving patterns of relations may require this syntactic level of formal analysis (Hillier et. al., 1976 p. 149.).

Through this publication, it is possible to observe that the initial concern is the consistency of the defined system within its own terms rather than mathematically appropriate definitions. This approach steered the proposed model from adoption, to the development of a morphic language that provided these three provisions.

In Hillier et. al. (1976), various aspects and similarities in the structure of languages and spatial organization are explored and the possibility of a consistent model for spatial analysis based on linguistic principles -that rely on mathematical logic- of syntactic structure is discussed.

In *Social Logic of Space: 2 Logic of Space,* the minimal aims of the space syntax model are defined as "…-to find the elementary structures of the system of interest; -human spatial organization in all its variability; -to apprehend these elementary structures in some kind of notation or ideography, in order to escape from the difficulty of always having to use cumbersome verbal constructs for sets of ideas which are used repeatedly; - to show how elementary structures are related to each other to make a coherent system; - to show how they may be combined together to form more complex structures…" (Hillier & Hanson, 1984, p. 52) From these statements the possibility of constructing a consistent system that encapsulates the interrelations of spatial elements was associated with the elimination of the problem of expression which relies on the deficiencies of language -prepositions and such.

As discussed earlier, in structural linguistics, phrase structure analysis, and Chomsky's generative syntax, a morphic language requires its elements to be defined in a context-free manner while keeping the flexibility to capture possible relations of its elements by providing a simple interface. The intentions of space syntax research and the provisions of structural linguistics are consistent as space syntax research relies on the explanation of spatial relations as a morphic language and fundamental problem of definition and proposing a system of consistency of definitions are suggested to be explained in a morphic language that defines, spatial units, their network relations and quantification under one simple method in a comparable sense.

However, the existing geometrical primitives (i.e. physical measurements or ratios) were found to be less related to behavioral characteristics -of inhabitants/constructors- and through the early research of space syntax and contributed less to the comparability of proposed structures. Therefore, the space syntax focused on the connections that construct the network of spatial relations to define the basic spatial units.

The definition of space in a flexible sense of logical terms permitted the application of the method independently of scale or context. Description of an urban spatial order by use of similar systematic approaches -defining the streets and open spaces as primary spatial units (nodes) and their connections as links- provided the possibility of measuring the relative centrality of individual streets or specified spaces in the system.

The concepts such as centrality, connectedness, and isolation shared the same flexibility as they are relative and defined regardless of their context while allowing the interpretation of social context -without any prior knowledge of their forming factors such as social history, land use, economy, and such -in quantifiable statistical terms (Hillier & Raford, 2010).

After examining the logical characteristics of a built space complex in mathematical terms, the "function" can be extracted through the proposed structural logic. Function -which is a determining factor for a space's sociality/social use- of a space in such a system can be defined by the configurational values that explain that space with the other spaces of the network that can be presented in a mathematical expression (Hillier & Raford, 2010).

These configurational values have been refined and developed since the introduction of space syntax. The primary factor that helps shape configurational values is the notion of privacy. Hillier and Hanson (1984, pp. 167-170) suggest that the social space consists of spatial units that can be categorized by their level of privacy and syntactic relations. The main assumption is treating individual streets and open spaces as nodes, and the connections between them as links therefore it is possible to measure the relative centrality and effect of any street within the network.

Hillier's book *Space is the Machine* (1996), Hillier expands his discussion by converting his modernist analogy of architecture as a "machine for living" and by using this argument as an analysis of reflections of spatial organization on social conduct. His ideas have been increasingly adopted in application practices such as "programming of large built environments, urban design and crime control (Dovey, 1999, p.25).

The cellular analysis makes it possible to decide on the precise measurement of structural features of a given spatial unit. Although conventional power centers can be regarded as straightforward, quite a few modern buildings represent an apparent division (Dovey, 1999, p.25).

The space syntax approach belongs to the emerging methodological developments of Durkheimian scholarship. Equipped with space syntax tools scholars may, for the first

time, quantify the “non-discursive regularity” (Hillier, 1996) of space as a “social fact”, and thus systematically examine this exterior and restraining “thing” as an agential force that shapes dynamic densities and social life (Liebst & Griffiths, 2020, p. 222)

In its course of development, space syntax methods were subject to criticism from various aspects including epistemological limitations, determinism, and its explanation of morphological transformations and their social implications (Netto, 2016, p. 26). Other critics include a wide range of subjects from the deficiencies in mathematical logic to Durkheimian socio-spatial interpretation.

One of the most significant publications that critically evaluate the space syntax methods in the field of archaeology came from Leach. According to Leach, the results collected by implementing the space syntax analyses are made coherent and comprehensible only through analogous explanations of the potentially adverse effect of undefined culture-specific implications within the space analyzed with space syntax applications (Leach, 1978; Pearson & Richards, 1994; Fladd, 2017, p. 128). Therefore, the representative characteristics of the spatial units –and the architecture of the built environment as a whole– are likely to be neglected in the process of converting this entity into a graphic form (Osborne, 2012; Fladd, 2017, p.128).

Ratti (2004, pp.1-2) draws attention to the deficiencies of a former version of space syntax analysis software- in the interpretation of the geometrical qualities by omitting metric data and 3rd dimension (urban fabric and height of structures). Ratti (2004) also questions the limitations of space syntax analysis on a regular grid plan. Hillier & Penn (2004) respond to these concerns by comparing similar examples with minor differences and emphasizing that digital space syntax applications provide consistent results but to be improved in certain ways such as sensitivity to detailed variations along lines. While Ratti focuses on a technical aspect of space syntax application, the philosophical and semantic concerns about the assumptions behind the social use of space and neglecting the time dimension have more weight in the criticisms concerning space syntax research especially when the subject space requires historical sensitivity.

Netto (2016, p. 25) concentrates on some of these limitations summarized as "…the reduction of social practice to movement; human interaction to social interfaces and encounter; the actor to bodily presence…". This approach stresses the consideration of syntax over semantics, therefore, function over culture. This publication also includes a comprehensive outline of space syntax methods with the limitations explained in various aspects.

Griffiths (2011, p. 92-93) points out a similar contrast and focuses on the limitations of space syntax in historical research stressing the isolated nature of space syntax's theoretical basis of spatial description. Griffiths depends on his criticism on the preference of synchrony over temporality and proposes an enhancement in the statistical/theoretical definitions that could cover the historical sensitivity. An additional critique is mentioned in Liebst & Griffiths (2020, p. 222) which locates space syntax in structuralist-functionalist Durkheimian sociology and exemplifies the theoretical deficiencies in the sociological background of the theory.

In the archaeological context, Morrow's (2009) study focuses on the limitations of space syntax application in fragmented built spaces accentuating the risk of forced interpretations on obscured cognitions of ancient minds and advocating the use of space syntax analysis as a "tool to think with" rather than a direct result or interpretation, inspired by Cutting (Morrow, 2009, p. 5-7; Cutting, 2003, p. 18-19).

This thesis will execute axial integration analysis for global, r3, and r2 levels to examine accessibility patterns, and segment choice and integration analysis to examine movement potentials and route selections at the local level for 1000, 800, 400, 250, and 100m radii.

CHAPTER 3

ARCHAEOLOGICAL PERSPECTIVES ON SPACE SYNTAX

Space syntax tools have been employed in archaeological and historical studies since their introduction in 1976. This chapter will focus on Classical and Roman archaeological studies carried on while overviewing the prominent works that influenced the approach of archaeology to space syntax.

Several publications include brief overviews and references to exemplify archaeological approaches to space syntax (Thaler, 2020; Morrow, 2009; Stöger, 2011; Fladd 2017; Assassi & Mebraki, 2020; Fredric & Vennarucci, 2021). Among these Stöger (2011), and Thaler (2020) follow a similar approach and include summaries concentrating on European approaches mentioning a clustering between quantitative and qualitative approaches while Morrow (2009), Fladd (2017), and Assassi and Mebraki's study summaries tend to focus on the new world archaeology.

From Stöger (2011, pp. 46-49) and Thaler (2020, pp. 324-327) it can be observed that the conventional main concerns of archaeology to use space syntax for providing an additional perspective, integration of spatial dimension, providing a syntactical framework to organize complementary data sets and similar deeds. Thaler (2020) and Stöger (2011) both mention the "toolbox" approach which was defined by Batty (2004, p .3) exemplifying Fairclough (1992) that attempts to demonstrate the potential resourcefulness spatial syntactic analysis of medieval complex high-status buildings' social function; Chapman (1990) that compares space syntax and architectural dimension data to demonstrate social dynamics in Chalcolithic Bulgaria and Gilchrist (1994) which utilized functional spatial analysis of medieval religious houses to demonstrate permeability of gender, Foster (1989) an access pattern analysis to shed light on Scottish Atlantic Ironage social structure. From these Fairclough (1992) which is a status over subjective analysis using spatial and formal data to provide social

function and Cutting (2003) an access analysis on Çatalhöyük and Hacılar to demonstrate space syntax's use in the interpretation of limited archaeological data, are also mentioned in Thaler (2020) to exemplify the qualitative aspects of the analysis. These works tend to use and modify the j-graphs to interpret the social aspects of built environments.

Another significant work, Fisher (2009), attempts to improve certain deficiencies of space syntax tools regarding the integration of symbolic aspects of buildings. In his attempt to develop his "Integrative approach" the main concern was to understand the means of non-verbal communication provided by the built environments (p. 455) Fisher attempts to incorporate the encoded meanings (like decorative elements, and artifacts that shape social relations) and their influences on inhabitants, visitors and their interactions using the mathematical base of access analysis on the case of Ashlar Building (LBA,1650-1100 BC) in Enkomi, Cyprus (Fisher, 2009). In this study architectural spaces are classified by their effects on perception derived from E.H. Hall's *The hidden dimension* (1966) which studies personal space in relation to its qualities defined by human perception. Geometrical interpretations and decorative elements are attempted to be integrated into the access analysis with the aim of reconstructing contexts of social interaction in this integrative approach. Fisher uses a similar methodology on two buildings in Kalavasos and Alassa Paliotaverna taking into account the social meaning of architectural elements, furnishings, and artifacts in the context of daily practice to explain social transformations (Fisher, 2014).

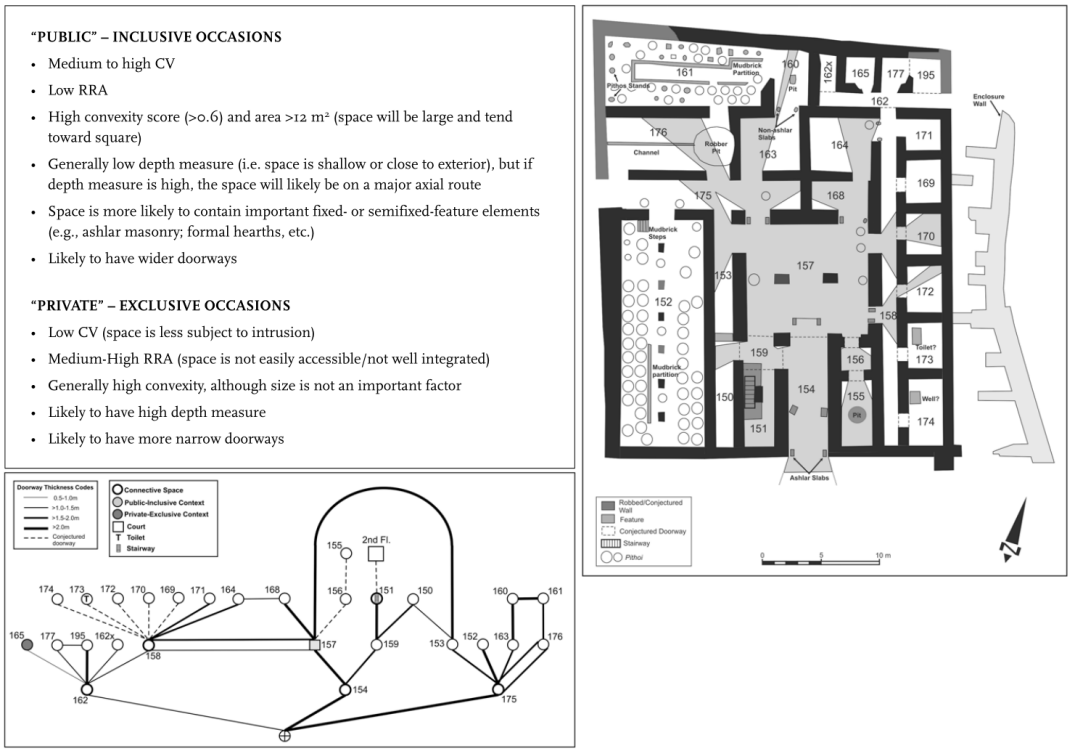


Figure 17: Top: architectural and syntactic correlates of public and private social interactions (left), schematic plan showing isovist field from central court Bottom: j-graph demonstrating the syntactic structure (Fisher, 2014, pp. 172, 176, 177)

Stöger's dissertation (2011) mentions several studies in the *Space Syntax and Archaeology* chapter. From these Laurence (1994), Fridell et al. (2003), Newsome (2009) and van Nes (2009) concentrate on the street network while Anderson (2003) and Grahame (2000) concentrate on the domestic aspects of Pompeii. Stöger draws attention to van Nes (2009)'s contributions such as the integration of micro/macro scale statistical data sets, agent-based modeling, and analysis based on the comparison of interrelated factors such as density of movement, topological context, and land use with contemporary urban context using Depthmap software. Derived from the contemporary empirical studies, van Nes (2009, pp. 101-102) bases his study on the assumption that macro-scale street and road network analysis clues information about economic clustering, spatial arrangement, and property values thus the crime rates distribution while micro-scale analysis like the number of direct connections to a street indicates the degree of social interactions between visitors and inhabitants.

Another mentioned study is Benech's analysis which uses geophysical data from two building blocks of Doura-Europos to interpret characteristics of domestic space and organization of public and private spaces and compares the results with the excavation

data for confirmation. This study is significant as it promotes the use of space syntax tools on non-invasive geophysical datasets (Benech, 2007) (Stöger, 2011, p. 33).

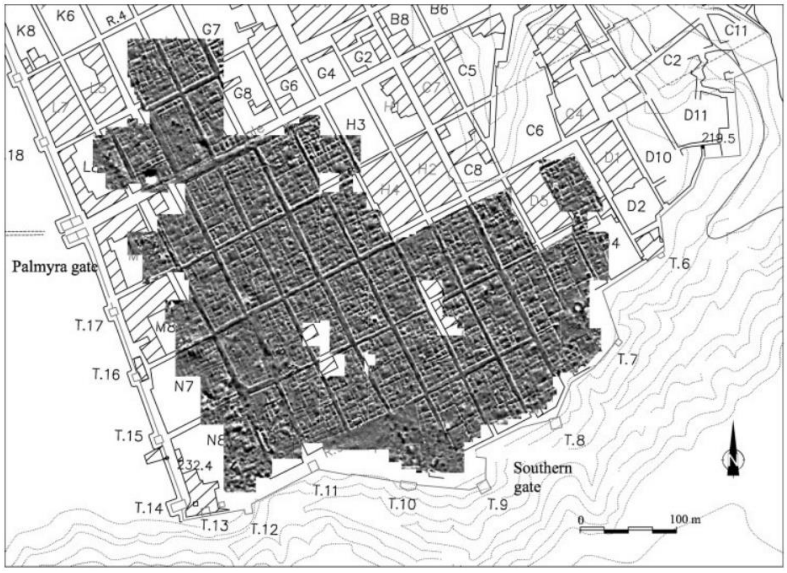


Figure 18: Geomagnetic map of the southern part of Doura-Europos (Benech, 2007, p. 91)

Figure 19: Hypothetical division of the space inside a block (left) and distribution of courtyards and reception rooms (right) overlayed on a magnetic map for Doura-Europos (Benech, 2007, p. 100)

In the "Roman Urban Studies" chapter of her dissertation, Stöger (2011) mentions several studies case by case with their influences on each other and space syntax-related research on archaeological context. Grahame (2000), Laurence (1994), and

Kaiser (2000) discussed to give an outline of the methodological approaches that integrate space syntax in archaeological research.

Grahame (2000) is a study on the Roman domestic space that uses sample data from 144 Pompeian houses to compare their layouts and explain relations with sociality. The access analysis data is used to challenge the traditional conceptualization of domestic space which suggests standardized patterns of interaction. Grahame used spatial values to extend access analysis to approximate potential social encounters for each room, concluding the dissimilarities in the house layouts are produced within their individuality. According to Grahame, this condition indicates heterogeneity thus a social hierarchy. Connecting these with the localized power among the various layouts Grahame carries on the interpretation to the urban level suggesting these irregularities stem from the heterogeneous nature of the society in Pompeii. While his study demonstrates the potential of space syntax, his omission of cultural data and sole reliance on house layouts was subject to criticisms (Stöger, 2011, pp. 28-30)

Laurence (1994) attempts to address the social functional interpretation of the Pompeii urban space that is neglected in earlier historical and archaeological work. Laurence's approach employs comprehensive data from historical, literary, and archaeological sources. The concentrations of workshops, commercial activities, inns, brothels, architectural elements, and the number of doorways on a street interpret street activity through the urban network. While the first five chapters are more reliant on qualitative observations, chapters 6 and 7 integrate statistical approaches. The 6th chapter presents an analysis of street activity based on the number of graffiti and the doorways to the street fronts. Concluding that an increase in doorway and graffiti numbers indicate higher street activity and integration (Laurence, 1994, pp. 73-81; Stöger, 2011, pp. 30-32). The 7th chapter concentrates on the interrelations of buildings, insulae, and the streets. Laurence uses space syntax in building, insula, and street levels to identify a correlation between the depth of buildings and the number of doorways that opens to each street. According to the results, a lower number of doorways are present with the segregated buildings and high numbers with shallow buildings that are more integrated with the street front. These correlations are also compared region by region to observe to quantify the regional correlations inside the urban space (Stöger, 2011, p. 33). The chapter 8 is significant for introducing a time dimension retrieved from literary sources

to interpret what parts of the neighborhoods or streets were in use and how the spatial network organized the public interaction between inhabitants/visitors or different social strata through certain intervals of the day. Laurence assumes that daily usages define a temporal framework that constrains the use of urban space and therefore affects the level of social interaction depending on the fraction of day (Laurence, 1994, pp. 3-4) (Laurence, 2005, pp. 69-77).

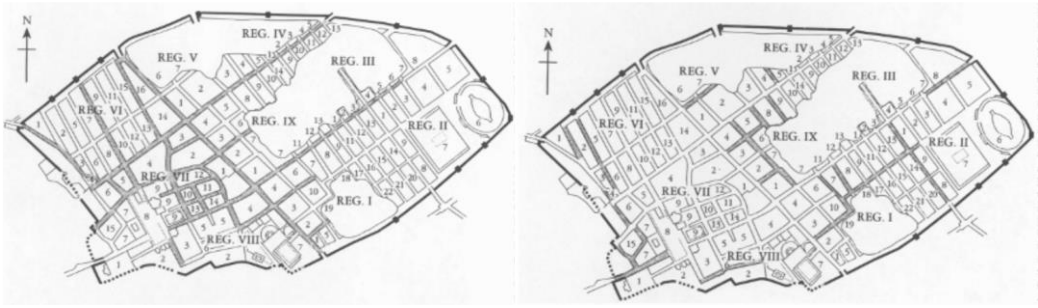
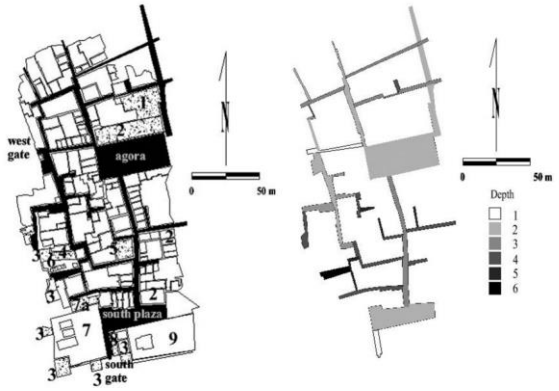


Figure 20: Occurrences of doorways within 0-5m radii (left) and 6-10m radii (right) for Pompeii as presented in "Organization of Space in Pompeii" (Laurence, 2005, p. 70)

Kaiser's study, like Laurence's, employs a set of data from an archaeological context, literature, and space syntax on Empuries to challenge the earlier views of Roman urban land use. According to Kaiser, the former studies tended to adopt Raper's (1977) thesis. In Raper's conclusion urban land use in Pompeii did not provide evidence for a structured urban space which conventionally led to the assumption that Roman urban land use is un-structured. Kaiser challenged this opinion utilizing a similar methodology to Raper in a different site: Empuries. Raper's approach was based on the frequency count of the twelve certain object categories in connection with the building forms and placing them on a uniform grid system using the existing map. On the other hand, Kaiser's methodology improves this with several contributions: formulating the object categories considering Vitruvian literature based on function instead of form, using GIS-based statistical applications, and explaining the social implications of urban space from the perspective of inhabitants and visitors. (Stöger, 2011, pp. 33-35). This allowed him to group similarly functioning buildings together and make intra-site comparisons to find distribution patterns among these structures and relate these with social structure.

Another part of his study was "the nature of streets" that examines movement and social interaction by executing analyses of "on-street" activity, land use along the

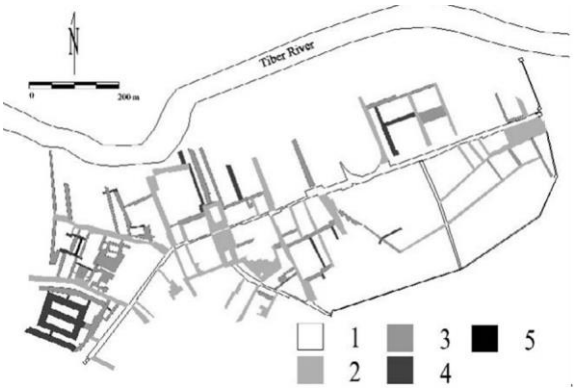
street fronts, and space syntax. Kaiser utilizes various space syntax tools to determine resident-resident and resident-non-resident relationships in Empuries. Reasonably, the interaction between residents and non-residents is expected to occur in the most integrated places (shallow depth in the syntactic sense) while the less integrated places (higher depth values) provide more privacy to the residents from outsiders. Kaiser evaluated these values of the street network with the earlier categorical distribution analysis of land-use along street fronts he acquired by using RRA (real relative asymmetry) values from space syntax and calculated integration values for defined streets in relation to remaining streets of the urban network. Additionally, Kaiser used the control values to examine whether a street facilitates or impedes movement in the city. The comparison between the distribution of land-use categories and control values revealed a correlation between commercial parts of the street network and control values (Stöger, 2011, 39-40) which can be interpreted that commercial streets also serve as control points for organizing access to more residential areas.



Architectural Category	Examples of Structures	Number of Observed Examples
administrative	stoa, storage rooms for military equipment	7
commercial	shop (*taberna*), market building (*macellum*), warehouse (*horrea*)	64
entertainment	—	0
health-related	bath, fountain, well, public cistern	5
production	kiln, forge, *garum* workshop	9
religious	temple, ritual sleeping place (abaton)	7
residential	elite house, nonelite house	35
unknown	—	20

Figure 21: From left: The general plan, depth from gates, categories for architectural units for Neapolis as presented in Kaiser (2011, pp. 172, 176, 179)

Kaiser's other contribution is the *Roman Urban Street Networks* (2011) which examines four cities (Pompeii, Ostia, Silchester, and Empuries) using similar categorizations following the buildings' functions and identified prioritizations to the movement potentials of the street and public spaces in coordination with remote sensing techniques while limiting his use of space syntax tools to depth values from city gates and forums for each city. In this work Kaiser aims to extend the knowledge about Roman urban space and support his criticisms about the earlier Roman urban studies led by Raper's work (Kaiser, 2011, pp. 84, 122, 154, 179, 199-205).



Street Depth from City Gate	Category of Structure													
	Commercial		Health		Religious		Residential		Administrative		Entertainment		Production	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
1	280	168	6	5	17	7	36	42	1	1	1	0	2	4
2	381	402	11	12	12	15	77	101	5	2	0	1	6	9
3	285	320	4	9	10	12	84	80	0	2	0	0	13	8
4	68	119	9	4	0	5	51	30	0	1	0	0	3	3
5	0	5	0	0	0	0	6	1	0	0	0	0	0	0
Total	1,014	1,014	30	30	39	39	254	254	6	6	1	1	24	24
Chi-square Probability (%)	4^{10-20}		5		0.045		0.0000002		—		—		27	
Comments	*Statistically significant results*								*Not statistically significant results*					

Figure 22: A map showing the street depths from city gates (top) and architectural categories in comparison with the street depths (bottom) for Ostia from Kaiser (2011, pp. 117, 119)

Stöger's dissertation (2011) is an urban and structural scale study that combines tools and concepts of space syntax and classical approaches of archaeology including surveys and field observations. Following the introductory chapters concerning the research history of Ostia, the Roman urban research history, and archaeological use of space syntax, Stöger explains the methodology in chapter 4 giving details from the technical background of her study to digital tools and technologies and their utilization in the enhancement and processing maps and their integration with the databases in clear terms (Stöger, 2011, p-51-66). Reconstruction and examination of Insula IV ii and its development between the 2nd and 3rd centuries are explained in the 5th chapter. This chapter approaches insula IV ii as a spatial entity on its own and approaches the buildings as forming blocks of a neighborhood with their spatial relations. Insula's spatial relations with the public space through the street network are examined after addressing the 14 buildings of the insula individually (Stöger, 2011, pp. 67-155). The organization and spatial assessment of Insula IV ii are discussed in detail in chapter 6. Following subchapter 6.3 three space syntax tools are executed to explain three types of spatial relations on and between the building blocks that form the insula: access analysis to examine potential interaction points for each building, axial analysis to examine movement patterns between the buildings using relying on the shortest paths that connect the space and lastly visibility graph analysis to express the movement

potential. Additionally, an agent-based simulation based on the visibility analysis is applied to demonstrate the density of movement inside the insula. (Stöger, 2011, pp. 163-195) 7th chapter employs these three types of analyses on Ostia's street network to explain the movement economy. Visibility analysis was used to define the densely visible parts of the city and compare them with the architectural markers to explain the role of inter-visibility in urban cohesion. (Stöger, 2011, pp. 223, 227) Chapter 8 again uses the same space syntax tools to define a possible relationship with the movement economy and location of the guild buildings. In addition, the correlation of RRA (Real Relative Asymmetry) and control values were used to interpret where the most significant social interaction took place considering the location of the guild buildings (p. 249-253). Stöger's more recent works on Ostia develop the study further with insula IV iv (Stöger, 2015).

Figure 23: A map showing Ostia urban layout with the excavated areas and insula iv (top), a global axial integration graph (bottom) for the Ostia street network (Stöger, 2011, p. 214)

Weilguni's dissertation (2011) uses the distribution of doorways to interpret street activity, depth analysis at the building level to identify building functions, comparing these to investigate the interface between public and building spaces and movement axes and how the interface regulates the interaction of inhabitants and visitors exploring space syntax tools' possibilities. The study concludes with the limitations of space syntax and limitations of archaeological nature that affect the analyses in concern.

From the more recent research, Cujipers (2016) employs a methodology in line with Stöger on the site of Olynthos. Cujipers use access and visibility analysis to interpret movement through the city's street network. As for the microanalysis and distinction between the public and private space uses the doorway counts and segment length of street networks in a similar manner with Laurence.

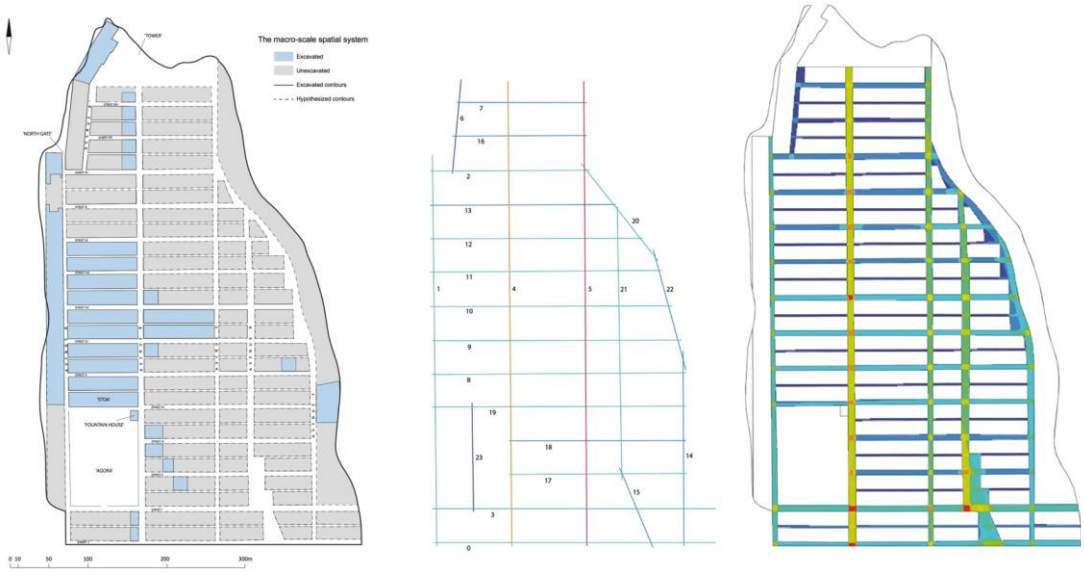


Figure 24: From left to right: Spatial system, axial analysis, isovist analysis for Olynthos street network (Cujipers, 2016)

Fredrich & Vennarucci (2021) is reminiscent of Fischer's 2009 publication which utilizes the visibility analysis and perception elements to investigate the meaning behind the location of artworks and how they influence movement inside the buildings and space syntax analysis' correlation with the conducted experiment on movement. This study attempts to measure space syntax tools' predictive power by conducting an experiment in which data from 45 human subjects are tested against 4 scenarios and 3 house layouts to modifying space syntax, concluding that space syntax analysis

showed a weak correlation with the actual human movement patterns in a structure in this experimental context, however provided a potential probability for these movements (Fredrich & Vennarucci, 2021, pp. 192-194, 217-218).

From these research, it is possible to observe that there is a tendency to combine the archaeological, architectural, geophysical, urban data and even experimental sets with the space syntax tools to improve consistency while overcoming the limitations of archaeological data and space syntax tools themselves.

CHAPTER 4

THE CASE OF MILETUS

4.1 The Location and History of Miletus

Miletus was a coastal town on the western coast of the Aegean region in Anatolia, close to the mouth of the Meander River now located 5km north of Didyma close to the present village of Balat. Miletus was located on the coast, as a result of the silting of the Meander River, it is now approximately 10km far from the sea (Sacks, 2005).

Miletus was located on a peninsula with three extensions in north-northwest directions on the southern side of the now -extinct Latmos Gulf in the southwest of ancient Ionia. These extensions provided four natural harbours to the city according to Strabo (Gorman, 2020, pp. 3-4) (Akurgal, 1978, p. 206). Around 2500 B.C. the settlement consisted of a group of islands. In the following years, the silting from the Meander River developed and resulted in the merging of the islands to form a peninsula (Brückner et al., 2014a).

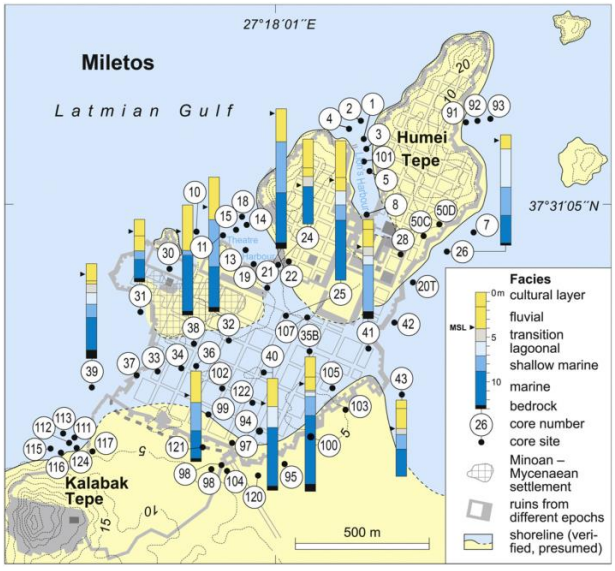


Figure 25: The Milesian archipelago in 2500 BCE (Brückner et al. 2017, p. 884)

It is assumed that the first settlers of Miletus were part of a migration movement from mainland Greece to Ionia around the 12th-11th centuries B.C. (Cartledge, 2011, p. 46). In the first half of the 7th century, the settlement developed around Kalabaktepe. In the mid-7th century, Miletus was affected by the Cimmerian raids and later the expansion of the Lydian Empire (Cobet, 2002). After the fall of Samos -the only autonomous Ionian city-state that resisted Persian occupation- the leading role passed to Miletus which was a semi-independent city at the time. Encouraged by the success of Miletus' fleet against Darius' Scythian campaign around 513, the city was led into the Ionian Revolt in 499 by the tyrants which resulted in the destruction of Sardis and Miletus (Akurgal, 1978) and deportation of the high number of inhabitants. However, there is evidence that supports the continuity and repopulation in Kalabaktepe (Cobet, 2002).

In the following decades after the destruction of Miletus, the Persian fleet was neutralized by Greek and Ionian fleets in Mykale in 479 B.C. and Delian Maritime League formed in 478 B.C., and the cities kept their autonomy until its dispersion in 412 B.C. which resulted in the Persian rule over these cities until the conquest of Alexander the Great in 334 B.C. (Akurgal, 1978, p. 207).

During the Hellenistic period, Miletus retained its independence through treaties with Tralleis (212 B.C.), Mylasa (209 B.C.), Pidasa (188 B.C.), and Herakleia (185 B.C.) that strengthened its position with its rivals & neighbors, Magnesia and Priene (Cobet, 2002). After the collapse of Alexander’s empire, the city remained independent until 133 B.C. Pergamon kingdom was donated to Rome and Miletus became a part of Asia province. Miletus was prosperous as a Roman city and new buildings were built where Jewish and an early Christian communities existed simultaneously. (Ohrloge, 2022)

Miletus had already been in contact with Rome before its victory over the Seleucid Antiochos III at Magnesia in 190 B.C. and was favored in the peace settlements of Apameia in 188. With the year of the secular celebration in Rome in 17 B.C., a new list of eponyms began in Miletus with Augustus (Cobet, 2002)

In imperial times, Miletus was a wealthy city but did not have any privileges like its opponent Ephesus which was the provincial capital of Asia Province. The city fortifications were rebuilt in 262 A.D. as protection against the Goth's invasions. In the 4th century, the majority of the city became Christian and paganism faded (Greaves, 2005, p. 138, Ohrloge, 2022).

The (northern) gate of the southern Agora became the southern city gate of a greatly reduced city area under Justinian in 538 (Cobet, 2002). In the 7th century, a Persian invasion was followed by Arab armies and led to the construction of additional walls which reduced the urban area again (Ohrloge, 2022). The Byzantines built a fort above the theatre in the 7th/8th century, and in the 12th century the theatre hill was walled in its entirety; this part of the city was named Palátia. Miletus was the seat of a bishop until the 14th century (Cobet, 2002). From the beginning of the 14th century, it belonged to the Seljuk emirates first of Aydin, then to that of the Menteşe of Milas. At this time Miletus was a river port with trade connections and a Venetian consul (Ohrloge, 2022). Venice had maintained factories there since 1352; İlyas Bey, as Dominus Palatie, concluded treaties with Venice in 1403 and 1414. The harbours had long since silted up, but the antiquary Cyriacus of Ancona, as Scriba Minor on an Alfieri merchant ship, still reached the port of Palatia at the Ancient Theatre harbour in 1412 via a canal (Cobet, 2002).

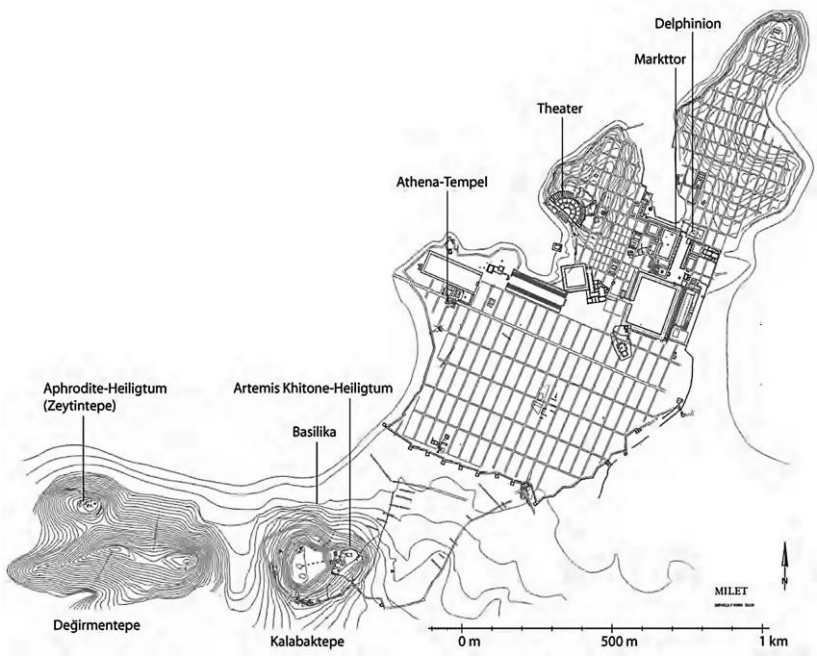


Figure 26: Location of Zeytintepe, Kalabaktepe, and main structures of the central area of Miletus (von Graeve, 2008)

4.2 Excavations in Miletus

The first archaeological investigations in Miletus were carried out in 1873 by the French archaeologist O. Rayet. However, systematic research of the ancient city did not begin until 1899 under Theodor Wiegand, who was commissioned by the Berlin Museum to uncover the basic features of the city and a large part of the public buildings in the city center until the First World War (Senff, 2002)

Wiegand's objective was to illuminate the aspects between the Archaic and Middle Ages. Most of the artifacts were related to the Hellenistic and Roman Periods. In 1955 when Gerhard Kleiner took over, the excavation carried on with a focus on the Mycenaean and archaic periods of the city, additionally, the work included some restorations of late antique and early medieval buildings uncovered by Wiegand. Wolfgang-Müller Wiener - Istanbul German Archaeology Institute director at the time (Akurgal,1978, p. 205)- succeeded in the excavations from 1975 to 1988 bringing the focus on the Hellenistic sanctuaries, also evidence of the prehistoric settlement uncovered in this course.

Volkmar von Graeve carried on the research focusing on the archaic city. The evidence from Kalabaktepe and Zeytintepe drew attention to the archaic urban area and settlement of Miletus after the 494 B.C. catastrophe and in the 1990s a series of surveys concentrating on the urban area has been executed with geophysical studies (Stümpel & Erkul, 2008) which unveiled buildings, division of streets, and insulae (Ohrlogge, 2022). These studies yielded important results on house architecture, craft workshops, defense installations, and sacred buildings. The discovery of the sanctuary of Aphrodite, located to the west in a suburb in Kalabaktepe, complements the picture of the supra-regional relations of the former commercial metropolis through a large number of finds (Senff, 2002) Philipp Niewohner carried on the excavations between 2012 – 2016 with a focus on Byzantine City. Since 2018 the excavations are directed by Christof Berns (Ohrlogge, 2022).

4.3 City Plan of Miletus

The city plan is presented as the main source of the data that will be used to extract the organization of Miletus' urban street network for space syntax analysis. This part aims to give an outline about the city plan of Miletus and its development in the history of research.

Berthold F. Weber (2007) gives a detailed history of the various stages in the development of the city plan of Miletus from the initial sketches in the late 19th century. The first city plan of Miletus was created by Carl Humann and Friedrich Freiherr Hiller von Gaertringen in June 1891 (Weber, 2007, 328). This plan included the topography with the contemporary course of the Meander River, the location of the village of Balat at the time, the hills Zeytintepe, Değirmentepe, and Kalabaktepe in the southwest and the Humeitepe in the northeast, the buildings from the Emirate period and the visible ruins of the ancient city in 1:5000 scale. This was followed by Theodor Wiegand's 1901 plan which was based on the original plans from Humann with additions of the sacred gate, parts of the north agora and main street, Bouleterion, and Capito baths. The complete stadium, the temple of Athena with the broad east-west street to the south, parts of the hall of the Muses of the Faustina baths, Delphinion, Harbour Gate to the west and a tangent street to the east, the harbour hall at Lion Harbour and the large harbour monument, was presented by Theodor Wiegand in 1905. This plan was improved by additions of the missing parts of the north agora, Justinian walls to the east of Faustina baths, hall of the muses, quay walls of the Lion Harbour, and the great church in the 1906 plan. The 1908 publication of the city plan was based on the 1905 organization plan, following improvements took place: the city area was enclosed in the north by the former course of the Meander and contains a detailed drawing of the theatre, the Apodyterion of the Faustina baths, Capito Baths, the Ionic Hall, the Hellenistic Gymnasium, the hall square west of the North Agora and the Great Church (Weber, 2007, p. 327-331).

One improvement in the progress of the city plans is the attempt to reconstruct the insula system in the northern part of the city which can be seen in Wiegand's 1911 publication of the city plan. In 1924, the site plan appears with the complete reconstruction of the assumed insulae grid. In his 1940 publication, Wiegand mentions

that this plan presents the last century B.C., thus does not include the thermal baths, the Serapion, the Ionic Hall, the Harbour Gate, Heroon III and Nymphaeum, and the theatre appears as the one prepared for the Hellenistic period (Weber, 2007, p. 332). Another important point is that this division of the street system is based on the length of Athena Temple located in the south of the western agora resulting in almost "square shaped" insulae which are dissimilar to the proposed insulae of the northern part (Weber, 2007, p. 332-337). von Gerkan's 1935 plan captures all the past excavations of its time. This plan includes the large thermal complexes, the Nymphaeum and the Heroon III, the wall that remains in the center of the southern part, and the Justinian wall that restricts Miletus city center and theatre hill without including the Islamic structures of later centuries (Weber, 2007, p.338).

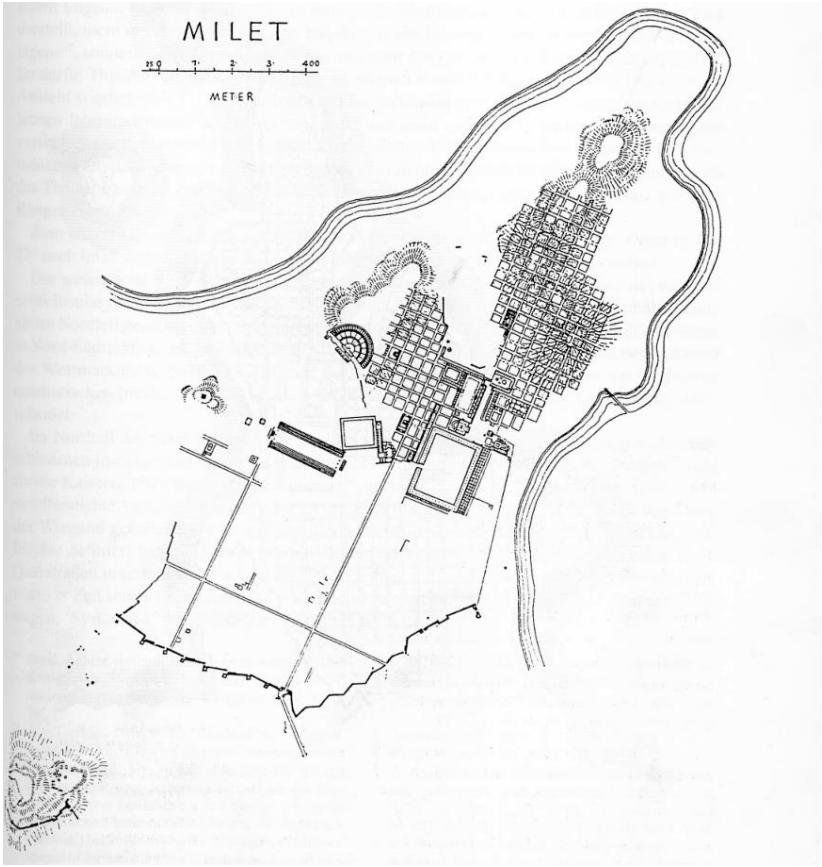


Figure 27: 1911 plan by Theodor Wiegand which includes the suggested reconstruction of the street grid (Weber, 2007, p. 335)

The islamic structures are covered in another plan under the title *Das islamische Milet* by Karl Wulzinger in 1935. This plan was based on the thermal baths on Humeitepe which results in a rectangular insula form (Weber, 2007, p. 338). It can be said that the

shape of insulae had been in debate since its proposal. In the following years, Wurlitzer published a plan that relies on the rectangular insulae that was on a remark made by von Gerkan in 1928 with the size of 52.93 m x 28.30 m which he (v. Gerkan) recognized as the Milesian normal island size (Weber, 2007, 338). After the war, a topological survey was conducted by Walter Bendt in the urban area of Miletus between 1959- 1964. His published a plan that includes all the buildings published until its time including Byzantine and Emirate period buildings (Weber, 2007, 339).

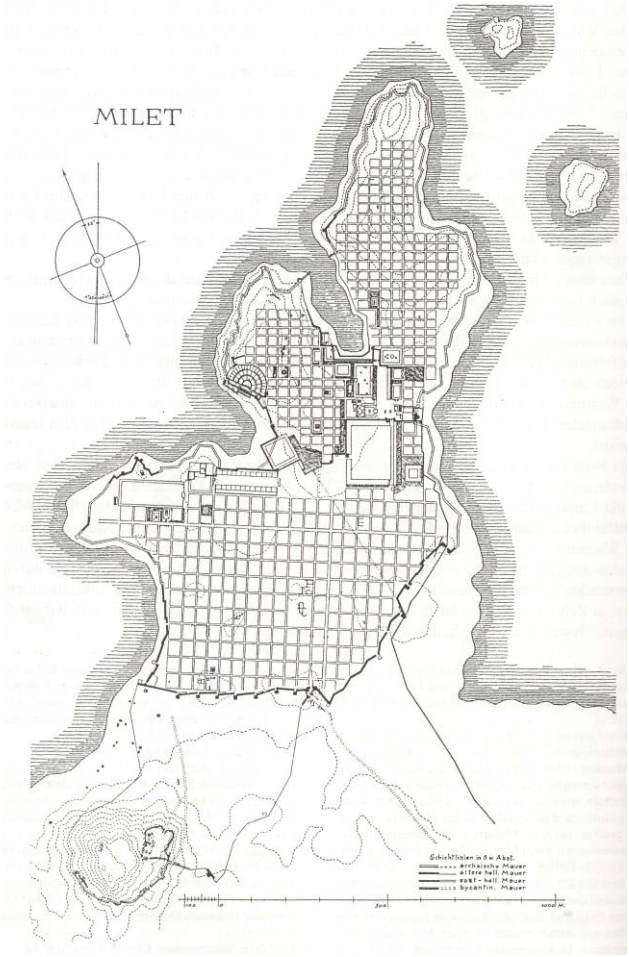


Figure 28: Armin von Gerkan's 1935 plan (Weber, 2007, p. 338)

In 1970, Walter Voigtländer's 1967 plan was published, this plan is based on the plan Armin von Gerkan presented in 1935. The hypothetical extent of the Mycenaean settlement in the vicinity of the Temple of Athena and Stadium Hill had been newly entered. Another important addition is the shortening of the magazine hall in the east-west direction that ends at the road that was uncovered in the south of Buleuterion to the Theatre Harbour (Weber, 2007, 341)

Volker Rödel's 1980 plan was also based on Walter Bendt's topographical map that shows earlier settlement bases of Miletus. In 1986 Wolfgang Müller-Wiener presented the *Lageplan der archaischen Fundund Grabungsgebiete* which is the first attempt to reconstruct the Archaic city plan including the coastline changes in the south-east of the city. The same year Wolfram Hoepfner attempted a reconstruction of the plan of the newly laid out city in 478 B.C. (depicting the period following the Persian invasion) based on the 1935 city plan of von Gerkan, assuming that the classical city wall surrounds the entire area from the northern end of the Humeitepe to the southern slope and strip-shaped open spaces divided the city into individual residential quarters designed independently (Weber, 2007, pp. 343-345).

Manfred Klinkott conducted and analysis on the grid, space, and visual connections of Miletus. His analysis is based on the assumption that the public buildings could have been erected on the inner-city open spaces without external planning constraints and concludes that the conception of the routing of the public buildings along the Holy Street (ger. *Prozessionsweges*, referred to as "Processional Street" in this thesis), follows the principle of diagonal lines of sight, even the deliberate asymmetry. However, the exterior lines of the public squares and buildings are almost exclusively integrated into the street system even if their dimensions are usually far greater than the size of a normal insula, and some streets are built over, the street system also provides the outer planning framework for the inner-city open spaces (Weber, 2007, 345).

1998 plan is based on von Gerkan's city plan (1935) and adopts his insula system again however it uses the ground plans taken from the topographical map by W. Bendt. This version contributes to the Miletus plan even if the Hellenistic Heroon on theatre hill was deformed contrary to the excavation results. Additionally, the partly explored, partly reconstructed city walls along the coast, were omitted to extend Gerkan's insula system beyond the city limits there. The "course of the coast in antiquity" proposed here, however, cannot be justified historically or topologically and renders the Theatre Harbour useless (Weber, 2007, p. 346). More recent geophysical and palynological studies (see Stümpel & Erkul, 2008; Brückner, 2017) improved the data related to the condition and transformation of shoreline with the silting processes and provided a more clear definition of the coastal areas and environment of Miletus.

4.3.1 The Street System in the Northern and Southern parts

The resemblance of the alignment and the dimensions of the classical Delphinion and the Heroon III, which was extended to the north, were the basis for the reconstruction of the street system in the northern part of the city presented in this area. The distance from the northeast corner of the Heroon III to the southwest corner of the Dionysostemenos measures 58 m, which is sufficient for a division of the area into an insula (50.27m) and two transverse roads with a 4m width. These specifications of the street system also comply with the excavated buildings in the west of the Bouleuterion and can be developed with insulae divided into four plots. The extension of the same insula system can be reconstructed, starting from the Delphinion, to the east of Processional Street. This assumption can be confirmed by the location of the baths on the Humeitepe, even allowing the road system to be continued to the northern tip of the hill. The orientation of the Temenos wall of the Demeter temple is consistent with this information (Weber, 2007, p. 353).

There is a shift of axes between the eastern and western parts of the city (respectively Delphinos Quarter and Dionysus Quarter – the latter is located in the west of North Agora) when the insula system is developed with the same dimensions. The existence and significance of the Dionysus cult are evident in the four construction phases that precede the Hellenistic temple's construction. Hypothetically this building might be the reason for the shift in the street grid. Additionally, the east-west oriented street on the south of the Delphinionis seems to have determined the planning of the street system in the west of the Lion Harbour. This street was overbuilt by Northern Agora and the adjacent hall in the Hellenistic period. (Weber, 2007, pp. 351-353).

The excavation work at the beginning of the 20th century around the Temple of Athena revealed a street system in the southern part of the city that is designed independently from the northern part which was reconstructed approximated square insulae by von Gerkan. This was changed by the geophysical prospections conducted by Herald Stümpel first of which is executed in 1997. The results showed rectangular stripe-like insulae laid in a north-south direction with approximate dimensions of 36 m x 90 m which is consistent with the common archaic dimensions (Weber, 2007, pp. 355-357)

4.3.2 Urban Armature of Miletus

Miletus is located on a peninsula and its armature is formed respectively with its bays. Miletus is surrounded by four harbours: Theater Harbour in the west, Lion Harbour in the north, Athena Harbour in the southwest, and eastern harbour according to Strabo. In addition to these, recent studies uncovered another harbour in the north of Humeitepe after extensive geophysical studies (Brückner et al., 2014a). Miletus was mainly reached through these harbours and from land. The "Sacred Way" provided access to the city from the Sacred Gate which is the southernmost entrance to the city. Most of the main public structures were built in the Hellenistic period and reused/ expanded in the Roman period. The three agoras of the city are constructed considering the bay areas. The Processional Street is assumed to be the most central area in the Roman period. Lion Harbour was connected to the Processional Street, which was surrounded by the Northern Agora, Capito Baths, Ionic Stoa, Gymnasium, Bouleuterion, Nymphaeum, and newly constructed Northern Gate of the Southern Agora via the Harbour Gate. The Theatre Harbour vicinity accessed from another prominent street where the Theatre, Faustina Baths, and Stadium were located on. The older Athena harbour area was the last of the central locations of the city which included the 5th-century B. C. Athena Temple (Graeves, 2005, p. 138 ; Uğurlu, 2004, p. 68).

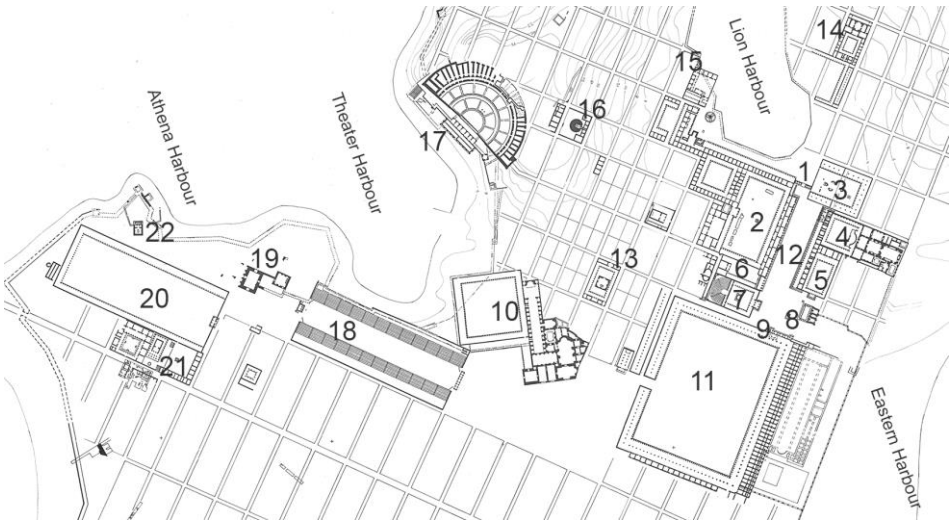


Figure 29: Structures of Roman Miletus: 1. Harbour Gate; 2. Northern Agora, 3. Delphinion; 4. Capito Baths, 5. Gymnasium, 6. Sanctuary, 7. Bouleuterion, 8. Nymphaeum; 9. Northern Gate of South Agora,10. Faustina Baths, 11. South Agora, 12. Processional Street, 13. Roman Heroon, 14. Humeitepe Baths, 15. Synagogue, 6. Hellenistic Heroon, 17. Theather, 18. Stadion, 19. Roman Bath, 20. Western Agora, 21. AthenaTemple, 22. Hellenistic Heroon

4.3.4 Geophysics Studies and Recent Publications

Von Graeve (1993) describes the objective of the surveys in 1992 as to extract a plan of artifacts in the surrounding areas of Miletus. In light of this projection, a series of geophysical prospections were executed in the following years (Stümpel & Erkul, 2008). The initial geophysics research was conducted in 1994-1995 to determine the location and dating of the archaic city walls. The study aimed to identify the connections between the visible city walls that surround Kalabaktepe with the rest of the city walls. The geophysical prospections supported the assumption of the presence of city walls for the rest of the city to the north. The new evidence was supported with drills (von Graeve, 1997).

The geophysical prospections were carried out by Herald Stümpel in 1996 concentrating on the Lion Harbour, Hellenistic city walls in the southwest of the Athena Temple, and the archaic walls located on the northern slope of Kalabaktepe (von Graeves, 1999). In 1997 the geophysical studies on the amount of debris from the Persian invasion and the original form of Kalabaktepe were attempted to be determined, the depth of the Lion Harbour was defined as 20m and the Archaic city walls were located in the west of Kalabaktepe (von Graeve, 2002).

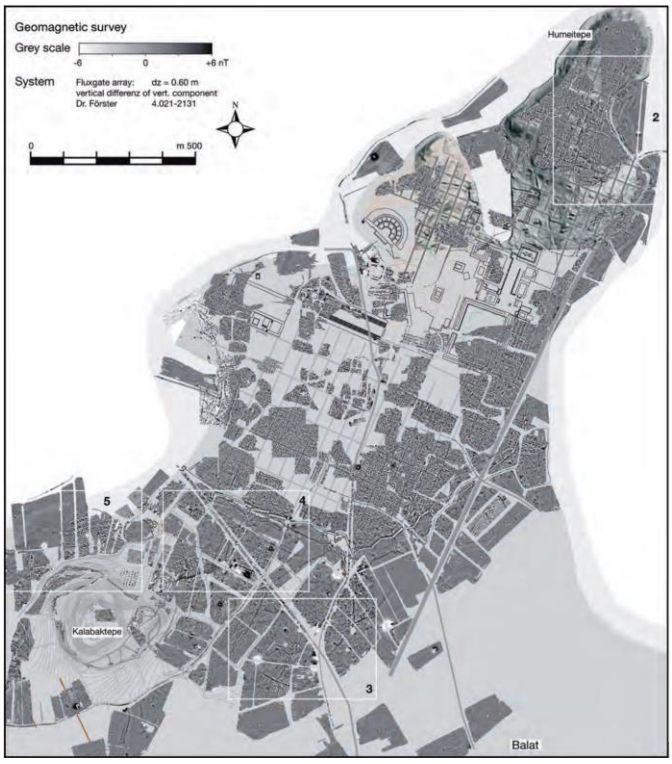


Figure 30: The results of geomagnetic surveys between 1997-2003 in Miletus (Stümpel & Erkul, 2008)

In the year 2001 eastern slope of Humeitepe was measured from the central area to the northern end of the peninsula and the Temenos walls of the Demeter temple are located. In 2003 a significant measurement showed that the insula size in Humeitepe is valid for Kaletepe (located in the north of the theatre see figure 17. Additionally, measurements were taken in the Faustina Baths' infrastructure and through the direction of the sacred road in the southern part of the city (von Graeves, 2005).

The location and plan of the Basilica were uncovered in 2004. On the western part, a structure was detected that lies in the north-south direction. City walls have been detected in the west of Stadion hill closer to the western bathhouse. In 2005 geophysical prospections were conducted in the northeastern part of Humeitepe, between Kalabaktepe and late Hellenistic city walls and south of Kalabaktepe in front of the walls. Also, another harbour was detected in the east of Humeitepe by geomagnetic measurements. Evidence of a harbour complex has been observed in front of the city walls that surround the bay. Additionally, some evidence was observed for the continuity of the street system in the southern part of Kalabaktepe (von Graeve, 2007)

Geomagnetic surveys conducted between 2003-2005 supported the presence of an additional harbour area on the eastern edge of Humeitepe (Bumke & Tanrıöver, 2017, p. 133)

Through the geophysical surveys conducted in 2007, a building complex in Kalabaktepe Arthemis Chitone Sacred area and under the Faustina baths a wall structure from the former periods has been detected (von Graeve, 2010).

Through the timeline of recent and past geophysical studies, almost all of the surrounding area and the peninsula of Miletus city are covered and the objective of extracting the city plan of Miletus city has been carried on with archaeological surveys, coring samples, and excavations. The recent publications use geophysical data combined with multidisciplinary approaches to address a wide range of research questions.

Geophysical studies focused on Kale Tepe in the north of the theatre in 2013. The underlying settlement pattern of the Byzantine period was proposed by Philipp

Niewöhner and developed further to expand the Byzantine settlement history using quantitative methods on evidence from stratigraphy, pottery, anthropology, coins, and palynological research conducted (Niewöhner, 2015; Niewöhner, 2016a). These studies were supported by the former geophysical studies and improved with coring samples and archaeological surveys. Niewöhner (2016b) developed the analysis spectrum further to uncover a cave sanctuary (with a wide range of pottery from archaic to late antique) below the theatre by use of geo-radar and geo-electric in addition to the geophysical studies that included geo-magnetic analysis.

On the Lion Harbour and other Harbours (Brückner et al., 2014a) is one of the significant works with a focus on the harbours of Miletus. This study uses the results of the geophysical studies along with the philological evidence, historical accounts, former palynological studies, and the data from coring samples for demonstrating the geoarchaeological potential of Miletus. This study includes a historical timeline of Miletus and examines the sea level changes and the silting processes that transformed the shoreline to build a new profile for the gates of Lion harbour from archaic periods and seeks to identify the location of commercial harbour "Emporion" and the slave market. (Brückner et al., 2014 pp. 50-56-65, 71). Another publication from Brückner explains the land formation and silting processes that transform the geography of Miletus and Ephesus with supporting evidence from coring samples (Brückner et. al, 2017).

Figure 31: Humei Tepe and the Lion Harbour with topographical relief and superimposed magnetic map including the proposed insula system (Brückner et al. 2014a).

Bumke & Tanrıöver's *The Humeitepe Harbour in Miletus. Results of the Excavations in 2011* contributes to the geophysical studies with archaeological surveys and excavation results that focus on one of the harbour gates and a near building located in the eastern bay of Humeitepe, dating the architectural and ceramic finds to the late Hellenistic - early imperial periods with the supporting ceramic data. This indicates extensive usage from the Hellenistic period which together signal underlying structures are related to commercial usage in the harbour area (Bumke & Tanrıöver, 2017).

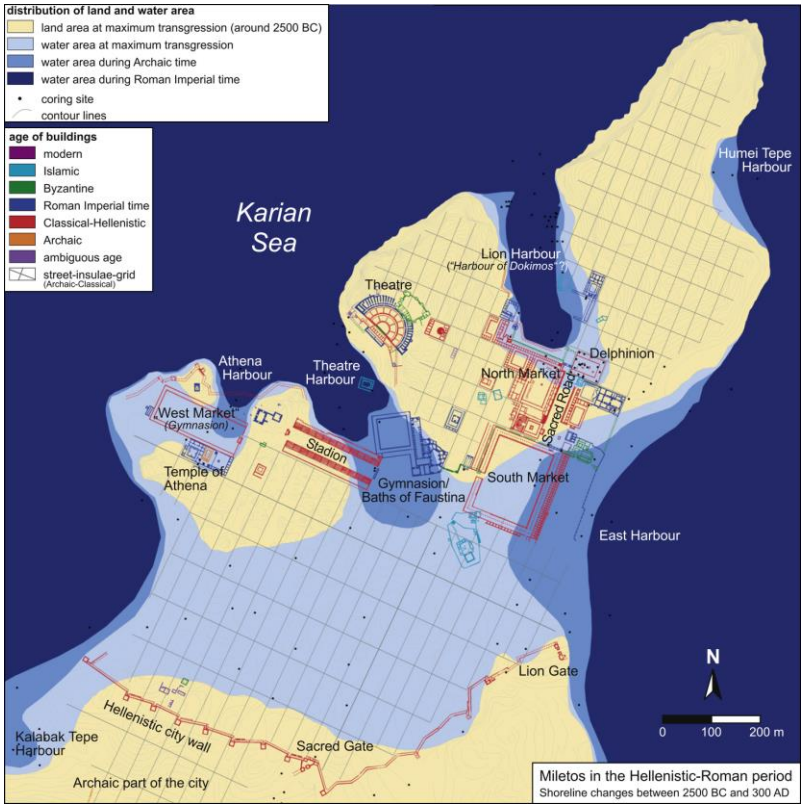


Figure 32: A map showing Hellenistic and Roman structures with sea level changes from 2500B.C. (Brückner et al.,2014a)

The studies on Humeitepe were further developed by Huy and Weissová's GIS-based study (2020) which uses systematic urban survey data (mostly architectural ceramics and pottery). The survey was conducted in 2014-2015 by Christoph Berns to observe the spatio-temporal transformation of Humeitepe in relation to the city center from the archaic to Byzantine periods. The study concludes that the area has been intensively used between 4th B.C. to 2nd A.D. and while the eastern part is characterized by a harbour, the central and southern parts are inhabited by wealthy houses (Huy & Weissova, 2020).

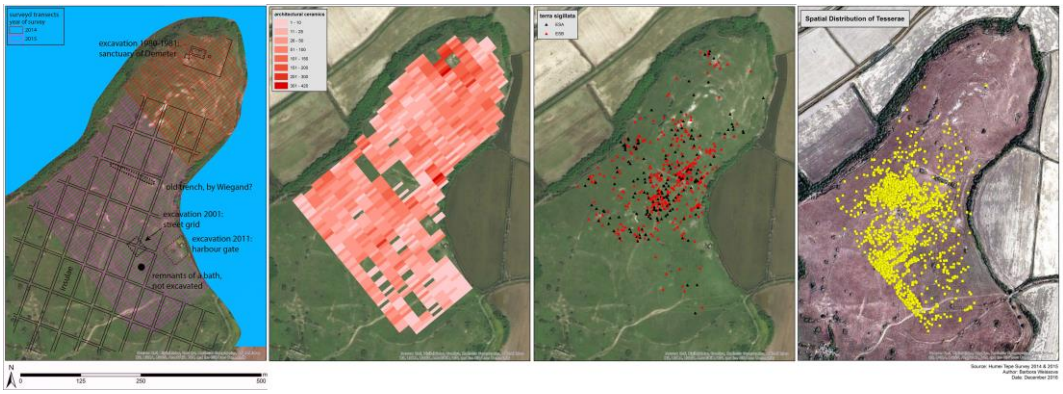


Figure 33: From left: Surveyed areas, spatial distribution of architectural ceramics, terra sigillata, and tesserae (Huy & Weissova, 2020)

Maurice Thurn's analysis of the infrastructure of Humeitepe harbour (2020), scrutinizes the excavation, geophysics, and survey data with the addition of infrastructure elements to propose a high trading activity occurred in Humeitepe harbour from the late Hellenistic to imperial periods this is supported by Huy and Weissova's survey results (Thurn, 2020).

Wilkinson and Slawisch (2019) utilize aerial imagery and remote sensing techniques to present evidence about the rural activities of Miletus. The traces exposed by modern farming activities are used to trace underlying linear features to provide insights into the rural and urban economy of Miletus.

An earlier publication by Slawisch and Wilkinson (2018) aims to explicate potential routes of the "Sacred Way" between Didyma and Miletus by re-evaluation of epigraphic and archaeological evidence to clarify the dating and reconsidering geomorphological changes. This publication argues that different paths might have been preferred during the Archaic to Hellenistic and Roman periods as a result of the cultural and environmental changes and execute a GIS-based model of potential routes to examine these paths under their temporal, cultural, and geographical context (Slawisch & Wilkinson, 2018, p.139-140).

Lana Radloff's 2019 study *'Placing' a Maritime Territory at Hellenistic Miletos* examines the integration of terrestrial and maritime spaces to interpret the mechanisms that shape the maritime space within the city boundaries from residents' perspective in the Hellenistic period. The study is significant with its approach to the process of creation and formation of space with its consideration of social dimension.

Several works tend to use more historical and geographical accounts in combination with archaeological data. Alexander Herda's *How to run a state cult* (Herda, 2011) is a systematic analysis of the historical and epigraphical evidence in the light of archaeological evidence, *From the gulf of Latmos to Lake Bafa* uses historical, and geographical accounts with charter myths and supporting evidence from geoarchaeological and palynological perspectives to present "a comprehensive anthropogeography" of lower meander delta (Herda, 2019a). *Copy and paste? Miletos before and after the Persian Wars* brings an archaeological insight to validate historical accounts of the Persian wars and the transformation of the city in the following periods (Herda, 2019b).

To summarize, extracting an accurate plan of Miletus city was an important goal from the initial excavations to the recent studies. The information about urban evolution evidenced by geophysical studies influenced the revision of the grid plan, and locations and orientations of underlying structures multiple times. The results of geophysical studies present a breaking point that dramatically influenced and improved a wide range of research.

To conclude, the geophysical studies and recently conducted studies provide the general allocation of buildings (locations of public, cult, administrative and domestic structures, etc.) and probable urban zones of Miletus city to extract a hypothetical layout for the Roman period of Miletus. This layout is used for axial and segment analysis to uncover the accessibility and movement patterns through the street network of Roman Miletus.

CHAPTER 5

ANALYSIS OF THE ROMAN STREET NETWORK IN MILETUS BY SPACE SYNTAX TOOLS

5.1 Depthmap Software

Numerous software applications were developed to perform various space syntax tasks that require heavy calculations (i.e. AJAX, JASS, isovist, Depthmap). Some of these tools are coded with specific task in mind. For example, while JASS concentrates on syntactic structure and depth analysis, isovist focuses on visibility and isovist analysis.

Depthmap (by UCL) is a comprehensive software that presents various space syntax analysis tools in one package, including convex space, axial and segment analyses, and visual graph and isovist analyses with the ability to import conventional formats (i.e. dxf, cat, csv). Depthmap uses a heatmap-like coloring (a spectrum arranged between darker blue (lower values) and bright red (higher values) to display the numerical values for concepts like mean depth, connectivity, integration, control, and so on. The axial line and segment analyses in this thesis are performed through Depthmap software (version: 0.8.0, build: master, b1d410f) and the extracted results are adapted for better visibility in printed form.

5.2 Plans

As mentioned in the 4th chapter Miletus urban grid was hypothetically reconstructed several times to provide a consistent plan for the city. Geophysical studies carried on by Herald Stümpel have been a great influence in most studies and the recent plans they utilize. This thesis uses a combination of Weber's 2002 (Weber, 2007, p. 239) plan -which was revised after Stümpel's geophysics studies- and a compilation of mentioned studies as a reference, to extract the spatial arrangement for the city's grid

structure, location and orientation of buildings, and the public spaces for the Roman period.

The analyzed spatial plan of Miletus is based on the predominant assumption that the existing grid system was repurposed via the addition of new structures and/or modification of existing ones through the transformation of the urban layout. Thus, the presented urban layout is an approximation of the Miletus urban layout in the Roman period.

5.3 A short description of Miletus urban layout

The main administrative, commercial, public, and religious structures of Miletus are located on the two distinguishable grid systems that merge between the three former archipelagos and the mainland (see, fig. 22). The northernmost and largest one of these archipelagos consists of two hills -Humeitepe and Theatre Hills- that merge in the north and form a "U" shape that is inhabited by a natural harbour -the Lion Harbour. The other two archipelagos -one of which forms the stadion hill- are smaller and located on the southwest of the former and connect to the mainland in the south. The merged landform provides three natural harbours -lion harbour, theatre harbour, and Athena harbour in the east- and two bays -Humeitepe Harbour and Eastern Harbour- all of which were utilized as commercial and military harbours.

The northern archipelago and the two southern archipelagos merge with the mainland in the south. The streets of Miletus are oriented roughly in north-south and east-west directions. The northern archipelago streets have an angular deviation of 22 degrees from the true north while the southern archipelagos and the mainland streets have an angular deviation of 23.5 degrees from the true north. These grids merge in three streets between the western gate of Southern Agora on the east and Faustina Baths on the west which provides the main connections between the Theatre and Humeitepe Hills to the southern part of the city where the mainland connection occurs. Here is an arterial street that lies between the western entrance and the eastern entrance (Lion Gate) to the city. On the south where western agora, Athena Temple, Stadion, and the Southern entrance of South Agora are located on its route. On the southernmost section of the Miletus, the "Sacred Gate" is located to the east. The gate connects to the northern parts of the city via the proposed "Sacred Way" and is accompanied by two

more streets -on the east- that extend towards the Northern Agora proceeding from between the Faustina Baths and the western entrance of South Agora where they merge with the northern grid mentioned. The Sacred Way and the most of the remaining parallel streets in the north-south direction seem blocked by the Faustina Baths in the west or South Agora on the east this condition renders the remaining two parallel streets as the longest streets and the only connections to the northern parts.

For more direct addressing, the main axes are referred to as by the following in this thesis. In the east-west direction: the street that proceeds from the Theatre Harbour entrance through the Southern section of the Processional Street to the northern entrance of south agora and Nymphaeum on the east -will be referred to as the northern east-west axis in this thesis-, the street that proceeds between the western entrance and Lion Gate -will be referred to as east-west axis-, and in the north-south direction: the first street in the east of the Sacred Way that approaches to Northern Agora from the south -will be referred to as north-south axis-. The reason for not using the "Sacred Way" as the main axis is that the access is interrupted by the Faustina Baths before reaching the Northern Agora. Probably in the Classical period before the Faustina baths were constructed and its extension reached the Northern Agora.

The most prominent street in the network seems to be the Processional Street which is surrounded by the eastern part of Northern Agora on the west, Lion Harbour Gate on the north, Ionic Stoa, Gymnasium and Nymphaeum on the east, and northern entrance to the South Agora on the south. An extension of this street approaches the Theatre Harbour from the east and passes a route through the Roman Heroon and the storage building in the south and intersects the north-south axis while providing access to Humeitepe and most commercial, public, and administrative buildings from the Theatre Hill region. Additionally, Processional Street is connected to the Humeitepe's main streets -which provide connections between the Demeter Temple area on the north, Humeitepe Harbour area and storage areas in the east (Thurn, 2020), a rich housing area (Huy & Weissova, 2020) in the middle and Humeitepe Baths in the west- in the east of Delphinion.

Processional Street is connected to the Lion Harbour by the Harbour Gates located on the north end. The Lion Harbour is located between the Humeitepe and Theatre Hills

as a result of its natural formation. The harbour area is shaped by Humeitepe Baths and Delphinion on the east and the Northern Agora on the south and to the west The Harbour Gates are located between the Northern Agora and Delphinion. The westernmost section of the harbour area provides access to the Northern Agora and Synagogue with two monuments on the route.

The Theatre hill is surrounded by the Theatre building on the east, Synagogue and Northern Agora on the west, and the Theatre Harbour area on the south. Hellenistic Heroon is located east of Theatre and further to the east a Roman Courthouse is located (Maischberger et al., 2009, p. 1). Additionally, there is evidence of an Atrium House in the insulae between the Northern Agora and the Theatre area as attested by the ceramic data (Şahin, 2020).

Further to the south three streets and the intersection of the northern section of north-south and northern east-west axes are surrounded by the Theatre building on the north, Theatre Harbour on the west, the Faustina baths on the south, the storage building and Serapeion on the southwest, western entrance of the Southern Agora on the east and extends to the north to the east-west axis. The central area of the defined region includes a Roman Heroon and the Roman Courtyard in the Northern most section neighboring Northern Agora.

The Western Agora, Athena Temple, and Stadion on the west and southern entrance of South Agora on the north are connected to the east-west axis which lies between the western entrance and the Lion Gate of the city. The south of the region defined by Western Agora and the old Athena Temple, The Stadion and the Stadion Baths, and the southern walls of the Southern Agora is referred to as the southern part in this thesis and is inhabited by the distinguishable stripe-like insulae structure. The published plans demonstrate mainland connections of the city from the southern part which includes the Sacred Gate on the south, Lion Gate on the east, and several other entrances located on the surrounding fortifications.

On the East of the South Agora a basilica and further east, the eastern harbour is located. The insula structure here is roughly defined in publications. The Goth walls (the renewed Hellenistic fortifications following the Goth raids in the 3rd century

A.D.) and the Roman aqueducts define the boundaries of the urban layout according to the published plans.

To summarize, the structures of Miletus are located on northern-east-west, east-west, and north-south axes along with the Sacred Way as mentioned above seem to provide access in the city whether they be intra-site or off-site. These streets possibly include most of the destinations and routes between various units in the city. The following will pursue possible movement patterns on the street network of Roman Miletus.

Figure 34: A reconstruction of spatial arrangement in Roman Miletus based on Weber, 2007, p. 239and recent publications (see Maischberger et al. 2009, p. 1 , Herda, 2011; Bumke, 2011; Brückner et al., 2014; Bruckner et al., 2017; Niewöhner, 2015; Şahin, 2014; Huy & Weissova, 2020; Thurn, 2020 for details)

5.4 Axial analysis

This thesis analyzes the Miletus urban structure in the Roman period in two stages: an axial analysis and a segment analysis.

As mentioned before axial analyses are conventionally used in linear urban spaces of the city such as street networks and public spaces. The axial analysis is based on the longest straight line that passes through a convex space which provides an axial map that covers all the lines and intersections forming a network.

This thesis examines integration values for each street in relation to all remaining (global integration) streets and their immediate neighbors (local integration - r3 and r2) using the axial analysis tool of Depthmap software. As mentioned before, these values are the representation of topologically defined distances rather than physical distances. Integration indicates ease of access calculating the number of directional changes for each street from every street in the network (Stöger, 2011, p. 63). While global values compare each street's accessibility from all streets in the street network by means of integration, the local values such as r2 and r3 indicate integration of certain streets within neighboring the range of 1 (r2) and 2 (r3) steps depth.

5.4.1 Axial Integration graphs

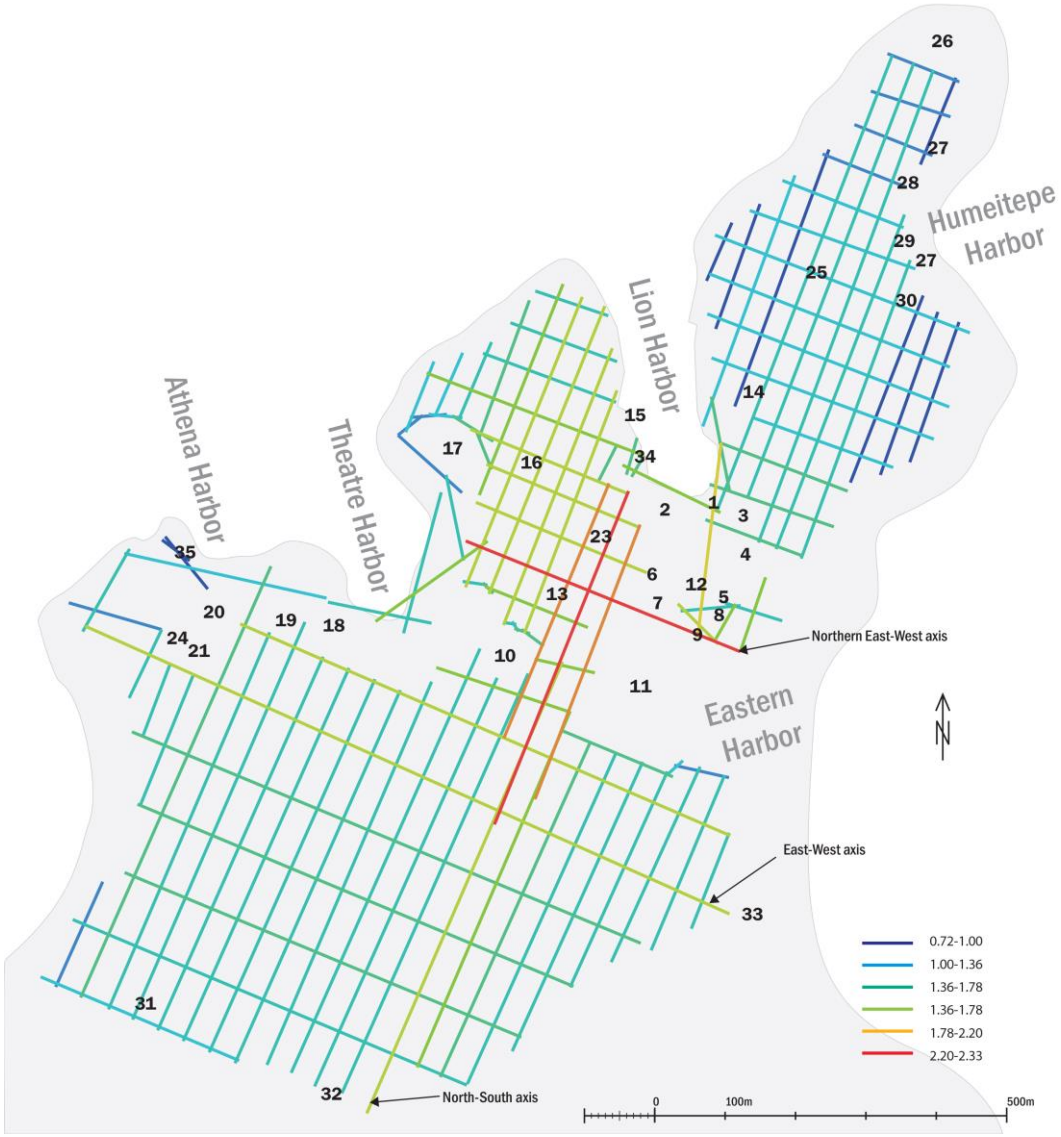


Figure 35: Axial Global Integration graph R(n) (HH) (n=150, n indicates the number of streets in the demonstrated system)

As mentioned, the accessibility within an urban system can be demonstrated by global and local integration values. The above graph (fig. 35) demonstrates that the north-south and northern-east-west axes of the city demonstrate the highest global integration values and are the most accessible points from any street in the network. The north-south axis, on the other hand, proceeds to the less integrated southern part of the city. On the route of this axis to the south, it is possible to observe that two parallel streets -in the east and the west and with relatively high integration values- accompany the north-south axis between the Southern Agora and Faustina baths from

Northern Agora. These streets are interrupted by the parallel street in the north of the east-west axis.

The intersection of the northern east-west axis and north-south axis form a sector in the southwest on Theatre Hill where relatively high values (indicated by yellowish green color) are concentrated. This sector of streets is surrounded by Theatre, Theatre Harbour entrance, Synagogue, and Northern Agora. Hellenistic Heroon is also located in this vicinity.

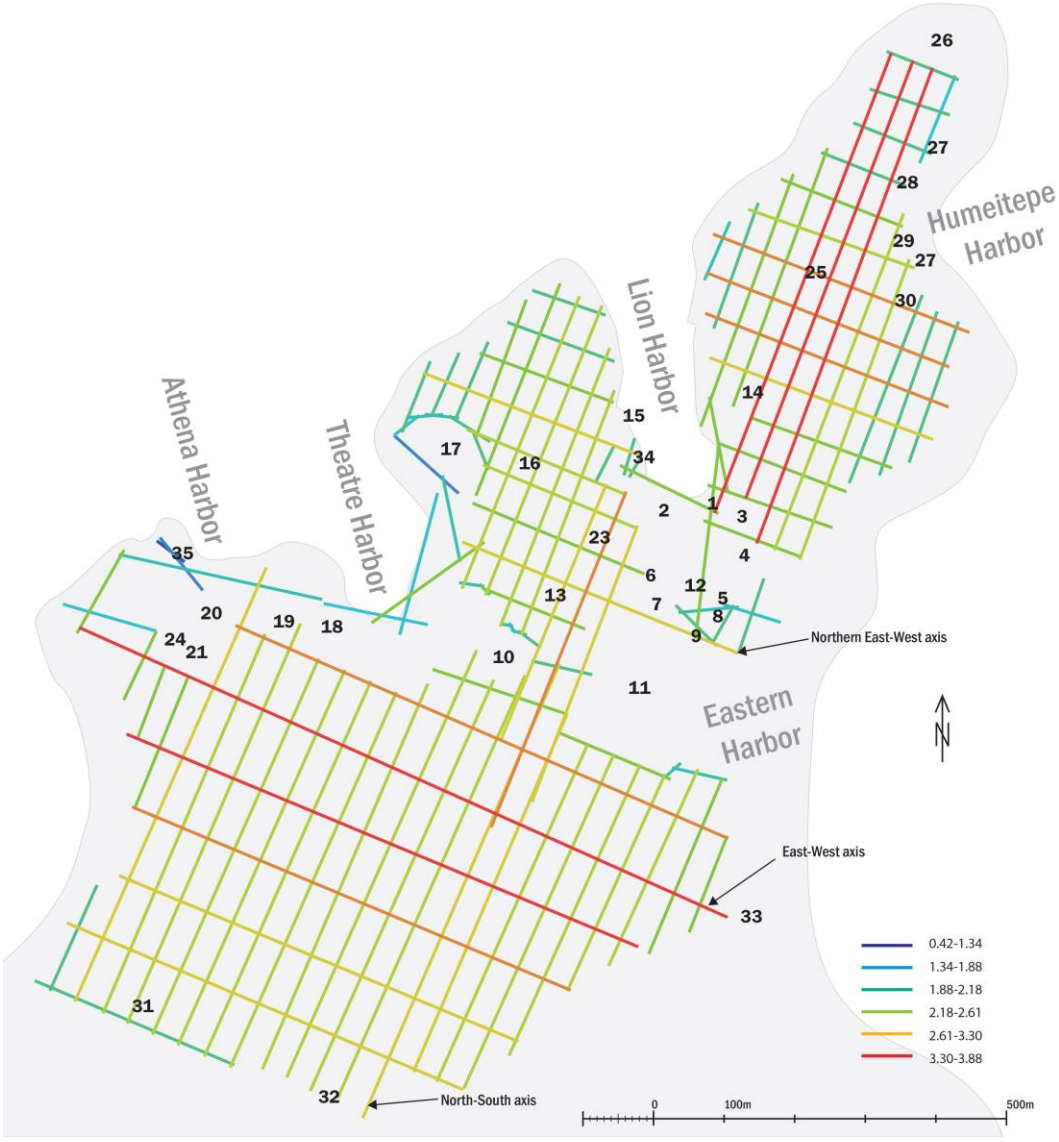


Figure 36: Axial Local Integration R3 (HH) graph

The R3 graph shows the accessibility of streets within 3 steps deep. The east-west axis and one parallel street in the south demonstrate higher accessibility while another cluster of highly accessible streets is located in Humeitepe with approximate

integration values. These are the streets connecting the Demeter temple area to Lion harbour (and passes by the Humeitepe Baths) and the Delphinion vicinity. These streets pass through the assumed location of the Humeitepe harbour area and Humeitepe Baths and are followed by three perpendicular streets with close values. From these results, it can be observed that higher accessibility shifts focus to Humeitepe where Humeitepe Harbour, Demeter Temple area, and Humeitepe Baths, and connect to Lion Harbour and Delphinion in the north. On the other hand, the highest values are located in the southern part city where the western entrance and Lion Gate are connected through the east-west axis passing by Western Agora, Athena Temple, an atrium house, the Stadium, and the southern gate of the Southern Agora.

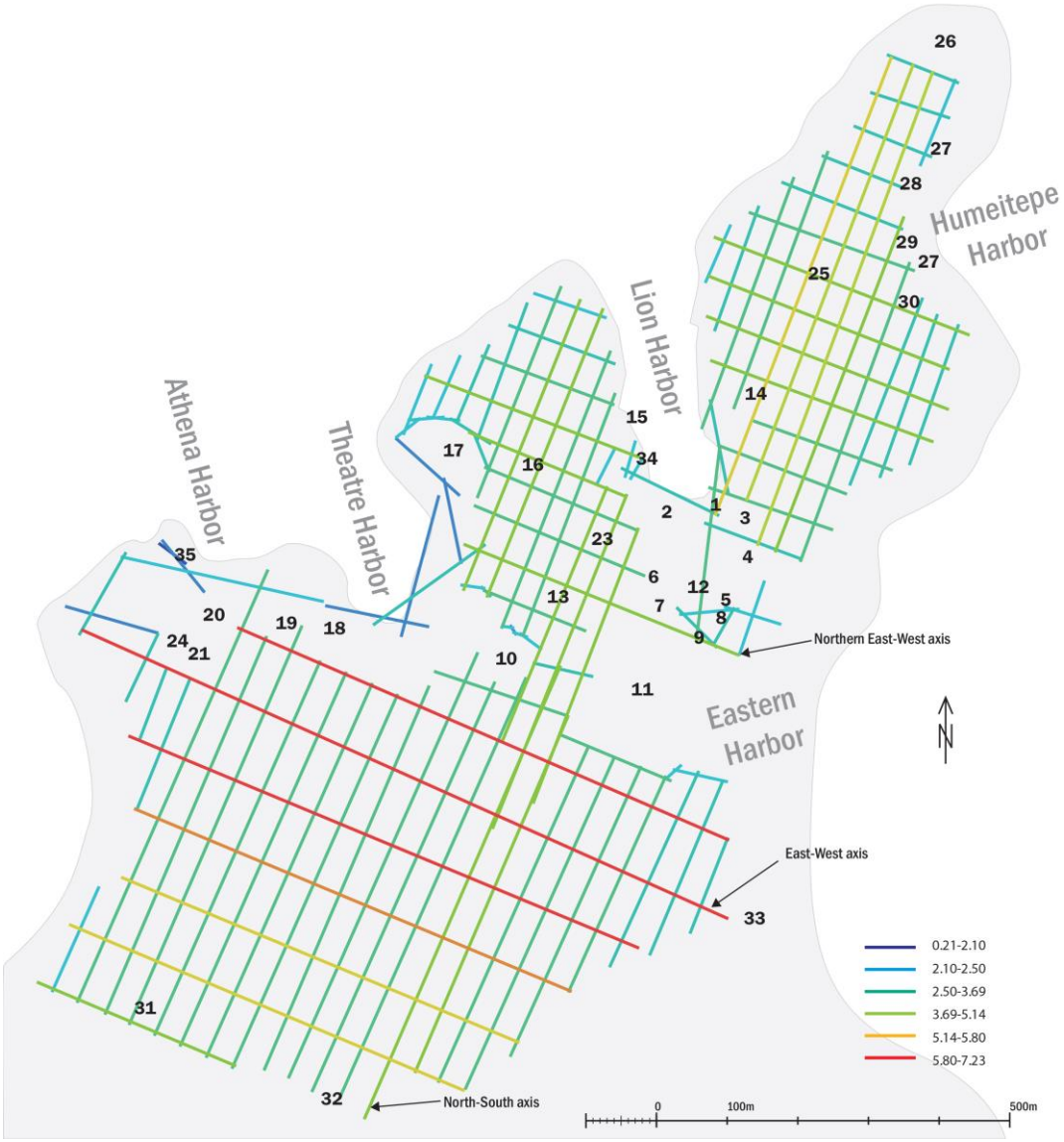


Figure 37: Axial Local Integration R2 (HH) graph

The r2 graph indicates that the most locally integrated streets are the east-west axis - which shows the highest accessibility within the range of 2-step depths. and to the three parallel streets to the north and south, gradually decreasing to the south. The accessibility values seem to demonstrate that the mid-range values are distributed from these axes to the south and in the west of Humeitepe on the street that connects the Demeter Temple area and Lion Harbour passing through Humeitepe Baths while gradually getting lower to the east.

As a result, the globally integrated streets (R=(n)) are clustered between Theatre, Theatre Harbour, Lion Harbour, and Northern Agora proceeding through Southern Agora and Nymphaeum area. These are followed by gradually lower values in the extensions of the north-south axis and east-west axis. The north-south oriented section of the Processional Street that proceeds to the Lion Harbour Gate demonstrates relatively less accessibility rendering the Humeitepe the least integrated part of the city in a global sense. On the other hand, the north-south oriented streets of the Humeitepe peninsula -located between the Demeter temple area, Humeitepe baths, Lion Harbour, and the assumed location of the Humeitepe harbour area- shows the highest accessibility within 3 steps distance, along with the east-west axis that passes by Western agora, Athena temple, Stadium and one step distance away from the southern gate of Southern Agora. This street keeps its prominence and outstands as the most accessible street within 2 steps depth with two parallel streets in the north and south while others lessen accessibility.

5.5 Segment Analysis

In the segment analysis, the unit of concern is the street segments defined in the street network. Segment analysis calculates the distances between units defined by the number of changes in refraction angles. Hillier and Iida argue that the paths with the least number of angular changes positively correlate with actual movement patterns relying on empirical evidence (2005, p. 483). These assumptions depend on the "movement economy" concept which discusses grid structure and movement patterns in the urban context (Hillier, 1996, pp. 47-50). This thesis uses integration and choice values for various radii (100, 250, 400, 800, and 1000m) to examine movement

patterns in relation to the city's street network. While integration values are an indicator of destination-to-destination accessibility by passing the least angles possible within a certain radius, the choice values are an indicator of the probability of a street segment being chosen when traveling between any two destinations. Hillier and Iida (2005, p. 484) define this phenomenon as "through" movement.

According to Hillier, integration and choice values indicate *destination* and *route* potentials. i.e. a shop would be located in a highly accessible street since with higher rates of short trips and lower rates of long trips would be preferable to provide as much human traffic as possible so "…closer a segment is to all others the more promise it offers as a destination…" (Hillier, 2008, p. 2). On the other hand, Hillier exemplifies choice as a potential for *passing trade*.

5.5.1 Segment Analysis Graphs (Integration and Choice values)

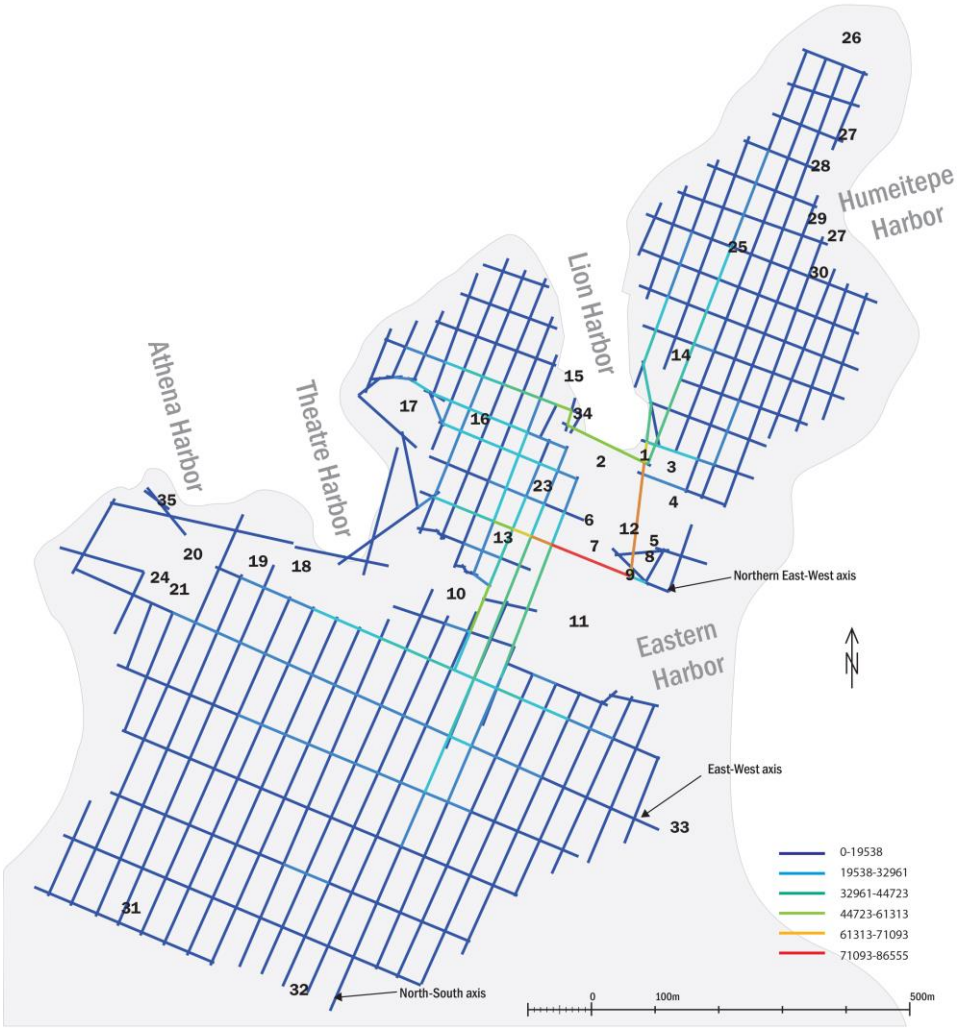


Figure 38: Axial Segment Choice for 1000m radius

The choice values (r1000) indicate that the most probable street segments to travel between any two destinations -possible routes- within a 1000m radius are positioned with respect to the Processional Street. The most preferred routes are the segments that pass through the path from Northern Gates of South Agora, Processional Street, Harbour Gates, Lion Harbour monuments, and Northern Agora entrances with the relatively lower choice values are extended to the northwest of the intersection of north-south and east-west agora. It can be said that these routes are easily accessible from the surroundings of the Processional Street and have extensions to the vicinity of Theatre, Humeitepe's southern regions -that include Humeitepe Baths-, and streets between the South Agora and Faustina Baths and proceed with gradually lower values to the south.

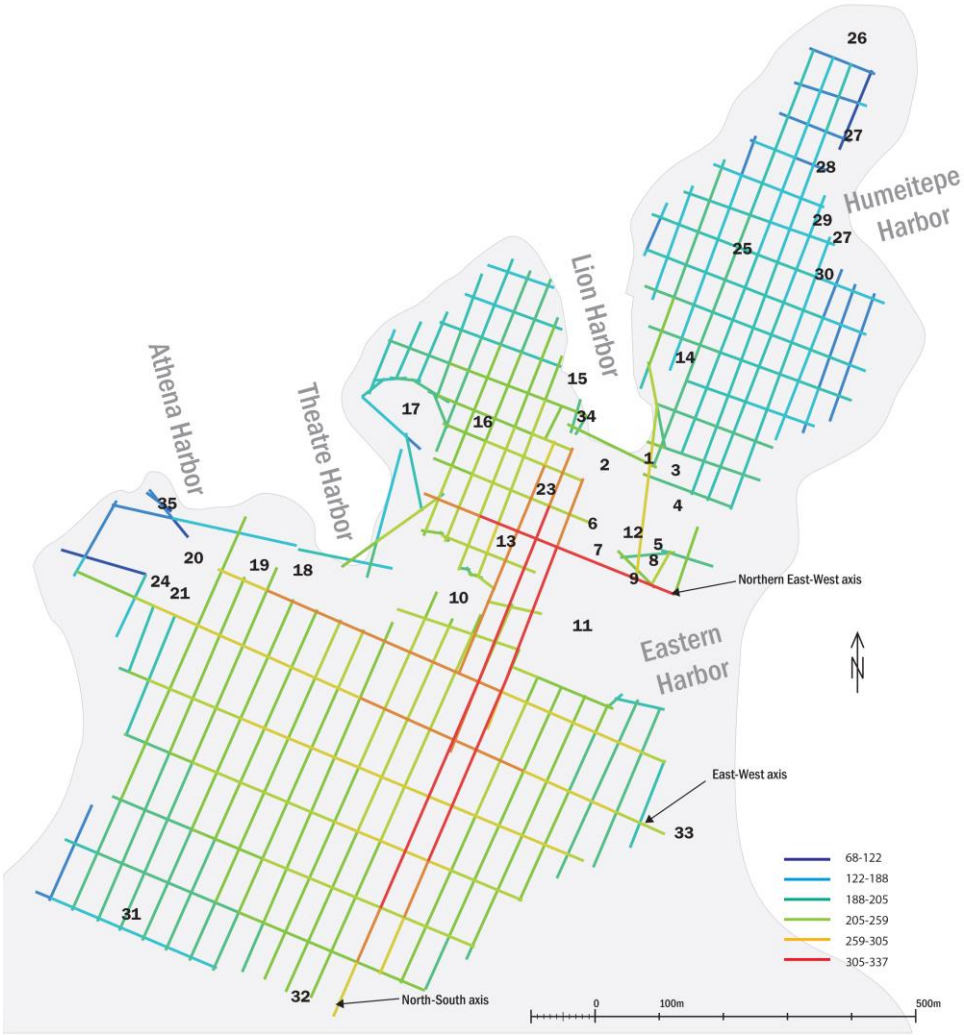


Figure 39: Axial Segment Integration for 1000m radius

For the 1000m radius, the higher integration values are distributed between the Theatre Harbour entrance, Northern Agora, and the southern part of the Processional Street with a sharper focus on the intersection of east-west and north-south axes accompanied by another highly integrated street on the east which proceeds from south to north from between the western wall of the South Agora to the insula that includes the Serapheum and the storage building. The values gradually decrease in extension to the vicinity of the Stadion to the south, the Theatre Harbour, and Northern Agora to the east. The Roman Heroon (III), an Atrium house and Roman Court buildings, Faustina Baths and Stadion are located on these extensions.

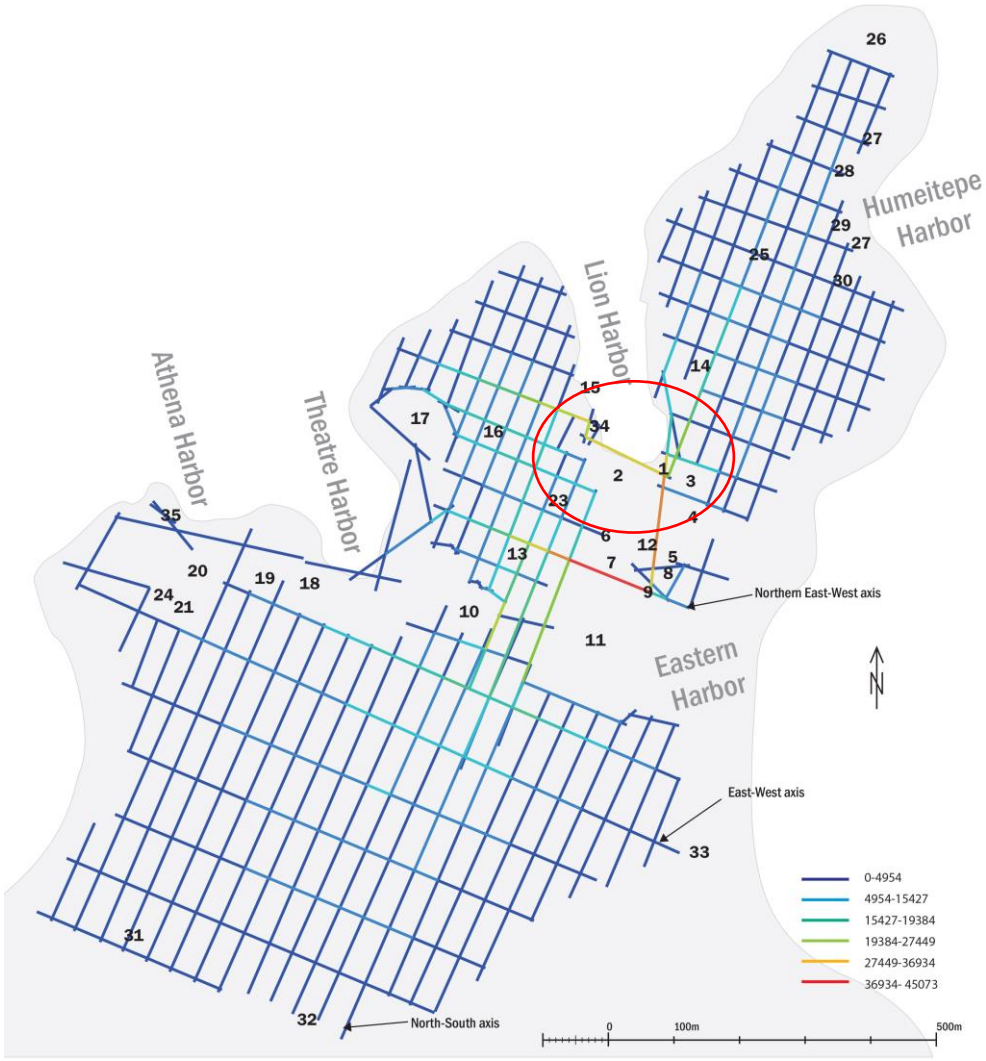


Figure 40: Axial Segment Choice graph for 800m radius (the red loop indicates the increased values in comparison with the 1000m radius graph)

The distribution of higher choice values for the 800m radius tends to shift towards the Lion Habour, Harbour monuments, and synagogue direction again with extensions

towards the Humeitepe, and between Southern Agora and Faustina Baths. For the radius of 800m, the higher integration values shift the focus to the south where an insula in the southwest of the Southern Agora is surrounded.

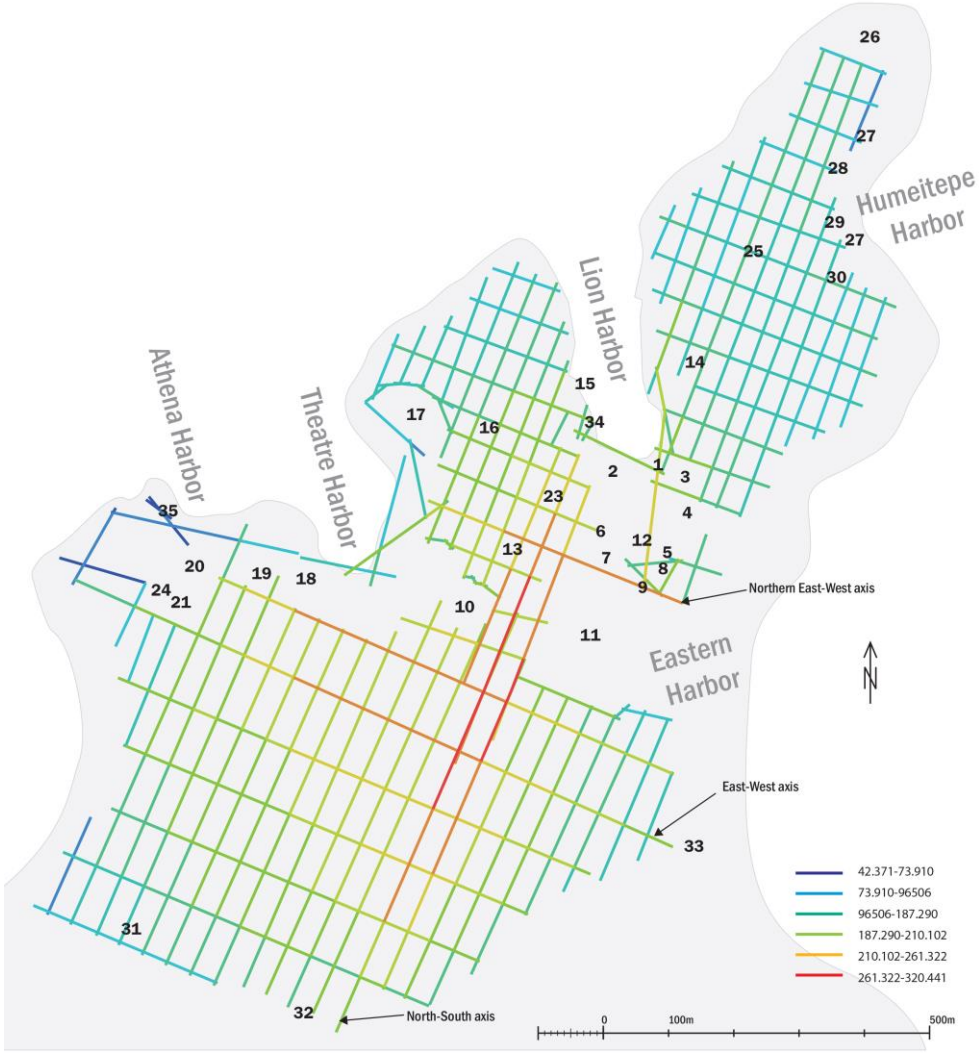


Figure 41: Axial Segment Integration graph for 800m radius (a slight decrease can be observed in the distribution of higher values shifting the focus to the south)

For both choice and integration values, it is possible to say that the focuses tend to shift toward opposite directions. While higher integration values accumulate on the streets in the west and southwestern regions or south agora, the choice values -while keeping the highest value in the southern section of Processional Street- have slightly increased in the Lion harbour and monument area.

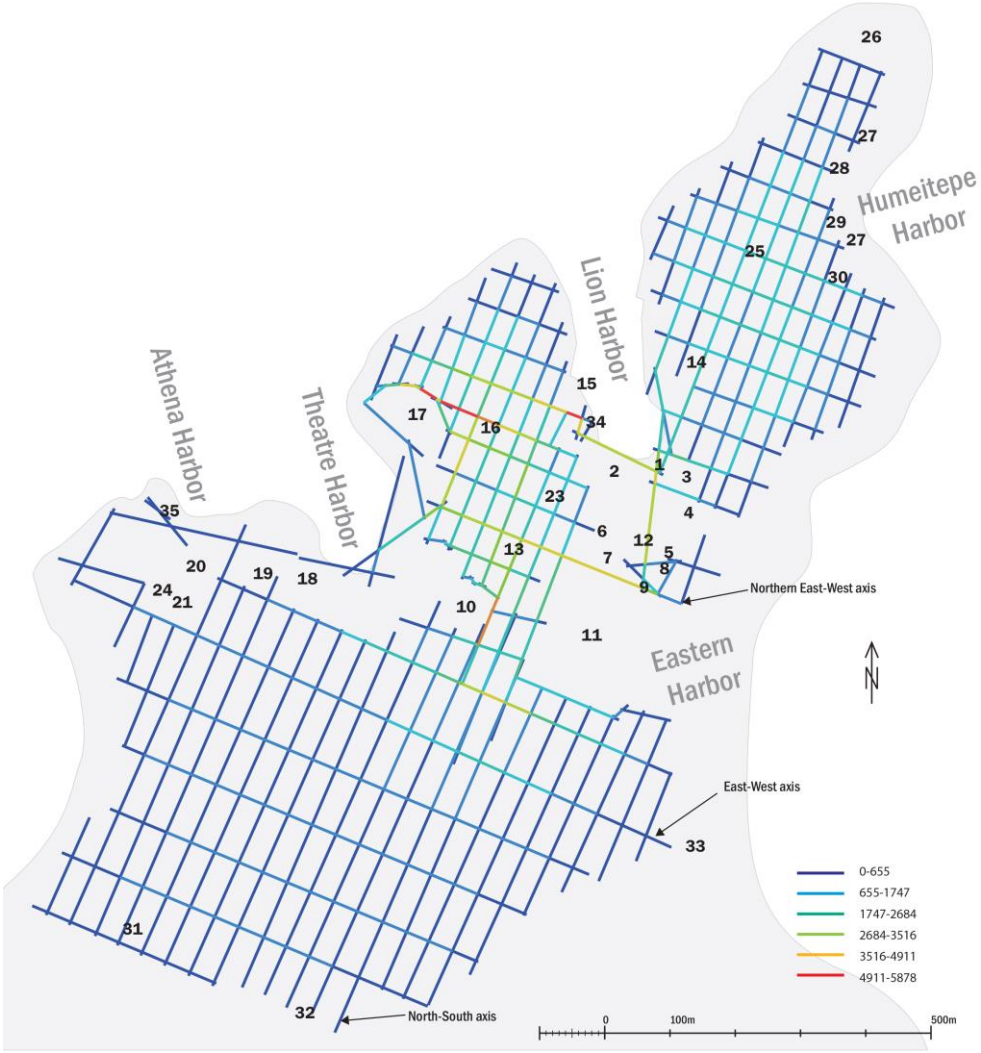


Figure 42: Axial Segment Choice graph for 400m radius

For the 400m radius, the highest choice values are concentrated in the north of the monument, the Lion Harbour to the west, the street segment in the south of Synagogue, the north of the Theatre building neighborhood, and a street segment located in the east of Faustina Baths. It is possible to observe that higher choice values are concentrated on the districts between Theatre Hill and Northern Agora, the monuments' vicinity, the Lion Harbour, and Processional Street while relatively lower values of choice are located in the central areas of Humeitepe.

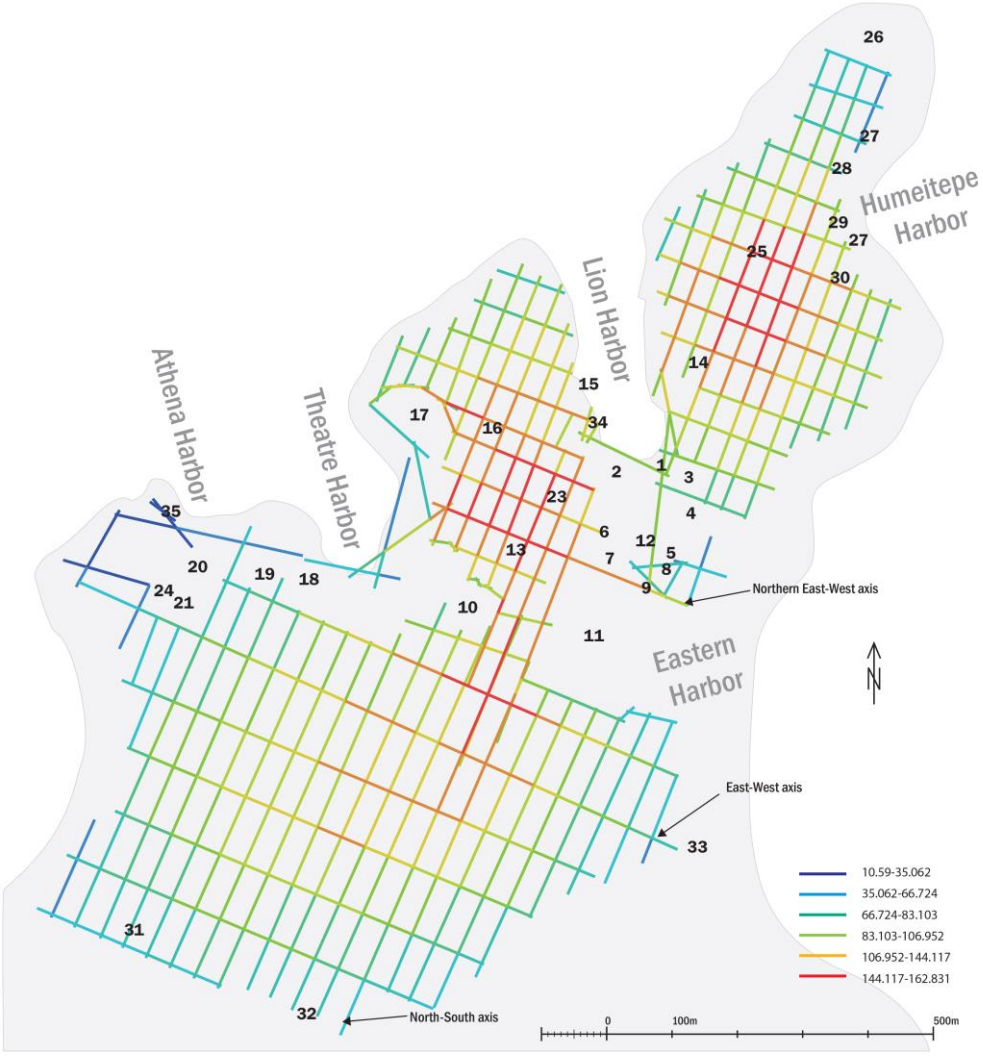


Figure 43: Axial Segment Integration graph for 400m radius

On the other hand, for the integration values, it is possible to observe a wider range of distribution which shows a negative correlation with the decreasing radii. In the 400m integration graph the higher values are clustered in the central districts of Humeitepe, between the Theatre Harbour and Northern Agora, and to the south the central districts of the southern region closer to the connections to the city center where north-south and east-west axes intersect.

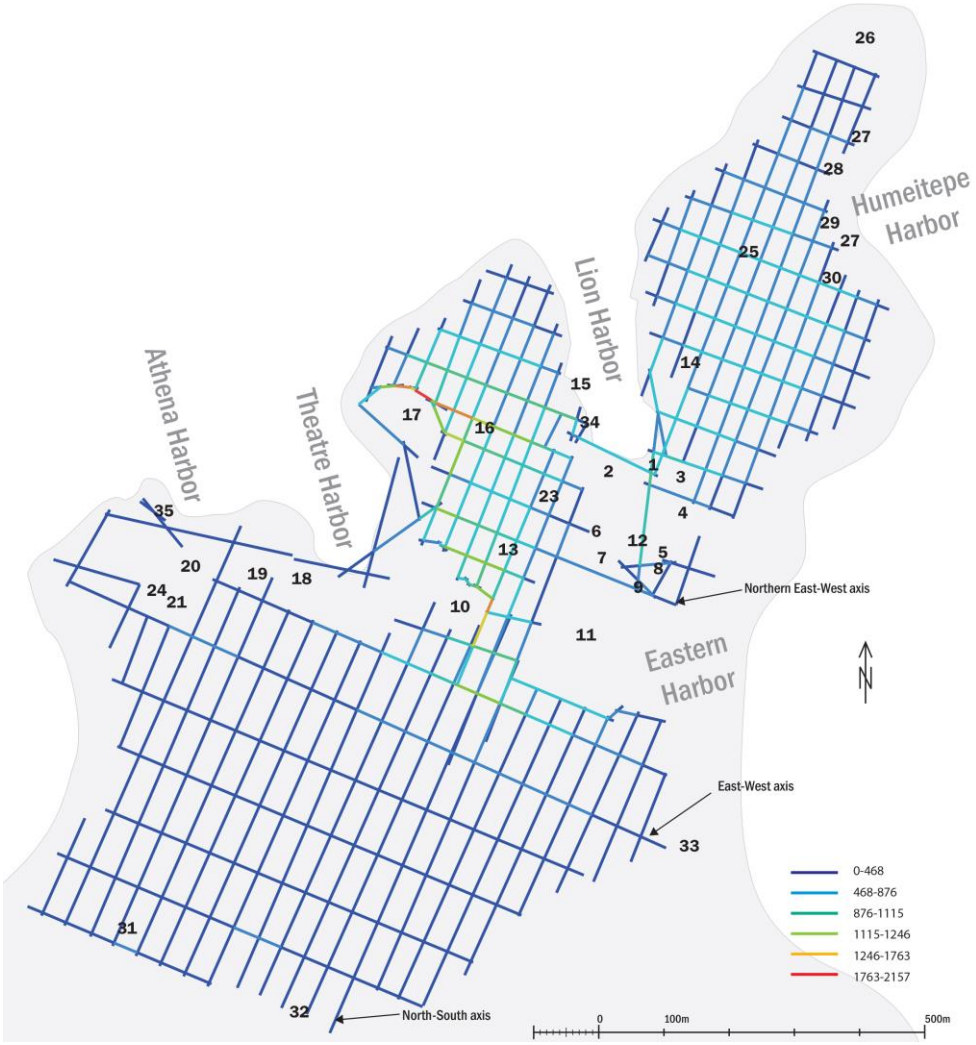


Figure 44: Axial Segment Choice graph for 250m radius

The higher choice values for a 250m radius are accumulated in the north and to the east of the theatre building and a street in the east of Faustina Baths. There is a distribution of relatively lower values in the area between Theatre Hill and Lion Harbour. This area extends to the south to the vicinity of the western gates of South Agora where the Serapheum and storage building is located. Additionally, several lower-value extensions approach the Lion Harbour and Theatre Harbour entrances and the central districts of Humeitepe. The Processional Street on the other hand shows higher choice values in relation to the surrounding districts in the northern section that is located between Lion Harbour and the northern gates of South Agora.

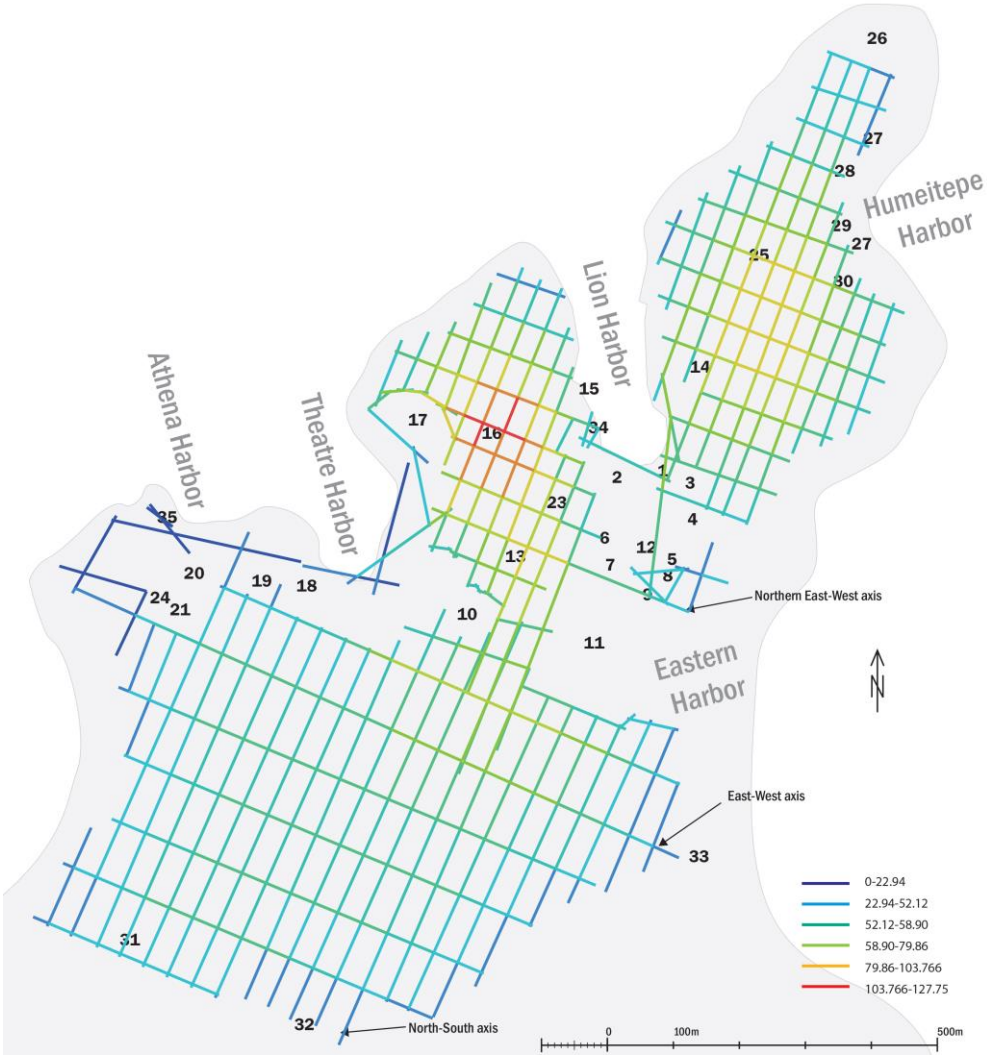


Figure 45: Axial Segment Integration graph for 250m radius

On the integration values, it is possible to observe a complete shift of the higher integration values to the Theatre Hill and the surroundings of Hellenistic Heroon. Additionally, several values with mid-high range are accumulated in the central districts of Humeitepe and to the south where east-west and north-south axes intersect. Another addition to the mid-range values can be seen in the extension of the Processional Street from the Harbour gates east of the Delphinion and the Humeitepe Baths. On the other hand, the relatively lower values are located in the south and to the periphery of the higher values in Theatre Hill and Humeitepe.

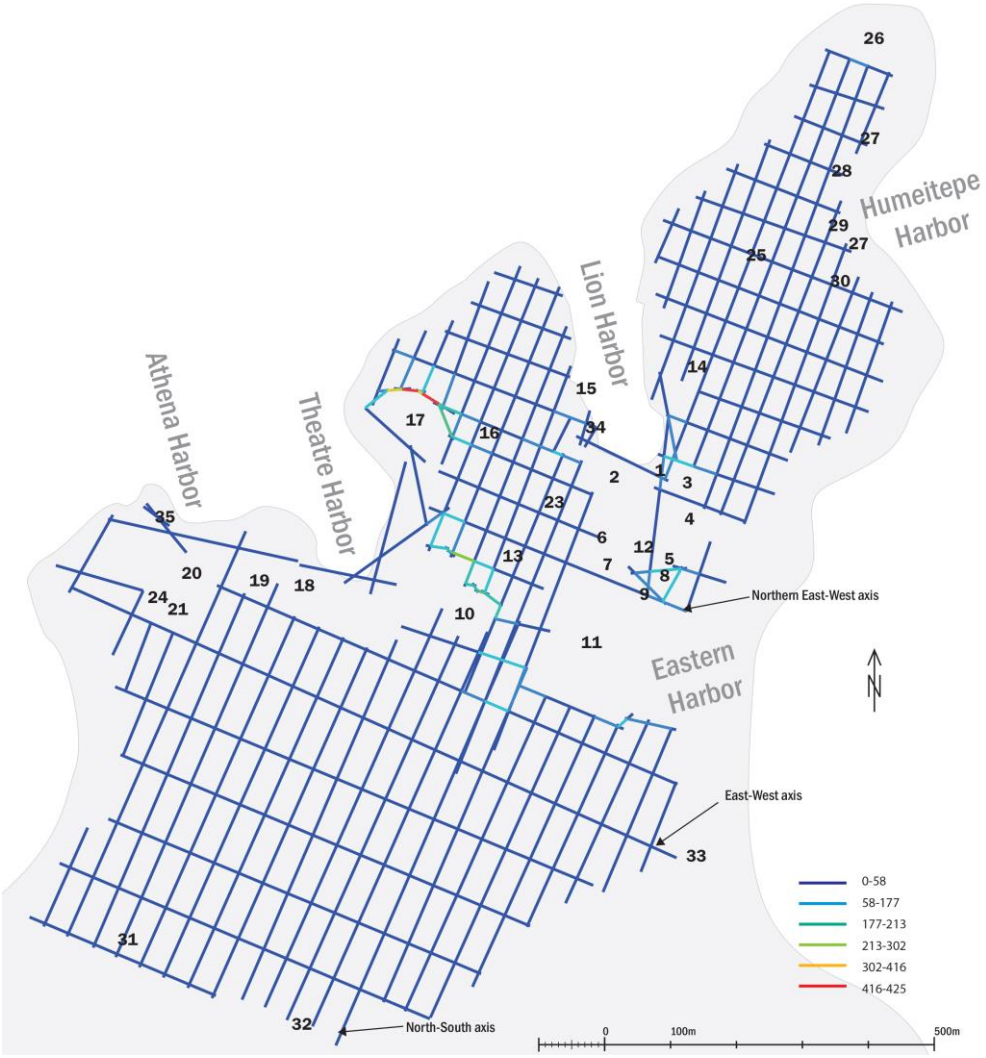


Figure 46: Axial Segment Choice graph for 100m radius

The 100m range patterns produced similar results with 250m with a sharper focus on the northern periphery of the Theatre building and Faustina Baths. Several relatively lower values are located between the Theatre harbour entrance and Faustina Baths, the vicinity of the Nymphaeum and the northern gate of South agora, and between Lion Harbour Gates and Delphinion.

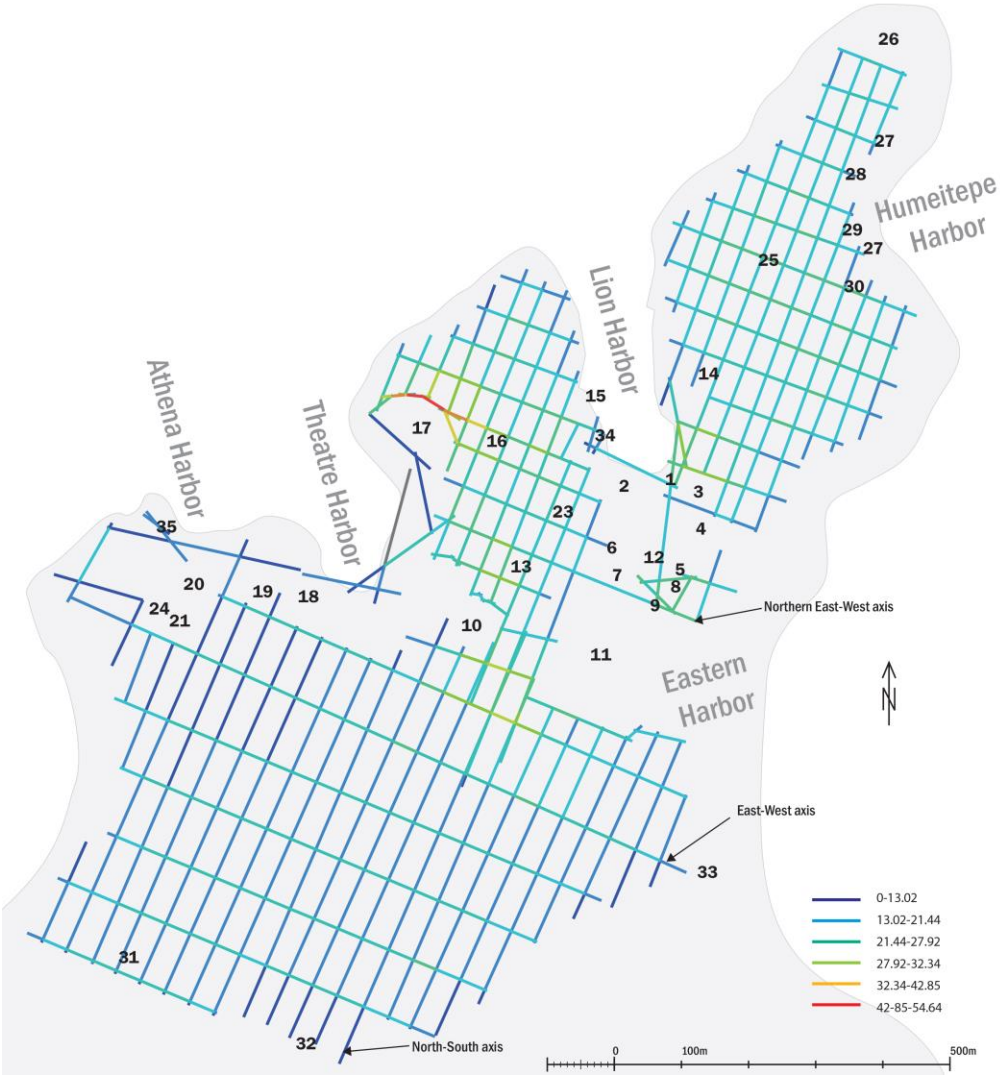


Figure 47: Axial Segment Integration graph for 100m radius

The higher integration values for a 100m radius are located in the north of the Theatre building. The mid-range values are located in the districts that surround the Hellenistic Heroon, the vicinity of Delphinion, and the districts located in the south-east of South Agora.

5.6 Interpretations

The results of the axial integration analysis graphs demonstrate possible accessibility and movement patterns of the Miletus street network in the Roman period. It is possible to observe that the most globally accessible parts of the street network accumulate in the surroundings of the north-south and east-west axes intersection. This is followed by relatively lower values in the districts surrounded by Theatre Harbour, Northern Agora, and the extension of the Processional Street that proceeds to the Southern agora in the east-west direction. Since Miletus was a harbour city this condition can be explained with a lower activity -fewer destinations- in the areas accessible from land (that are located in the southern part of the city) and a higher activity -more potential destinations- in the areas accessible from the sea (that are located in the north). On the other hand, locations of the concentration areas of higher local integration for 3-step depths (R3) demonstrate two clusters oriented perpendicularly. The southern cluster consists of two highly accessible streets oriented in the east-west direction -the east-west axis and one parallel street in the south- with gradually decreasing values to the north and south. The northern cluster consists of three highly integrated streets in the north-south direction which connect the Demeter Temple area to the Delphinion. These intersect with three highly accessible streets that are perpendicular in orientation. The R3 graph indicates the accessibility within 3-step depths. It can be observed that the lowest accessibility for R3 demonstrates very limited distribution in general and the locations are Nymphaeum, the northern gates of South Agora, Theatre Harbour, and Athena Temple. It can be fairly said that the most accessible streets are located in Humeitepe and the northern section of the southern part of the city within three steps radius. Relying on the buildings located on these paths, it can be said that Humeitepe districts are accessible within 3 step depths from the Humeitepe Baths, Humeitepe Harbour area, Delphinion, and Lion Harbour. In the southern part of the city, the most accessible street is the east-west axis with two parallel streets. Other central buildings to the north and the rest of the city to the south with gradually lower accessibility values are located on these streets. It is possible to observe segregation between the Humeitepe peninsula and the rest of the city. Additionally, Processional Street is less accessible when compared with the rest of the main axes. On the other hand, accessibility to the Processional Street seems to be limited when compared with the other parts of the network both in the global and R3

integration graphs. The integration R2 graph shows higher values for the east-west axis and three parallel streets. This is followed by lower values in the east of Humeitepe between the Demeter Temple area and Delphinion. This condition indicates that the most accessible locations within two step depths are located on the east-west axis which lies between Lion Gate and Western Agora.

Humeitepe which is connected to the rest of the city via the Processional Street and Lion Harbour shows an almost autonomous condition and its only connection to the network is less accessible within three steps. The Lion Harbour is assumed to serve various purposes after Trajan (1st century A.D.) including military and welcoming diplomatic missions while providing quick access to the Delphinion and had political and religious importance (Brückner et al., 2014a). This condition seems consistent with the demonstrated R3 graph which shows segregation between Humeitepe and southern parts. It is possible to interpret that the less accessible parts such as the northern part of the Processional Street, the surroundings of the Lion Harbour monuments, the Nymphaeum, and the Northern Gates of the Agora provided access to certain groups of people while limiting access between Humeitepe and the southern parts of the city. This segregation is also consistent with the proposed location of rich houses in the eastern and central regions of Humeitepe (Huy & Weissova, 2020) which might be inhabited by privileged classes.

The R2 integration graph shows a single cluster of streets in the east-west orientation located in the southern part of the city. The integration values decrease gradually to the south and are sharply interrupted with Stadion street in the north of the east-west axis. This condition shows that there is segregation in the southern parts of the city which can be related to land access to the city. Since these parts of the city are accessed from various gates located through the fortifications of the city including the Lion Gate and the western entrance of the city which are connected by the most accessible street in the R2 graph. This also shows that the land access to the city is limited to two steps in depth which might indicate that access is facilitated to the Western Agora and southern parts of the city from Lion Gate and western entrance while being limited to the northern parts of the city within 2 step depths.

Additionally, the districts between the intersections of highly accessible streets in Humeitepe correspond to “rich houses” described in the spatial analysis results Huy & Weissova, 2020). The axial integration R3 graph shows relatively consistent results in the distribution of assemblage of Roman ceramics (1st-3rd century A.D.) while rather more consistent results in architectural assemblages that correspond to Hellenistic and early Roman (1stcentury B.C.-1st century A.D.) (see figure 31 for Huy and Weissova’s spatial distribution results).

The segment analysis results indicate movement through the urban space. While vehicle traffic is defined by the higher radiuses such as 800 or 1000m, 400m and smaller radii refer to more local movements and are associated with pedestrian movement (Hillier, 2008, p. 2; Stöger, 2011, p. 217).

The integration values are associated with the possible destinations for the given radii according to Hillier (2008, p. 2). Given the graphs for 1000, 800, 400, 250, and 100m, the 400m radius demonstrates a climax in the distribution of highly integrated units/street segments. While for the 1000m radius the highly integrated street segments are located on the intersection of the north-south axis and the east-west axis. With the descending radii, the distribution of the highly integrated segments tends to increase and for a 400m radius cover the central regions of Humeitepe, the region between Theatre and North Agora, and its extension to the north between the Faustina Baths and western gate of South Agora. With the decreasing radii from 400m to 100m, the distribution of highly integrated areas tends to shift the concentration area to the Theatre vicinity finally contracting to the north of the Theatre neighborhood in the 250m to 100m radius in segment integration analysis.

As mentioned, the segment integration values for the 400m radius are assumed to represent potential destinations for pedestrian movement. It can be observed that from 1000m to 400m radius the higher integration value distributions tend to increase reaching the maximum coverage in 400m. The distribution contracts and the shifts focus on the Theatre vicinity with decreasing values (250m and 100m radii). According to the segment integration graphs, it is possible to suggest that potential pedestrian destinations are accumulated between the Theatre Harbour and Northern Agora, around the intersection of the north-south axis and Stadion street and central

districts of Humeitepe. The segment integration R400 graph shows a similar segregation with the axial integration R3 graph supporting the suggestion that Processional Street might be serving as a control point that limits the access to Humeitepe and Lion Harbour.

The choice values, on the other hand, indicate potential routes for traveling between any two destinations in the network. The higher choice values within the 1000m radius are arranged with respect to the southern part of the Processional Street, which is aligned with the northern walls of the South Agora and passes by the northern gates of the South Agora and Nymphaeum, where most of the movement density occurred. This density shifts to the vicinity of the Lion Harbour monument and the synagogue area in a 400m radius and finally reaches the theatre neighborhood in 250m and 100m radii. From an 800m to 400m radius, the concentration area of the higher choice values shift north passing by the Lion Harbour and Harbour Monuments to the Synagogue neighborhood and demonstrating a more distributed graph. On the smaller radii (250m and 100m) higher choice values are accumulated in the Theatre neighborhood and higher integration values concentrate to the north of the Theatre building.

According to the choice value graphs, R1000 and R800, the most probable routes for higher radii are in connection with the northern gates of South Agora, Nymphaeum, the Processional Street, the Lion Harbour, and the Synagogue vicinity. Since the vehicle movement is associated with these higher values, it can be suggested that the vehicle movement occurred *through* (higher choice values) northern gates of South Agora, Nymphaeum, the Processional Street, the Lion Harbour, and Synagogue vicinity *to* (higher integration values) Roman Courthouse, Atrium House, Northern Agora, Faustina Baths, western and northern gates of South Agora, north-south axis.

On the other hand, for the lower radius of 400m, the most selected routes occur in the theatre vicinity which is connected to the Theatre Harbour. This suggests that pedestrian movement occurs *through* the Theatre vicinity and Theatre Harbour area *to* central regions of Humeitepe, the intersection of north-south and east-west axes to the south of Faustina Baths, western gates of South Agora, and the Theatre Hill where Synagogue, Northern Agora, Theatre building are located.

For a 250m radius, the higher integration values are located in the central region of Theater Hill around the Hellenistic Heroon and mid-range values in the central districts of Humeitepe. The highest choice values occur in the northern districts of the Theatre building, this is followed by relatively lower values that accumulate between the Theatre and Northern Agora and around the Hellenistic Heroon. Processional Street shows a slightly higher value when compared to its surrounding segments. For a 100m radius, the higher integration values are located in the central region of Theater Hill. Humeitepe shows integration within the low range. Similarly with the R250 graph, the high choice R100 values are accumulated around the Faustina Baths and north of the Theatre building.

The results of the 250m radius graphs show clusters of relatively higher integration and choice values around the Theatre vicinity. Since this area has direct street connections with Theatre Harbour, Northern Agora, the Synagogue, and the Lion Harbour, the results might indicate high local pedestrian movement in the neighborhood surrounded by these structures which might include domestic structures. The same condition is valid for the central regions of Humeitepe.

Additionally, from the lower radii integration values of Humeitepe, it is possible to speculate that the rich houses were more isolated from their neighborhood and as a result allow fewer social encounters within their vicinity in a 250m radius. When compared with Theatre Hill which provides more local accessibility within the region and might result in more social encounters. This argument is supported by the choice values since the choice values indicate the most probably selected routes for the given radius. Also, it is possible to observe some overlaps in the 250m which becomes more visible in the 100m radius graph. These might indicate that Theatre Hill provides the most probable local encounters and is followed by Humeitepe and the southern part of the city with the lowest values.

Another observation can be made for Processional Street. This street provides most of the access between Humeitepe, Lion Harbour, Southern Agora, and Theatre region and most of the religious, administrative, public, and commercial buildings are in connection with this district, therefore it might be expected to demonstrate higher accessibility values. However, the presented axial and segment integration graphs

show mid-range values for Processional Street and this condition does not seem to be correlated with the given radius. However, in the choice graphs for radii 400m and larger, the Processional street provides a higher probability as a selected route, this probability decreases with the lower radii finally fading in 100m. It can be interpreted that the region of the Processional Street is not locally integrated while providing a preferred route for vehicle and pedestrian travels from destination to destination in various extensions. This assumption can be consistent with the location of Processional Street which is between the Theatre vicinity, Humeitepe, Lion Harbour, and Southern agora.

Another suggestion can be made for the Sacred Way which lies between the Sacred Gate in the south to the Northern Agora and Lion Harbour in the North. This street does not show particularly higher values in integration or choice graphs when compared to the north-south axis and other streets in oriented in this direction. This might show consistencies with the Slawisch and Wilkinson's (2018) approach to the location and route of the Sacred Way which might have been altered between Archaic to Hellenistic and Roman periods. This suggestion might be explored further comparing the integration and choice values for different periods such as the Classical and Roman periods which might provide probable routes and accessibility patterns between northern and southern parts of the city for each period. However, the defined clarity of the Eastern Harbour, and the east of Southern Agora is limited which might produce misguiding results.

According to Hillier (2008, p. 2), the lower radii (such as 250m or 100m) are associated with local movement patterns (i.e. within a neighborhood). The results for the lower radii in our analysis are most likely to be the result of limited detail of the spatial plan since the proposed size of the insulae changes between 30x36 in the Theatre region and 101x36 in the southern region of the city. The streets of the Theatre building might have had a higher ratio of changing angles caused by the Theatre building's curved structure which is idealized in our map. Furthermore, the northern sectors of the Theatre building are modified and altered into a castle in the Byzantine period, and these modifications probably obstruct the underlying insula structure. To understand the reason behind the accumulation of higher choice and integration values around the theatre and Hellenistic Heroon for lower radii, I tried different variations of the same

plan -removed the triangle-shaped insulae, fixed the grid structure to fit the area, etc-. These modified maps also produced similar results. Similar problems occurred around the Faustina Baths and the South Agora with similar results

CHAPTER 6

CONCLUSION

This thesis attempted to analyze accessibility and movement patterns for the Roman Miletus street network with space syntax tools axial integration, segment integration, and choice using geophysics, archaeological survey, and historical data from recent publications to reconstruct a proposed layout of the city's street system.

As mentioned before, space syntax methods have several limitations in archaeological contexts especially when the remains of the structures provide fragmented or missing information in architectural terms -such as an entrance or boundaries. This thesis attempted to overcome these limitations using published geophysical data and recent publications adopting a non-invasive approach.

The results of the analyses showed several consistencies with spatial analysis results of Huy and Weissova (2020) -that suggest rich houses dominate the central region of Humeitepe based on their GIS-based spatial distribution of architectural ceramics research-, the military and political function of Lion Harbour (Brückner et al. 2014) and general expectations from a Roman city center where administrative, public and religious buildings accumulated. However, the suggested results of the space syntax analysis cannot be accounted for or compared with evident information that already exists since it provides suggestions for possible routes and accessibility patterns that no longer exist.

As mentioned before space syntax approach has been criticized based on its theoretical roots as well as the technical limitations of its methods. Archaeological material, on the other hand, pushes these limitations further to the material level which makes it more challenging to present a proximation. The geophysical data, archaeological surveys, and historical accounts alone were used to produce a hypothetical layout -

used in this thesis- which is a limiting factor from the beginning. Additionally, the information on the street grid in the north-east of Theatre Hill, the southern part of the city -the regions in the west and north of Western Agora, Athena Harbour, and Eastern Harbour area are relatively limited when compared to Humeitepe or other more studied central parts of the city.

The interpretations made for the Theatre vicinity, Humeitepe, and Processional Street can be improved or updated with additional information about the street grid especially the contents of the southern part of the city, the regions that are located in the east of the South Agora, the periphery of the fortifications and the central regions of Theatre Hill. Since the information about the contents of these regions is limited, producing a grid reconstruction presents challenges and some parts of it are missing or relied on assumptions.

Considering these limitations space syntax can provide a blurred generalization as an insight into the accessibility and movement patterns within the boundary of this urban layout given the data used for this study. This study can be further improved with future archaeological surveys, excavation data, and revised plans. The excavation and survey data can be utilized to produce categorizations for architectural elements and ceramic data in digital environments and be compared with the space syntax analysis similar to the studies of Kaiser and Laurence.

In conclusion, this thesis used a non-invasive approach to extract the Roman urban layout of Miletus which was crucial for the execution of space syntax analysis. While the clarification of several points in the urban layout of Roman Miletus might provide more accurate results, the executed analysis and its results have the potential to provide a lot of research questions for further research such as explaining the segregation of Humeitepe in relation to the harbours and southern part of the city, or the functions of streets in relation to the land and marine transportation. These can also be combined with the social aspect of space syntax to explain privileges or restrictions of access in certain regions. In this respect including additional syntactic values such as “control” or “controllability” -which have the potential to represent the visitor/inhabitant relations or segregation between groups of inhabitants- of space syntax has the potential to provide more insight into the social dimension of Roman Miletus.

Additionally, examining changes in the syntactic relationships / access and movement patterns of an urban layout (or the modifications to an urban network that occurred) have a potential to provide insight for explaining rules or approaches that differentiated between specific periods. For example, space syntax might have a potential to suggest a common grammar for Roman urban street network or rules for the modifications of Imperial Rome on the existing city networks. This might be useful for discovering the general rules that reflect the Roman approach to urbanization of a specific city, or exploring the main concerns in utilization of a specific city in Imperial network might be a possibility. For example, for a case like Miletus it might be possible to explain the assigned commercial function to the city in the Imperial trade network examining layout changes before and after the Imperial period.

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APPENDICES

A. TURKISH SUMMARY / TÜRKÇE ÖZET

Giriş

Mekan dizim (ing. *space syntax*) yöntemleri, 1970'lerin başlarında bu konuda yapılan ilk yayınlardan bu yana mimari ve kentesel örüntüler ile ilgili soruları cevaplamak için yaygın olarak mimari, kentsel tasarım, tarihsel araştırmalar ve arkeoloji gibi çeşitli alanlarda yaygınlaşmıştır. Mekan dizim, mekansal ilişkilerin sentaktik yöntemler kullanılarak ile ölçülebilir hale getirilebileceği argümanından yola çıkmaktadır. Bu nedenle mekansal sistemleri (kentsel veya mimari olmasından bağımsız biçimde) ölçülebilir biçimde tanımlamayı ve sakinlerin (ing. *inhabitants*) mekanla olan ilişkilerini mekanın kendisiyle tutarlı bir biçimde açıklamaya yönelik işlevsel analizler üretmeyi amaçlamaktadır.

Mekan dizimsel analiz metodları mekanları ya da mekansal sistemleri, içerisinde bulunan yada kullanımında bulundukları kullanıcıların/sakinlerin sistem içerisindeki hareketlerini yönlendiren ve aynı derecede de bu sakinler tarafından biçimlendirilen/tekrar kurgulanan bir sistem olarak tanımlayarak sistemileri bu bağlamda tanımlamak ve analiz etmeyi amaçlamaktadır. Bu analizlerin gerçekleştirilebilmesi için sistem onu oluşturan en küçük mekansal birimlere indirgenmekte ve bu birimlerin arasındaki sentaktik ilişkiler mimari veya daha geniş kurgudaki mekansal düzenlemeleri/sistemleri tanımlamak için kullanılmaktadır (Hillier et al. 1976, pp.; Hillier & Hanson, 1984, pp. 146-147).

Bu tezde, Roma dönemi Milet sokak ağı, mekan dizimsel analiz yöntemlerinden eksenel (axial) ve eksenel segment analizi araçları kullanılarak, kentsel mekândaki erişim ve hareket örüntüsünü inceleyecektir. Bu tür mekan dizimsel analizler için mekan veya sistem içerisinde hareketi yönlendiren veya sınırlarını belirleyen

boşluklar sisteminin (ing. *spatial layout*) tanımlanmış olması gerekmektedir. Bu tez, M.Ö. 1. ve 3. yüzyıllar arasında Helenistik binaların yeniden inşaatı ve modifikasyonlarının ardından Roma dönemindeki Miletus için sokak ağının tanımlanması için yayımlanan planlar, arkeolojik araştırmalar, haritalar, ve kazılar ve güncel jeofizik haritaların verilerinden yararlanmaktadır.

Milet şehir planı ilk defa Carl Humann ve Friedrich Freiherr Hiller von Gaertringen tarafından Haziran 1891'da tasvir edilmiştir ve şehir merkezindeki belli başlı yapılarla beraber şehrin ana akslarının hipotetik bir kurgusunu içermektedir. Bu plan devam eden kazılar, yüzey araştırmaları ve diğer multidisipliner çalışmaların sağladığı veriler ışığında sürekli güncellenmiştir (Weber, 2007, s. 328). Bu güncellemeleri en büyük ölçüde etkileyen çalışmalar 1996'da Herald Stümpel tarafından başlatılan ve günümüzde devam eden jeofizik çalışmalardır. Bu çalışmalar daha önce yapılan kazı ve araştırmalarda önerilen Milet kent planlarının daha doğru ve hassas biçimde güncellenmesini sağlayarak Milet ile ilgili çalışmalar için yönlendirici olmuştur (von Graeve, 1999). Bu tezde kullanılan Milet planı, Weber tarafından 2002'yılında hazırlanmış olan ve jeofizik çalışmalarla desteklenen şehir planının yakın zamandaki bilimsel yayınlar da eklenerek modifiye edilmiş bir hali üzerinden gerçekleştirilmektedir (bkz. Weber, 2007; Maischberger et al., 2009, Herda, 2011; Bumke, 2011; Brückner, 2014; Brückner, 2017, Niewöhner, 2015; Thurn, 2020; Huy & Weissova, 2020; Slawisch & Wilkinson, 2018).

Bu tez, Roma Dönemi Milet sokak ağı ile ilgili olarakaşağıdaki sorulara cevap aramaktadır:

a. Roma Milet şehir örüntüsü üzerinde eksenel analiz ve eksenel segment analizi uygulayarak incelenebilir mi?

b. Milet sokak ağının eksenel ve segment analizi, Roma dönemi Miletus sokak ağının erişilebilirlik ve hareket örüntüsüyle ilgili bilgi sağlayabilir mi?

c. Milet örneğinde aksial ve segment analizi uygulamaları için sınırlayıcı faktörler nelerdir?

Mekan Dizimsel Analiz ve İlgili Metodolojiler

Mekan dizim araştırma programı (ing. *space syntax research program*) inşa edilmiş mekanları belli işlevlere hizmet etmek için boşlukları düzenleme çabasının bir ürünü olarak tanımlayarak, mekanların sentaktik kurgusunun bu işlevleri dolayısıyla da mekanların sosyal işlevini okumak için kullanılabileceği savı üzerine kuruludur. Bu konudaki yayınlarda en çok referans verilen temel kaynaklar *Space Syntax* (Hillier et al., 1976) ve *Social Logic of Space* (Hillier & Hanson, 1984) olarak gözlemlenebilir. Diğer yandan mekan dizimsel analiz yöntemleri yaygınlaşmalarını takip eden süreçte geliştirilmiş ve dijital araçların da dahil edilmesiyle uygulamaları daha pratik bir hal almıştır.

Mekan dizimsel analiz, sistemleri oluşturan mekanların sosyal fonskiyonlarını kamusal veya özel olma durumlarına göre değerlendirmektedir. Bunun için ise temel istatistiksel değerler derinlik (ing. *depth*), bağlantısallık (ing. *connectivity*), erişilebilirlik-entegrasyon (ing. *accessibility-integration*) olarak tanımlanarak mekanın sosyalliği ölçülebilir hale getirilmeye çalışılmıştır (Hillier & Hanson, 1984, 106-109). Mekan dizimsel analiz metodları mekan ve onun sakinleri arasında süregelen ilişkileri ve bunlar arasındaki korelasyonlu sürekli ve kendi içerisinde tutarlı bir biçimde görselleştirebilme yeteneğinden ötürü mimari, şehir planlama, tarihsel araştırmalar, arkeoloji ve mekan araştırmaları ile ilgili alanlarda geniş bir taban bulmuştur.

*Space Syntax'*da (Hillier et al., 1976), mekân dizimi araştırmasının amaçları, "...mimari ve kentsel mekân örüntülerinden oluşan 'bilgi alanı'nın etkili bir modelini geliştirmek..." olarak tanımlanmıştır ve böyle bir modelin öngörülen üç özelliğinin bulunması gerekliliği vurgulnamaktadır:

- model ile gözlemlenebilir veriler arasında bir uyum olması;
- modelin kendisi içerisinde tanımlanmış sentaktik birimleri ile tutarlılığı;
- mekansal ilişki örüntüleri içeren insan yapımı sistemlerin sentaktik düzeyde biçimsel analizler üretme olasılığı (Hillier ve diğerleri, 1976, p. 149.).

Space Syntax'da (Hillier et al., 1976), matematiksel olarak uygun tanımlardan ziyade, tanımlanan sistemin kendi terimleri içinde tutarlılığının önemsendiğini gözlemlemek mümkündür. Bu yaklaşım, önerilen model üzerinden geliştirilen mekan dizim analizlerinde verilen üç öngörüyü sağlayan biçimsel bir dilin (ing. *morphic language*) geliştirilmesini ve bu dilin mimari ve kentsel sistemleri tanımlamakta ve analiz etmekte kullanılmasını sağlamıştır. Burada sentaktik analizlerin önerilme sebebi temel olarak metrik ölçütlerden bağımsız olarak sadece mekan kurgusundaki mantıksal ilişkiler ile mekanların tanımlanıp analiz edilebileceği savırıdır.

Mekan Dizim Metodlarının Temel Prensipleri

Mekân dizimi araştırmasında, her mekansal birim (dışbükey boşluk (eng. *convex space*), eksenel boşluk (ing. *axial space*), izovist boşluk (ing. *isovist space*) vb. cinsinden ifade edilir ve bir nokta veya düğüm (ing. *node*) ile temsil edilir. Bu alanlar arasındaki karşılıklı ilişkiyi görsel olarak bir topolojik grafikle temsil etmek için, bir kapının iki odayı birbirine bağladığı yerde her düğüm veya nokta düz çizgilerle bağlanır. (Şekil 4b). Noktalar veya düğümler ve aralarındaki bağlantılar tanımlanmış olduğu için grafik bu bağlantılar değiştirilmeksizin farklı noktalar referans alınarak yeniden düzenlenebilir. Yaygın olarak kullanılan bu yeniden düzenlenmiş biçim, hizalanmış grafik (ing. *justified graph*) ya da kısaca j-grafiği (ing. *j-graph*) olarak adlandırılır (Şekil 4c) (Thaler, 2020, s. 298-300).

Bahsedildiği gibi, mekan dizimi metodolojisi, mekansal sistemleri birbiriyle ilişkili temel mekansal birimlerin bir düzenlemesi olarak ifade eder ve mekansal sistemleri tanımlamak için bu birimler arasındaki bağlantıyı analiz etmektedir. 1976'daki ilk mekan dizim araştırmalarından bu yana, üç çeşit temel birimin geliştirildiğini gözlemek mümkündür: dışbükey boşluk, eksenel boşluk ve izovist boşluk. j-grafiği, belirtilen bu temel birimler arasındaki mantıksal ilişkilerin görsel bir temsilidir. Hillier'in önerdiği mekansal sistem, ana alanın/boşluğun çeşitli şekillerde bölünmesi ile hareketi yönlendiren bir dizi engel olarak tanımlanabilir. Bu bölümlemeleri taşıyan ana mekan ise taşıyıcı mekan (ing. *carrier space*) olarak tanımlanır ve kök düğümü ya da başlangıç noktası (ing. *root node*) ile ifade edilir (Hillier & Hanson, 1984, s. 95). j-grafiğinde, taşıyıcı mekan, dendritik grafiğin başlangıç noktası olarak kabul edilen bir yerde üzerinde "+" işareti olan bir düğüm ile temsil edilir. Daha

sonra düğümler, erişilebilecekleri minimum veya maksimum kenar/kapı sayısı göz önünde bulundurularak aynı derinliğe sahip düğümler kök düğümden aynı uzaklığa denk gelecek biçimde, uzaklıklarına (adım mesafesi, derinlik; ing. *step depth, depth*) göre yatay çizgiler üzerinde hizalanarak ayarlanır.

j-grafiği, bazı sayısal değerlerin ve belirli mekansal/çevresel özelliklerin göstergelerinin tanımlanmasına olanak sağlar. Örneğin, önceden taşıyıcı/kök düğüm ile temsil edilen, belirli bir mekana (bir oda, bir mekânsal birim ya da bütün bir bina) dışarıdan erişimin ne kadar kolay olduğu ile "derinlik" ile ilişkilendirlerek değerlendirilebilir. Herbir düğümün, derinliği önceden belirlenmiş ve yatay olarak hizalanmış diğer düğümlere göre derinliği daha önce belirtildiği şekilde j-grafiğinde etiketlenerek gösterilmesi mümkündür. Bu işlem, binanın veya belirli bir mekansal birimin çevresinden veya dışından erişilebilirliğini ölçmede asıl niceliksel gösterge olan ortalama derinliğin hesaplanmasına izin vermektedir (Hillier & Hanson, 1984, p. 106).

Bu tekniği uygulayarak, j-grafiği, verilen tüm mekansal birimlerden algılanan bir mekansal sistemin toplam derinliğini görsel olarak tanımlamayı sağlar. Düğümlerin çoğunun kök düğümden birçok düzeyde uzakta olduğu dendritik olarak şekillendirilmiş bir j-grafiğinde, ortalama derinlik daha yüksek olacak ve bu nedenle "derin" olarak tanımlanacaktır. Öte yandan, kök düğümün yakınında çok sayıda düğüm bulunan bir j-grafiğinde ortalama derinlik daha düşük olacaktır; bu nedenle "sığ" olarak etiketlenecektir. Aynı sayıda temel birimin farklı bağlanmalarının sonucu olarak farklı derinlikte sistemler oluşturabilmektedir (bkz. Sayfa 19, Fig. 6). Derinlik-sığlık mekan dizimdeki en temel sayısal değerdir ve daha karmaşık istatistiksel değerlerin hesaplanmasına ve mekansal dizilimin sayısal bir şekilde metrik büyüklüklerden bağımsız olarak ifade edilmesine, değerlendirilmesine ve dolayısıyla birbiriyle karşılaştırılmasına olanak sağlamaktadır. Bu tez kapsamında erişilebilirlik (ing. *accessibility*) ve hareket (ing. *movement*) örüntülerini incelemek amacıyla eksenel entegrasyon (ing. *Axial integration*) ve eksenel segment entegrasyon ve seçim (ing. *axial segment integration and choice*) sayısal değerleri kullanılarak Milet'in Roma dönemi sokak ağı incelenmiştir.

Eksenel analiz yaygın olarak sokak ağları ve kamusal alanlar gibi doğrusal kentsel mekanlarında kullanılmaktadır. Eksenel harita (ing. *axial map*), bir kentsel ağı oluşturan tüm yolları ve kavşakları kapsayan en kısa ve en küçuk dışbükey alanlardan geçen en uzun düz çizgiylerden meydana gelir.

Entegrasyon kavrami, diğer tüm mekansal birimlerden (odalar veya kentsel planda sokaklar gibi) en kolay ulaşılan mekansal birimlerin, bütün sistem içerisinde daha bütünleşik (sisteme daha entegre) oldugu görüşüne dayanmaktadır. Bu, bir yol matrisine dayalı olarak yol uzunluklarının toplamı veya ortalama mesafe (ing. *mean distance/MD*) hesaplanarak ölçülebilir. Bu hesaplama, sistem bazında istenilen sayıdaki boşluğa uygulanabilir. En düşük MD'ye (ortalama mesafe) sahip kenasal birim en entegre olarak kabul edilirken, en yüksek MD'ye (ortalama mesafe) sahip birim en az entegre olarak kabul edilmektedir. Bu ölçü, farklı noktaları teorik derinliklerine ve sığlıklarına göre karşılaştırmak ve karşılaştırmak için kullanılır (Hillier & Hanson, 1984, s. 108; Thaler, 2020, s. 300). Diğer yandan eksenel segment analizi eksenel çizgilerin (ing. *axial line*) kesiştikleri noktaları (kensel bir örüntüde sokakların kesişim noktaları gibi) da göz önünde bulundurarak verilen bir çap değeri üzerinden daha lokal analizleri gerçekleştirmekte kullanılmaktadır.

Eksenel analizi uygulamak açisindan bir diger onemli deger ise “seçim” (ing. *choice*) dir. Thaler'a (2020) göre “seçim” terimi, bir yapı içindeki herhangi bir düğüm çifti arasındaki en kısa yol kümesini ifade eder (s. 305). Klarqvist (1993), “global seçim”, bir ortamın mekansal birimleri içinde meydana gelen akışın dinamik bir ölçüsü olarak tanımlar. Bir mekansal birim, onu aynı sistem içindeki diğer mekanlara bağlayan çok sayıda yola sahipse, içinden geçen yüksek bir trafiğe ve yüksek bir “seçim değerine” sahiptir (s. 12). “Aradalık” (ing. *betweenness*) terimi de alternatif bir terminoloji olarak kullanılmaktadır (Al Sayed ve diğerleri, 2014, s. 114, 117; Turner, 2007, s. 540; Thaler, 2020, s. 349).

Arkeolojide Mekan Dizimsel Analizeler

Arkeolojik çalışmalarda genellikle yeni bir bakış açısı sağlamak, mekansal verilerin çalışmalara yeni bir boyut olarak eklenmesi ve mevcut verilerin sentaktik bir temel üzerinde tekrar değerlendirilmesi gibi çeşitli amaçlarla mekan dizimsel yöntemlerin kullanıldığını görmek mümkündür. Bir çok arkeolojik araştırma arkeolojideki

mekandizimsel çalışmalara dair kısa tarihsel özetler içermektedir. Bu tez kapsamında Milet'in Roma dönemindeki şehir planı üzerinde bir analiz gerçekleştirildiği için arkeolojideki mekan dizimsel analizler bu bağlamda düzenlenmiştir.

Bahsedildiği gibi mekan dizim konusunda yapılan bir çok arkeolojik yayında daha önce yapılmış çalışmaları içeren bölümlere yer verilmektedir (bunlara örnek olarak bkz. Thaler, 2020; Morrow, 2009; Stöger, 2011; Fladd 2017; Assassi ve Mebraki, 2020; Fredric ve Vennarucci, 2021). Bunlar arasında Stöger (2011) ve Thaler (2020) benzer bir yaklaşımı takip ederek mekan dizimsel analizleri niceliksel ve niteliksel analizler içeren iki farklı grupta anlatmaktadır. Bunlardan Morrow (2009), Fladd (2017) ve Assassi ve Mebraki (2020) yeni dünya arkeolojisine odaklanmıştır. Diğer yandan, Cutting (2003), Fisher (2009; 2014), Laurence (1994;2005), van Nes (2009;2014) ve Stöger (2011; 2015) gibi yayınlar eski kıta arkeolojisine odaklanmıştır. Bahsedilen diğer bir çalışma, Doura-Europos'un iki yapı bloğundan elde edilen jeofizik verileri kullanarak bu yaşam alanılarının özelliklerini ve kamusal ve özel mekanların organizasyonunu yorumlayan ve sonuçları doğrulamak için kazı verileriyle karşılaştıran Benech'in analizidir. Bu çalışma, noninvasif bir anlayışla jeofizik verileri üzerinde mekandizimsel araçlarının kullanımını teşvik ettiği için önemlidir (Benech, 2007) (Stöger, 2011, 33).

Bu tezde önemle üzerinde durulan mekan dizim araştırmalarından biri Hanna Stöger'in Ostia üzerinde mikro ve makro ölçekte analizler gerçekleştirdiği doktora tezidir (Stöger, 2011). Bu çalışmada üç temel analiz metodunu kullanarak Ostia özelinde ve Roma kentsel planı bazında gerçekleştirilmiştir. Araştırma seçilmiş bir insula üzerinde gerçekleştirilen mimari mekan dizimsel analiz, Ostia kentsel planı üzerinde gerçekleştirilen bir erişilebilirlik ve hareket analizi, ve yine mimari ve kent ölçeğinde bir görünürlük analizini içermektedir (ing. *visibility*).

Stöger (2011) tezinde, "Roma Şehir Çalışmaları" bölümünde, arkeolojik bağlamda mekandizimsel araştırmasını geliştirirken ilham aldığı çalışmalardan Grahame (2000), Laurence (1994) ve Kaiser (2000) de dahil olmak üzere birkaç arkeolojik örnek çalışmaya yer vermiştir. Bu çalışmalar, arkeolojik araştırmalar ile mekandizimsel analizi bütünleştiren metodolojik yaklaşımlara genel bir çerçeve oluşturmaktadır.

Grahame (2000), Roma konut mimarisi üzerine yaptığı çalışmasında, yerleşim düzenlerini karşılaştırmak ve sosyal ilişkilerini açıklamak için 144 Pompei evinden alınmış örnek verileri kullanmıştır. Graham, daha önce standart olarak kabul gören sosyal kullanım alışkanlıklarını öngören geleneksel "homojen konut" konseptini sınamak için mekan dizimsel analizi kullandı ve herbir oda için potansiyel karşılaşmaları erişim analizi tekniklerini kullanarak gerçekleştirdi. Bunun sonucu olarak yaşam alanlarındaki farklılıkların bireysel tercihler doğrultusunda gerçekleştiği sonucuna vardı. Grahame'e göre bu durum, heterojenliği ve sosyal hiyerarşiyi göstermektedir. Bu bulguları çeşitli düzenler arasındaki lokal güç dinamiklerine bağlayarak, kentsel düzeydeki düzensizliklerin Pompeii'deki toplumun heterojen doğasından kaynaklandığı şeklinde yorumlamiştir. Çalışması, mekan dizimsel analizin potansiyelini gösterse de, kültürel verileri ihmal etmiş olmasi ve yalnızca konut yerleşimlerine odaklanmasından dolayi eleştirilere maruz kalmistir (Stöger, 2011, s. 28-30).

Laurence (1994), daha önceki tarihsel ve arkeolojik çalışmalarda ihmal edilen Pompeii kentsel mekanını sosyal kullanım ve işlev bağlamında incelemektedir. Bu çalışma tarihsel, edebi ve arkeolojik kaynaklardan alınan verileri beraber kullanmaktadır. Laurence atölye, ticari faaliyetler, hanlar, genelevler, mimari unsurlar ve sokaklara bakan kapı girişleri ile ilgili sayısal verileri kentsel düzendeki sokak aktivitelerini yorumlamak için kullanmıştır. Bu çalışmanın önemli özelliklerinden biri zamansallık boyutunu da yoruma dahil etme çabasıdır. Bu bağlamda günün belli zaman dilimlerinde kamusal etkileşimin nasıl düzenlendiğini edebi ve tarihsel kaynaklar üzerinden tanımlayıp kentsel bağlamda sokak aktivitesini zaman boyutu içerisinde ele almıştır.

Laurence gibi Kaiser'in çalışması Empuries üzerindeki çalışması, Roma'nın kentsel arazi kullanımına ilişkin daha önceki görüşlere karşı bir tutum sergilemektedir. Roma kentleri ile igili önceden benimsenen görüş Pompeii üzerinde araştırma yapan Raper'in (1977) kensel arazi kullanımının düzensiz olduğu varsayımına dayanmaktaydı. Raper bu teze karşı çıkmak için imparatorluk şehirleri hakkında arkeolojik kaynaklar, literatür ve mekan dizim analizlerinden den elde ettiği bir dizi veri kullanarak Empuries üzerinde bir araştırma gerçekleştirmiştir. Raper'in metodu bina formlarıyla bağlantılı on iki tanımlanmış nesne kategorisi kullanarak yaptığı

frekans analizi ve bunların mevcut harita kullanılarak tek tip bir ızgara sistemine yerleştirmeye dayanıyordu. Raper'in kategorizasyonları nesnelerin formlarına göre gruplanması üzerinden yapılmıştı. Kaiser ise bu kategorizasyonları binaların formuna değil fonksiyonuna göre yaparak Raperin metodunu geliştirmeye çalışmış ve bu verileri CBS tabanlı (ing. *GIS-based*) istatistiksel uygulamaları kullanarak kentsel mekanın sosyal boyutunu sakinlerin ve ziyaretçilerin (ing. *inhabitants and visitors*) bakış açısından açıklamaya çalışmıştır (Stöger, 2011, s. 33-35). Bu metod, benzer şekilde işleyen binaların gruplandırılabilmesine ve bu yapıların kent içerisindeki dağılımının ortaya çıkartmasına, ve bu verilerin sosyal yapı ile ilişkilendirerek site bazında karşılaştırmalar yapmasına olanak sağladı. Kaiser ilerleyen yıllarda Pompeii, Ostia, Silchester, and Empuries şehirlerini benzer bir şekilde incelediği *Roma Kentsel Sokak Ağı*'nı (ing. *Roman Urban Street Network*) yayınlamıştır (Kaiser, 2011).

Sonuç olarak sözü geçen çalışmalarda mekan dizim analizleri farklı alanlardan verilerle iç içe kullanılarak çeşitli arkeolojik sorulara cevap arandığı gözlemlenebilir.

Miletin Konumu ve Tarihi

Milet, Anadolu'da Ege bölgesinin batı kıyısında, Menderes Nehri'nin denize döküldüğü bölgeye yakın bir kıyı kentiydi (Sacks, 2005). Antik İyonya'da Latmos Körfezi'nin güney tarafında kuzey-kuzeybatı doğrultularında üç uzantısı olan bir yarımada üzerinde yer alıyordu (Gorman, 2020, s. 3-4). Strabon'a göre yarımadanın dört doğal limanı vardı (Akurgal, 1978, s. 206). M.Ö. 2500 civarında, yerleşim,bir grup adadan oluşuyordu ve bu adalar Menderes Nehri'nden gelen alüvyonların birikmesi nedeniyle sonunda bir birleşerek bir yarımada halini aldı (Brückner ve diğerleri, 2017). Bugünkü Milet yerleşimi, Dydima'nın yaklaşık 5 km kuzeyinde, bugünkü Balat köyünün yakınında ve denizden yaklaşık 10 km uzaklıktadır.

Milet Kentsel Planının Gelişimi

Milet planının tarihsel gelişimini detaylı bir şekilde Berthold F. Weber'in *Der Stadtplan von Kaiserzeitlichen Milet* yayınında incelenmiştir. Milet'te gerçekleştirilen ilk kazilari takip eden surecte kentsel planla ilgili çeşitli farklı hipotezler ortaya atılmıştır. Bu hipotezler Milet'teki araştırmaların ilk yillarından

itibaren yayinlanan planlarda gozlemlenebilmektedir. İlk yayinlanan planlar şehrin zaten görünür durumda olan merkezi yapilari ve bunlarla iliskilendirilen akslarla sinirlidir. Izgara planı ve insula yapısıyla ilgili bir önerme içeren ilk plan Theodor Wiegand tarafından 1911'de yayınlanmıştır (Weber, 2007, p. 332). Zaman icerisinde süregelen arkeolojik kazılar, yüzey araştırmaları, ve çesitli akademik çalışmalarla iyileştirilmiş ve güncellemelere tabii tutulmustur. 1990'larda başlatılan ve hala yürütülmekte olan jeofizik calismaları şehir planının anlaşılmasına önemli katkılarda bulunmuştur. Herald Stümpel tarafindan yapılan jeofizik çalısmalar neticesinde daha önce varsayımsal olarak belirlenmiş olan şehrin izgara plani daha net ve hassas bir biçimde tanımlanabilmiştir.

Milet ızgara planıyla ilgili en önemli düzeltmeler ızgara planı ile ilgilidir.Yapılan araştırmalar ve devam eden kazılar sonucunda Humeitepe ve Tiyatro tepesi arasındaki bağlantı bölgedeki Heroon ve Delphinion referans alınarak çizilen grid ile kurgulanabilmiştir. Bu iki bölge arasındaki ilişkinin ortaya çıkarılmasını takibeden süreç ve Stümpel'in 1993'ten bu yana yürüttüğü jeofizik çalışmalar neticesinde daha önce önerilen ve daha küçük insulalardan oluşan sistem daha doğru ve hassas şekilde güncellenmiştir. (Weber, 2007, s. 332-346)

Milet Kent Plani

Milet'in ana idari, ticari, kamusal ve dini yapıları, üç eski takımada ve anakara arasında birleşen iki ızgara sistemi üzerinde yer almaktadır (şek. 25). Kuzeyde yer alan en büyük takımada, Aslan Limanı adı verilen doğal bir liman oluşturmak üzere birleşen iki tepeden (Humeitepe ve Tiyatro Tepeleri) oluşur. Daha küçük olan ve güneybatıda yer alan diğer iki takımada, güneyde anakaraya bağlanır. Bu birleştirilmiş yer şekli, tümü ticari ve askeri liman olarak kullanılan üç doğal liman (doğuda Aslan Limanı, Tiyatro Limanı ve Athena Limanı) ve iki koy (Humeitepe ve Doğu Limanları) sağlar.

Kentin sokak ağindaki en belirgin cadde, batıda Kuzey Agora'nın doğu kısmı, kuzeyde Aslanlı Liman Kapısı, İyonik Stoa, Gymnasium ve Nymphaeum ile çevrili olan Törensel Cadde (ing. *Processional Street* olarak geçmektedir) olarak tanımlanabilir. Bu cadde güneyde Güney Agora'nın kuzey girişinden batıya doğru uzanarak Tiyatro tepesi, Tiyatro Limanına ve kentin güney kesimlerine

bağlanmaktadır. Bu cadde güneyde Roma Heroonu ve depo binasının bulunduğu insulaların arasından geçerek bu tezde kuzey-güney aksı (ing. *north-south axis*) olarak bahsedilmiş olan caddeyi keser ve Tiyatro Tepesi bölgesinden Humeitepe'ye ve çoğu ticari, kamu ve idari binalara ulaşım sağlar. Kuzeyde Demeter Tapınağı çevresi, doğuda Humeitepe Limanı ve istifleme alanı (ing. *stacking area*, bkz. Thurn, 2020) arasında bağlantı sağlayan, zengin bir konut alanı (ing. *rich houses*, bkz. Huy ve Weissova, 2020) bulunduğu düşünülen Humeitepe'nin ana caddeleriyle ise Delphinion önünden Aslanlı liman kapısı aracılığı ile Törensel caddeye bağlanır (Thurn, 2020) (Huy ve Weissova, 2020)

Aslanli Liman, Humeitepe ile Tiyatro Tepeleri arasında yer alan doğal bir liman bölgesi üzerine yerleşmiştir. Liman bölgesi doğuda Humeitepe Hamamı ve Delphinion, güneyde ve batıda Kuzey Agora ile şekillenir. Liman girişi ise Kuzey Agora ile Delphinion arasında yer alır. Limanın batı bölgesine doğru devam eden güzergah üzerinde iki anıt bulunur ve Kuzey Agora ve Sinagog arasından geçen bir sokağa bağlanır.

Daha güneyde üç cadde ve kuzey-güney (*north-south axis*) ve kuzey doğu-batı (*northern east-west axis*) ekseninin kesiştiği bölge, kuzeyde Tiyatro binası, batıda Tiyatro Limanı, güneyde Faustina Hamamları, depo binası (ing. *Storage Building*) ve Serapeion ile çevrilidir.

Milet Kent Planının Analizi

Daha önce bahsedildiği gibi bu tezde Roma dönemi Milet kensel planı mekan dizimsel analiz metodlarından eksenel entegrasyon analizi ve eksenel segment entegrason ve seçim analizi araçları kullanılarak analiz edilerek kent içerisindeki erişim ve hereket örgüsü ortaya koyulmaya çalışılmıştır. Eksenel entegrasyon analizi n, 2 ve 3 adım derinliği için uygulanmış, global ve lokal erişim örüntüleri ortaya çıkarılmaya çalışılmıştır. Diğer yandan eksenel segment analizleri entegrasyon ve seçim değerleri için 1000, 800,400, 250, 100m analizler çaplarında gerçekleştirilmiştir. Bu analizler yorumlanırken Hillier'in (2008, p. 2) hereket ekonomisi (ing. *movement economy*) kavramı göz önünde bulundurulmuştur (ayrıca bkz. Hillier ve Iida, 2005). Buna göre 1000 ve 800 metre çaplar için öngörülen

entegrasyon ve seçim değerleri taşıtların hareketlerini temsil ederken, 400 metre ve daha küçük olan çaplar için öngörülen değerler yaya hareketini temsil etmektedir.

Özetle bu tez Milet sokak ağı üzerindeki erişim ve hareket örüntülerini mekandizimsel analiz metodlarıyla inceleyerek Milet özelinde mekandizimsel analiz metodlarının uygulanabilirliği konusunda bir değerlendirme sunmayı amaçlamaktadır. Bu analizleri gerçekleştirmek için gerek duyulan kentin ızgara sistemi ve sokakları bu güne kadar yayımlanmış olana kazı, yüzey araştırmaları, tarihsel veriler ve jeofizik çalışmalarından yararlanarak hipotetik bir plan oluşturulmuştur, non-invazif bir anlayış benimsenerek Milet özelinde ve kent ölçeğinde bir analiz orta koyulmaya çalışılmıştır.

Bu tez hem Milet özelinde hem de mekan dizimsel analiz metodlarının kent ölçeğinde uygulanması bağlamındaki sınırlayıcı faktörlerin ortaya koyulması ve devam eden süreçte mekan dizimsel analiz yöntemlerinin uygulanmasında ihtiyaç duyulabilecek yeterliliklerin örneklenmesi açısından literature katkıda bulunmayı amaçlamaktadır.

Analiz sonuçları mevcut kazı ve güncel yayınlarla tutarlı olabilecek veriler sağlamasının yanı sıra Milet özelinde erişim ve hareket örüntülerinin varsayımsal olarak ortaya koyulmasını sağlamıştır.

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