
Heraklion - Chania:

A study of the evolution of its spatial and functional patterns

CONTENTS

ACKNOWLEDGMENTS.....	I
ABSTRACT	II
1. INTRODUCTION	1
2 BACKGROUND.....	4
3. THEORETICAL FRAMEWORK.....	7
3.1 STRUCTURE AND ORDER	7
3.2. MOVEMENT AS THE FORCE OF URBAN SYSTEM	9
3.3 CENTRALITY AS A SPATIO-FUNCTIONAL PROCESS.....	9
4. DATA AND METHODOLOGY	11
5. HISTORICAL REVIEW	13
5.1 HERAKLION: HISTORICAL EVOLUTION OF THE SETTLEMENT	13
5.2 CHANIA: HISTORICAL EVOLUTION OF THE SETTLEMENT	18
5.3 FINDINGS	23
6. AXIAL ANALYSIS	24
6.1 HERAKLION	24
6.2 CHANIA	24
6.3 COMPARATIVE ANALYSIS	25
7. SYNTACTIC ANALYSIS	26
7.1 HERAKLION	28
7.2 CHANIA	32
7.3 FINDINGS	36
8. FUNCTIONAL ANALYSIS	36
8.1 HERAKLION: FUNCTIONAL PATTERNS	37
8.2 CHANIA: FUNCTIONAL PATTERNS.....	40
8.3 FINDINGS	42
9 .DISCUSSION.....	42
10 .CONCLUSIONS.....	44
PLATES.....	III
11 .APPENDIX	45
12. REFERENCES	52

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Abstract

This thesis is a comparable approach to the evolution of spatial and functional patterns of two Cretan cities: Heraklion and Chania. The starting point of this research is the different functional patterns of their contemporary old historical cores. This thesis aims at investigating the reasons that led to this difference. The research is based on the conjecture that it is the morphology of their grid that differs and this aspect is reflected on their different functional pattern. The analytical method employed is “space syntax”. Through this spatio-analytical method the research investigates the spatial organisation of these two Cretan cities in their stages of development and the evolution of their functional patterns. The study is based on the concept of “live centrality” as a spatio-functional process, which every urban system reinforces. In the light of this theoretical framework and through its analytical methodology this thesis explores the relation between the spatial and functional patterns of both cities.

1. Introduction

This study focuses on two “organic” cities: Heraklion and Chania in Crete. The term “organic” is used in contrast to the planned cities, being products of a pre-conceived plan. Both cities comprise an historical centre, encircled by the rest of the cities. These two contemporary settlements differ in terms of the function of their historical centres. Therefore, today the older part of Heraklion still remains a significant spatial element, which functions as the core of the urban tissue. On the contrary, the old historical core of Chania functions as tourist attraction, and thus the urban buzz seems to have been displaced outside the old historical centre.

This paper aims at investigating the following question: *why do the historical centres of these two cities function differently today?* The paper suggests that there is a question whether these different functional patterns are the product of a pure chance, a historical accident or of spatial factors such as the location of particular facilities or attractions. However, what underpins the whole study is the conjecture that is the morphology of the grid, which differs, and particularly the way in which the old city has expanded gradually in order to create the current urban fabric. The previous statement suggests that the spatial configuration of each city, throughout its evolution process and its influence on movement and the distribution of land uses may have led to different functional patterns.

The research is conducted through the spatio-analytical methodology known as “space syntax”. This analytical method is based on the notion that the relation between human agents and space is governed by two kinds of laws: the laws of spatial emergence, by which the larger-scale configurational properties of space follow as a necessary consequence from different kinds of local physical intervention; and the laws of “generic function”, by which constraints were placed on space by the most generic aspects of human activity like this one of occupying space or moving between spaces.(Hillier,B.,1996,p.335).

Therefore, the research aims at revealing the genotypical characteristic of both cities. This paper is a comparative approach to the urban structure of these two contemporary “organic” cities. Thus, it attempts an analytical investigation of their

urban space and structure through their evolution process. The previous statement is based on the belief that the spatial structure of the city is a dynamic product of the interaction between the forces, which tend to change the built fabric of the city and the forces that which tend to retain it. Both contribute to the investigation of the rules, which govern the emergence, and growth of organic cities. However, the analysis can also reveal how these features have been transformed through the imposed economical and social forces of each society. In the light of “space syntax”, the paper suggests that the underlying structure of both cities, that is the pattern of differences of the grid seems to describe the differences in movement rates and in the distribution of land uses through the principles of “natural movement” and “movement economy”. Therefore, my specific hypothesis in terms of the research question, is that there may be differences in the patterns of spatial evolution of these settlements which might provide the basis of the investigation of this study embedded in the theoretical framework described above.

The “natural movement” is the proportion of movement in the spaces making up a grid, which is occurred due to the grid configuration rather than the presence of specific attractors. The principle of “movement economy” describes a process in which the distribution of land uses is linked generatively through the by-product effect to the grid configuration. The by-product effect in terms of urban movement appears in the forms of sequence of spaces that are passed through on the way from origin to destination between the functions in the network. Thus, the “movement economy” describes the complexity of cities as a mixture of busy and dense mixed-use areas and quieter and homogeneous residential areas. Based on these two principles the concept of centrality is conceived as spatio-functional process. In terms of its spatiality, it is described both of the overall configuration of the grid and of the local grid conditions. Both of them suggest a dynamic, which the theory of “movement economy” captures. According to this theory, the “centre” is spatially identified as having an intensified local grid. The latter has been produced due to the principle of “movement economy” and it is further reinforced by the same principle according to the following procedure. The concept of “centre” implies the presence of functions, which benefit from movement. This aspect attracts greater movement according to the principle of “movement economy” and thus in the “centre” the blocks become smaller in order to enable movement. The latter procedure suggests the intensification of the grid (Hillier B, 2000).

The paper begins with establishing a theoretical background to this comparative study. In this part concepts like this one of the “organic city” versus the planned city or the “regularity” versus the “irregularity” are developed. Additionally, there is a brief description of the urban theories such as this one of “space syntax” articulated by Hillier,B. and Hanson,J.; and this one of fractal cities expressed by Batty,M., both developed as an attempt to explain the complex nature of cities

and consequently their physical evolution. The study focuses on the theoretical framework of “space syntax”, where concepts like “centrality” and ultimately “live centrality” are developed; both are strongly influenced by movement according to the theories of “natural movement” and “movement economy”, Continuously, the paper represents the research procedure. The study reviews the historical development and growth of each city in an attempt to find if there are any historical clues related to their different functional patterns. Apart from the spatio-functional aspects the historical review also includes details about the socio-economical forces of each settlement and their changes throughout the historical process. However, considering the specific hypothesis of this study what seems to give the answers to the initial research question is the spatial analysis of the evolution of the grid of both cities. For this study the urban grid is the pattern of public space linking the buildings of the settlements. The analysis of the historic spatial evolution of both cities is based on maps, provided by the local authorities and old historical maps. The study focused on the comparative scale of all the maps of both cities. These maps describe a similar historical process. Both aspects justify the comparative spatial analysis of the cities. Hence, for Heraklion the axial maps refer to the following years: 1668-69, 1936, 1960 and 1990, while for Chania the axial maps refer to the years: 1660, 1905, 1947, 1963,1990. As far as Heraklion in 1668-69 is concerned, the axial map has been based on one original plan designed by Hans Rudolf Werdmuller¹. Accordingly, for Chania in 1660 and 1905, the axial maps are based on a map designed by Fr. Collignon and a map surveyed by W. Chapman². The spatial structure as this has been revealed from the syntactic analysis is related with the changing functional pattern during every city’s historical process, whenever the appropriate data have been available. Hence, for Heraklion the study has plotted the distribution of land uses, in terms of the maps of 1666-68, 1960 and 1990. As for Chania, the distribution of land uses has been mapped in terms of the maps of 1905 and 1990. Because of the limited available maps and the limited historical data the study has resembled to the detective work, having imperfect data. However, the study has explored the relation between the findings of spatial analysis of the evolution process for both cities and their functional patterns. Therefore, the paper ends with a discussion regarding the findings of the research, in the light of concepts developed in the theoretical framework and the initial research question.

¹ The source of this map is the original plan der Festung Candia gezeichnet in den Jahren 1666-68 von Generalleutenant Hans Rudolf Werdmuller, Library of Zurich. The information about the map are provided in Steriotou, I. (1998) Τα Βενετικά Τείχη του Χάνδακα (τον 16^ο και τον 17^ο αι.). Το ιστορικό της κατασκευής τους σύμφωνα με βενετικές αρχαιακές πηγές. (The Venetian Walls of Chandakas (the 16th and 17th centuries). An account of their construction according to Venetian archival sources). “ Vikelaia Municipal Library, Borough of Heraklion, Heraklion

² Fr Collignon: Fifteen plans of fortifications in Candia(Catalogue of the printed map) 1660, map surveyed by W. Chapman, Chanea, or Khania; both found in A. S. Kalligas -A. G.Romanos (1977), The Medieval City of Chania, Chania

2 Background

The notion of “organic” city has its roots to the biological metaphor in city planning appeared since the 16th century. It was then, when man first began to explore the reality beyond the myth towards the scientific study of the body and when the analogy became one of the dominant ways of making progress in all the sciences (Batty et al., 1994, p.31). The analogy describes the visual characteristics of the city and seeks similarity between the urban elements and the human organs. Usually, the organic cities are described as opposed to the preconceived or planned cities. The key distinction between these two modes of urban formation can be summarised as follows: first, the city as a product of a pre-conceived plan ordered in terms of pure geometry; second, the city as a product of a diversity of local decisions over a long period of time.

Throughout history, all the cities have been classified between those, which grow “organically”, and those, which have been “artificial” or “planned”. However, the boundaries between the organic and the planned cities are ambiguous. According to Batty, cities can display a mixture of these two styles. However, there are some determinants, which clarify the description: first is the speed at which cities change and second is the scale of every development. Thus, he argues that organically growing cities develop much more slowly than those which are planned and at much more smaller scale since they are grown based on some individual decisions and not on one well-defined strategic (Batty et al., 1994,p.8).

However, what seems to describe better the “organic” cities is the notion of “irregularity”. Thus, unlike the regular patterns, organic forms do not create obvious geometrical orders, as they have been expressed in Euclidean geometry, such as symmetry, alignment and so on. However, the notion of “irregularity” has not been conceived as equal to “disorder” or “chaos” by recent urban theorists. Therefore, the issue of “irregularity” of the urban grid has been approached either by employing a new form of geometry which seeks deeper patterns of order, or by broadening the concept of “order” to include the ways people use or perceive the urban grid.

The first approach describes the theory of the fractal cities and the application of fractal geometry in urban theory (Batty et al., 1994). This theory invokes the tradition that sees cities as simple ordered structures, which describe their overall morphology and the disposition of their elements. Batty focuses on cities as complex organisms, which evolve and change according to local rules as a result of a more global order across the scales and time. In this theoretical framework, system structures are defined as being comprised of elements and

relations. According to Batty there are many ways to describe the term “elements” in relation with the disciplinary perspective of each theory. Many of these approaches can be spatial or not. However, what seems to be emphasised is the fact that the most obvious way to describe cities is in terms of the way they develop. Thus, the elementary component of a city can be seen as an elementary unit of development. All together through a system of communication networks, which links them together along with all the related functions, which have their own networks, they compose a complex, which cannot be described by the traditional concepts of Euclidean geometry. With the previous statement Batty defines the framework within which the theory of fractal cities is developed. Therefore, this urban approach is through tracing the invisible structure of networks and relations which underlies “... the outwards appearance of cities, using ideas involving hierarchies and networks and searching for functions which are consistent with the shape of cities and their evolution” (Batty et al., 1994, p.44).

This urban theory’s basic “organic” model focuses on the centre, usually containing the origin of growth. The latter continuously processes around the centre in waves. Sometimes radial lines of transportation along with growth proceeds faster, interrupt this process due to an increased access to the centre. Thus, the star-like shape resembles the ultimate form of the city. The following model by Doxiadis (1968) in *Ekistiks* represents this abstraction (*Fig. 1*). However, Batty argues that this model presumes that the process is not constrained by the need of a defensible wall; since the walls embracing towns in Middle Ages and beyond tended to minimise any radial distortion of the structure. He also claims that medieval towns despite the lack of an overall geometric plan, their small size, the density of their development and the intensity of use usually led to a considerable co ordination and control of development in social and economic terms, which ultimately would have had an impact physically. Thus, according to the theory of Fractal Cities the organic model as it features in *Fig. 1* it is not a representation of the real growth but an abstraction (Batty et al., 1994,p.33). For Batty the medieval town represents the last example of the slow growth of the “organic” city. By 17th century both American and European cities were led to be much bigger and much lower density cities due to the improvement of the transport systems or building technology. Batty argues that the walls were the first to be abandoned; thus enabling the urban growth to follow the star- like shape.

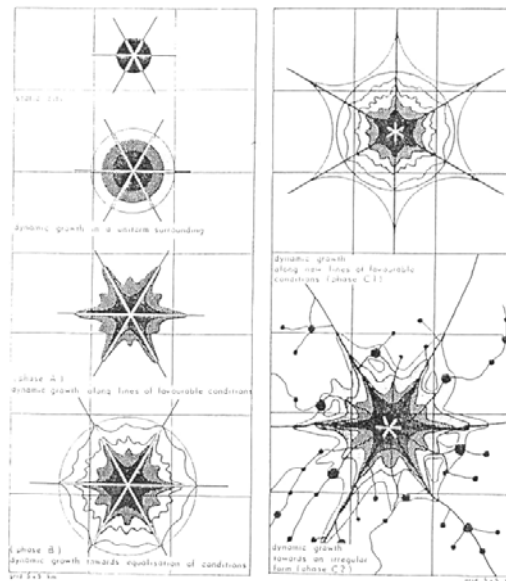


Fig. 1 The shape of the organically growing city by Doxiadis, *Ekistics*, 1968

The second approach, that is the broadening of the concept of “order” in order to include the way people are using or perceived the “regular” or “irregular” grid has been developed within the theory known as “space syntax”. “Space syntax” theory suggests that it is not the geometrical notions of spatial order that explain the nature of cities and buildings but the spatio-functional patterns, which are closer to topology than geometry (Hillier, B, 1999). In this framework, the urban grid itself creates the urban life, as generating the “city creating” process, while at the same time it is shaped by social forces which also function through autonomous spatial “laws” (Hillier, B, 2001). The latter are described as a system of possibilities, which can be used by individuals in order to achieve spatial and social effects. The grid is formed by the islands of building blocks that define the open space. This is continuous system of space that has a degree of “regularity” or “irregularity”.

3. Theoretical Framework

3.1 Structure and Order

In the light of “space syntax” framework, which is the spatio-analytical methodology of this study, Hanson J. distinguishes the concepts of order and structure based on the notion of city as manifested many variables, which cannot be reduced in the concept of the geometrical order. Thus, the concept of order is used “... in the sense of principles based on some generally accepted notion of sameness, repetition, geometry, grid, rhythm, symmetry, harmony and the like”; while the structure is used “...in the sense of making place intelligible through creating local differences which give both a sense of identity and a grasp of the relation between the parts and the whole, such that we are reliably to infer the global form from any position within it” (Hanson, J. 1989).

The previous distinction between *order* and *structure* is particularly clear considering two different town plans. The first one is this one of the ideal city of Palmanova (Fig. 2) and the second is this one of an organic real city like this one of Candia (later on named Heraklion) in Crete in 1666-68, as one of the case studies of this research (Fig. 3)³. The ideal town in Fig. 2 is dominated by rational *order* and can be grasped as a single concept, having a geometrical and “simple relational nature” (Hillier, B., 1996, p.234). On the contrary, real towns like the one in Fig.3 appear to be *disordered*, considering the previous definition of *order*. However, Candia in Fig.3 has *structure*, as it has been defined above, which is always discovered by human agents who are moving and living within it.

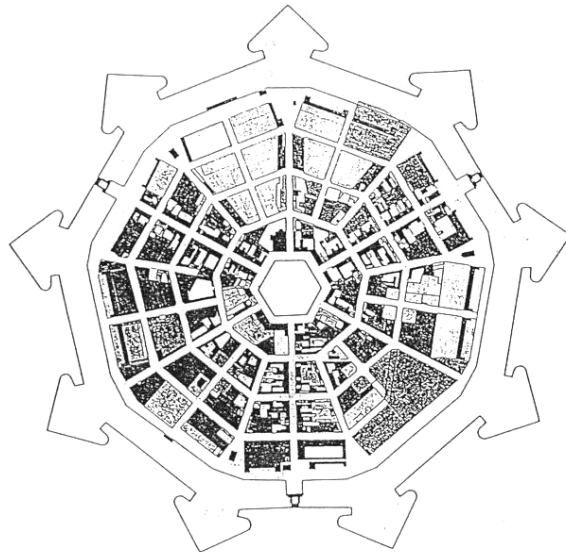


Fig. 2 The ideal city of Palmanova

³ For details see Footnote 1



Fig.3. Candia (Heraklion) 1666-68. The original plan der Festung Candia gezeichnet in den Jahren 1666-68 von Generalleutnant Hans Rudolf Werdmüller, Library of Zurich.

Hillier B. introduces *time*, as one of the aspects of space (Hillier, B., 1996). *Time* describes the peripatetic model of space, through which human agents understand space. Hence, it is the movement, which occupies time and which human agents use in order to overcome space. However, visibility is what substitutes for movement, “expanding space metrically brings more of it into a single space-time frame” (Hillier, B., 1996, p.233). Thus, moving about within a spatial complex such as the real town of *Fig. 3*, successively *synchronises* different spatial relations. In this space-time framework, the plan of the Palmanova can be grasped as a pattern *synchronously* because it is consisted of similar parts with similar relations. According to Hillier, B. this complex can be easily grasped because of the repetitiveness it bears and this is called *order*. However, this order cannot be seen from inside. Moving inside a geometrical ordered city, where similar elements having similar relations among them, confuses the observer. Instead, in the organic town of Candia there is little repetition, if any, considering the elements or their relations. However, all the organic towns have a powerful spatial patterning, which is interrelated with a functional pattern. These interrelated patterns Hillier B. calls *structure*. This structure is *asynchronous*, that is it cannot be seen all at once; but it is through the movement and everyday space use, that this is understood.

3.2. Movement as the force of urban system

In this theoretical framework the urban grid emerges as a “core urban element which in spite of its static nature, strongly influences the long term dynamics of the whole urban system”, while movement emerges as the “strong force that holds the whole urban system together” (Hillier B, 2001). The fundamental pattern of movement is generated by the urban grid. The urban grid is the pattern of open space whose “structure” emerges by expressing it as axial map⁴ and analysed configurationally. Thus, the urban grid is conceived as a system of “configurational inequalities” which generates a system of “attractional inequalities”, that is a pattern of different land uses, of different densities. The previous statement can be summarised in the argument that the spatial configuration generates the attraction.

The previous arguments manifest what space syntax theory seems to describe better, which is that spatial configuration through their effect on movement, shapes and ultimately, is shaped by land uses pattern and densities. The effect that spatial configuration has on movement patterns is captured through the measure of integration. Movement occurs at different scales: the globalised and the localised. The previous can be explained if we consider that long journeys tend to pass from spaces, which are globally more integrated, while shorter journeys, and thus local ones, tend to pass from spaces, which are locally integrated. Hence, the key to understand the structure of the urban system, that is the part and whole, is to understand the relation between the different scales, or in other words the relation between the different radii of integration. The interface between the different radii of integration, which can be realised spatially differently, is the means through which functional pattern is developed. Hillier, B. argues that “Historically, it seems cities exploited movement constructively to create dense but variable, encounter zones to become what made them useful: to be “mechanisms for generating contact” (Hillier, B.,1996, p.174).

3.3 Centrality as a spatio-functional process

The analysis of every urban settlement is usually concentrated on its centre. In the theoretical framework of “space syntax”, the term “centre” can be described of both functional and spatial elements. Thus, functionally, it means a concentration and mix of activities in a particular area, which spatially, it refers to

⁴ The axial map is the longest and fewest lines of direct movement that pass through all the open, public space of one settlement and makes all the connections (Hillier, B., 2001).

a certain position considered the settlement as a whole. However, what seems to remain ambiguous is whether this centre remains stable or there is a dynamic process which leads to its gradual displacement. Considering the “centre” having its own dynamic, the problematic is developed around whether this one is related only with economic or planning decisions or there are some spatial aspects which tend to push the centre one way or another (Hillier, B., 2000).

Therefore, the previous statement justifies the search for a spatial model of the key component of the urban concept of the “centre”; the “live centrality”. The term “live centrality” refers to the element of “centre” which is led by functions such as the retail, markets, catering and entertainment and all the other activities that benefit from movement. The “live centrality”, in terms of its functional elements, is distinguished from other central functions such as administration, religion or office employment. The former requires a distinctive spatial component, which is described by the spiral effects on the urban grid, and the distribution of land uses of movement through the principles of “natural movement” and “movement economy” as they have been already described above. The “movement economy” is responsible for the intensification of the local grid and the land uses choices, which both ultimately lead to an apparently network of higher and lower intensity areas. Locally the spiral effect can be specified furthermore by noticing that the “movement economy” process also selects for the “live centre “ locations with certain local grid conditions. However, the same process also works globally by selecting locations which have the appropriate degree of integration regarded the settlement as a whole. As it has been mentioned above, the measure of integration captures the effect that spatial configuration has on movement patterns.

According to Hillier, B, both processes are dynamic. Consequently, the growth of settlements changes the pattern of integration and this finally can cause a displacement of the location of “live centrality”. Usually, but not always one can notice an outward shift of it. Locally, the growth of settlements cause smaller block size or “islands” such as to allow greater and easier movement within the centre that is the local intensification of the grid. The greater the scale of the centre, the stronger this process is.

In terms of the historical cities such as the case studies of the present research, the growth of the cities creates a displacement of the centre of the historical and elementary core towards what once was an edge. However, what seems to enrich furthermore the understanding of the complex process of the urban growth is the fact that there is a simultaneously local process of creation sub-centres. Therefore, according to this argument, in historic cities the functional specialisation of sub-areas that one finds into the historic centre will be transformed as the urban grid grows, into distinct sub-centres with different

functions. And thus, the problem of centrality takes the form of including the “hierarchy of centres and sub-centres” (Hillier, B., 2000).

In terms of the present study, which is an investigation of the present spatial structure and functional system of two different historic cites and ultimately of their evolution process, the concept of “centrality” seems to be its foundation. However, the analysis of it above manifests that it is essential for this study and for every understanding of the urban settlements, to be conceived as dynamic spatio-functional process.

4. Data and Methodology

Since the research is an analytical investigation of the *structure* and its transformations of two “organic” cities Heraklion and Chania in Crete, the axial map of each city throughout its historical process appears to be its basic research implement. The axial maps, mainly provided by local authorities, as they have been named in the introduction have been related to the changing distributional pattern of land uses whenever the data have been available. Hence, for Heraklion the main sources of data have been a research conducted in 1966 by the architect A. Proveleggios for Heraklion and a complete report conducted in 1998 by the Ministry of Environment of Greece also for Heraklion, both provided by the local authorities.⁵ The data collected as mentioned above, have been completed by other documents and researcher’s observations. As far as Chania is concerned, the main source of data has been a research conducted in 1977 by A. S. Kalligas - A. G. Romanos for the medieval town of Chania, provided from the local authorities. However, these data have also been completed by other documents and by researcher’s observations.⁶

The methodology of the research required from the researcher to establish the research question, which focuses on the different functional patterns of the two case studies. In an attempt to investigate the reasons of the different functional pattern between Heraklion and Chania, the study makes a historical review of the two settlements. This review includes also some of aspects the socio-economic evolution of both cities. However, in terms of the hypothesis of this study the analysis of the spatial evolution of the two settlements is realised through the comparative axial analysis during the historical process of each city. This analysis has revealed the spatial structure of each town. The structure of the historical core and its evolution has emerged clearly from the axial analysis of the

⁵ For more details about the reports mentioned, see References.

⁶ For more details about the research see References

core itself separated from the surrounding urban structure. The spatial analysis comprises the integration analysis radius_n (global integration) and radius_3 (local integration) of Heraklion's and Chania's axial maps. The spatial analysis stresses on the radius-radius analysis of the contemporary settlements. For Heraklion in 1990 this analysis was set at radius_8 while for Chania in 1990, was set at radius_9. The radius-radius analysis is always set at the mean depth of the whole system from its main integrator. The effect of this analysis is that each axial line is analysed at the same radius, and thus the globality of the analysis is maximised while the tendency that the edges of the system have towards segregation (edge-effect) is minimised. (Hillier, B., 1996, p.163). This radius-radius integration analysis gives some true picture of how the city functions because of the powerful effect that natural movement has on the evolution of urban pattern and of the distribution of land uses. These effects have been already described in the theoretical framework of this study.

Having analysed the historic spatial evolution of both cities, the study focuses on mapping what is known of the functional pattern of both cities-case studies. As far as the land uses is concerned, retail and market are identified as the functions which are related with the concept of "live centre" and which have been developed above. Both of them are distinguished from other central functions such as administration or banks, in terms of the specific spatial conditions that require or even more they generate. In the light of "space syntax" theoretical framework, both functions are strongly bound up with the "natural movement" in contrast to movement, which often occurs because of the presence of certain attractors. The previous argument is described by the theory of "natural movement" and "movement economy", described above. Hence, for this study the functional patterns both of Heraklion and Chania comprise activities like the retail, the food market, the administration and the bank employment.

The initial research question is based on the different functional pattern of two cities, as this one has been already expressed. This difference mainly is expressed through the interface between the movement of the inhabitants and this one of strangers which entering and leaving the city. Therefore, for this study land uses have been mapped based on the elementary distinction between these that are related with the inhabitants and those, which are related with the strangers. In this framework, the study introduces a further distinction regarding retail; this one between boutiques and tourist shops. In some cases like the functional pattern of Chania in 1990, or this one of Heraklion in 1960, the study includes some special shops, selling handicrafts clustered in a certain location. Hence, land uses for both cities have been divided into the following categories: food shops, boutiques, tourist shops, administrative buildings and banks.

Finally, the study explores the relation between the functional and the historic spatial analysis of the two settlements, embedded in the theoretical framework,

described above. The latter constitutes the problematic of this study in terms of the initial research question.

5. Historical review

5.1 Heraklion: Historical evolution of the settlement

Heraklion is located in the middle of the north coast of the island of Crete. It is placed on the east-west main axis of the island, which relates all the large settlements of the island: Heraklion, Chania, Rethemno, St. Nicolas, Sitia. As far as its topography is concerned, the city has been formed into a valley between two minor rivers, which today are dry: Karteros and Giofiros. The extension of the city in terms of its east-west axis is about 20-30m above sea level, while its extension towards south is about or over 150m above sea level.

Despite the fact that there are records in terms of the urban structure and the morphology of the settlement after 9th century, the city appears to retain the same location since the first Byzantine period of Crete (330 - 823a. C.). During these centuries there were a lot of physical disasters and wars; however, the city had been always rebuilt on the same location.

The history of the settlement originates from the Minoan era, when Knossos was the capital city of island of Crete for more than 10 centuries and Heraklion was the harbour serving the roman Knossos. However, there are historical records for a settlement on the same location, named Heraklion during 480-67b.C., when the main city of Crete was Gortina. In 824 a.C. Arabs, who had occupied Crete constituted Heraklion, renamed as Castro, as their main settlement. In an attempt to protect it they built walls embracing it, encircled by a deep ditch (arabic: chandak), Because of this ditch the city was renamed as Rabdh el Chandak (english: the fortress of ditch).

During the second Byzantine period of Crete (961-1204a.C), its occupants used the foundations of Arabic walls and extended them onto the north side, towards the harbour (Georgopoulou, M., 2001). The settlement was developed around one main road which led from its centre towards the harbour. Today, the same road, named 25th Avgoustou functions as the main road which leads from the "centre" towards the sea and thus it is related with the movement of strangers who leaving or entering the city.

In 1211, when the Venetians occupied Crete, Candia (Heraklion) was reorganised and had its fortifications restored. Gradually, the city began to expand outside the walls (*Fig.4*). Therefore, Venetians decided to rebuild and

reinforce the fortifications in order to embrace the whole settlement, with all the formed suburbs (burgi), as an attempt to protect the settlement from the neighbours Ottomans, who had already threaten the Venetian sovereignty. The rebuilding of the walls started in 1462 according to the designs of Sammicheli, M. Thus, Candia became the most known fortress of the Venetian Empire in the eastern Mediterranean. In 16th century all the residents of Candia were divided in habitator Candidae, these who were living inside the walled city and habitator burgi Candidae, those who were living outside of it (Georgopoulou, M., 2001). The walls as the dominant spatial element of the settlement, provided "...psychological reassurance for the city dwellers by dividing, enclosing, and rendering space exclusive." (Georgopoulou M., 2001, p.48). Therefore, all these functions that constitute a city such as administrative buildings, churches and marketplace were located inside the city walls. The backbone of the settlement remained the same street as this one of the Byzantine settlement, known as Ruga Maistra. This street led to the central square of the settlement, this one of St Markos, a place of commercial and economic transaction, under the control of the authorities (Georgopoulou, M., 2001,p.48) (Figs. 3,5).

In 1669 Ottomans occupied Candia after a siege of 25 years. The long-term siege destroyed the settlement, while the majority of its citizens fled to other regions of the Venetian empire. In 1700 the French traveller Tournefort L.P. described the settlement as "city's skeleton" (Tzobanaki, Ch., 1996, p.85) (Fig. 6).



Fig.4 Heraklion-Chandakas. Plan by C.Buondelmonti, 1419

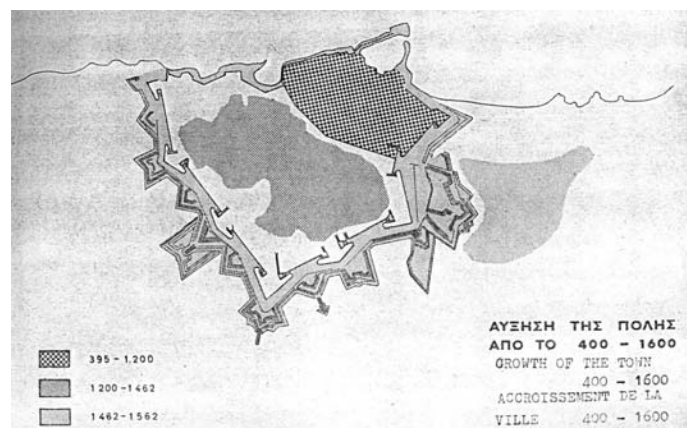


Fig. 5 Heraklion- Chandakas: The growth of the city from 400-1600

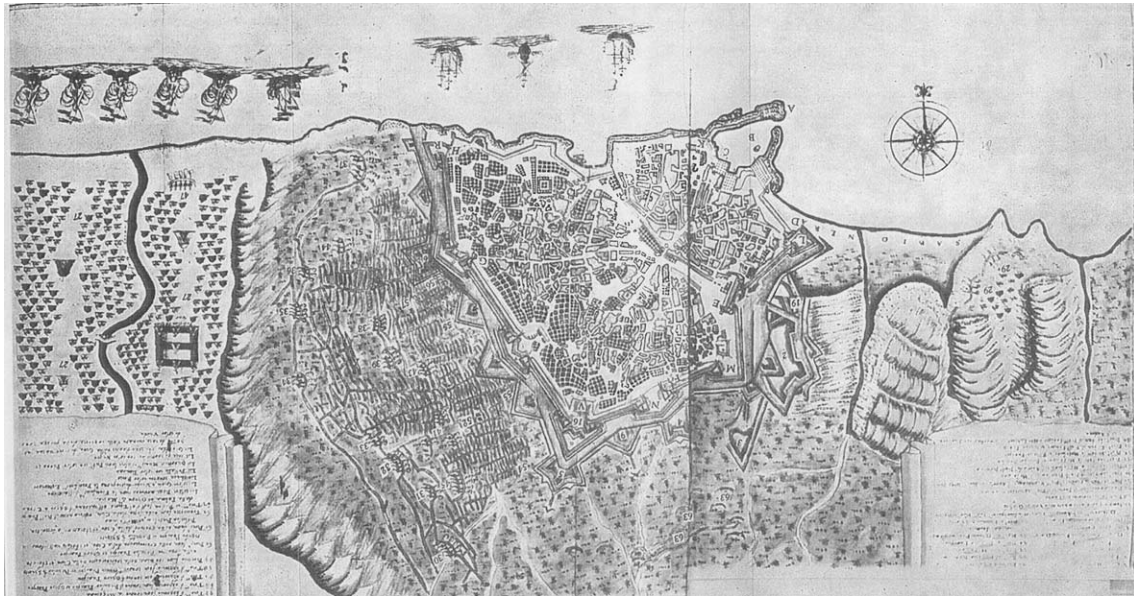


Fig. 6 Heraklion - Chandakas: Under siege by Ottomans, 1667. B M V.- It. CI VII 200 (10050). Relazione della Mossa...contro...Venezia...1645...1669. No. 110, cc. 227-228. In 1669 Ottomans occupied Candia after a siege of 25 years. The long-term siege destroyed the settlement, while the majority of the citizens fled to other regions of the Venetian empire.

Heraklion at the end of 19th century had been the most important urban and commercial centre in Crete. Thus, at the beginning of 20th century, there was a lot of discussion about planning the new city. The first plan of the city took place in 1901. However, what seems to be more significant is this one of 1936, when the city had already started to expand outside the walls. Since 1930 the city had expanded outside the 4 entrances of the Venetian walls along the streets that originated from the old city and heading towards other settlements (*Figs. 7,8*). The dominant idea of the plan of 1936 was the increase of the density of the city inside the walls, within which all the central functions of the city should have been located (Tzobanaki,C.,1996, p.91). The following years, the needs for spare room increased. These needs were satisfied through the construction of multi-storey buildings and the transformation of some parts of the urban grid. The following plans of the city had not changed the urban fabric. Hence, what seems to emerge from this brief description of Heraklion in 20th century is that the old core of the city has been remained the “live centre”, that is where the urban buzz is located (*Fig. 9*).



Fig. 7 Heraklion at the beginning of 20th century. The expansion of the city outside the walls

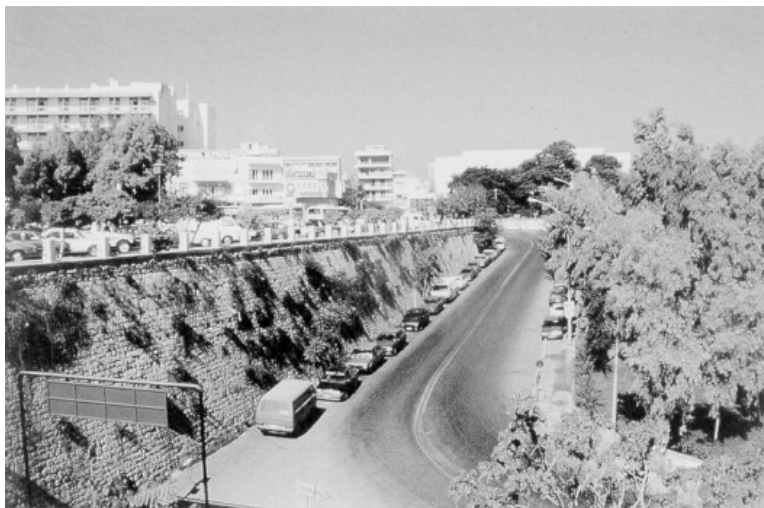


Fig. 8 Heraklion in 1995. Ikarou Str, connecting the old and the new city, being on the trace of the area of Fig.7



Fig. 9 Heraklion, during the late 20th century. Plan of the old historical core. The red circle indicates the location of Figs 7 and 8.

Today, Heraklion maintains the same structure as this one of the early 20th century, mainly in terms of the southern and the western part of the contemporary settlement. The old core is still surrounded by the Venetian walls. However, the structure has been enriched by small circular roads that connect the central radial streets and a main ring road, which practically embraces the most of the city. This road is part of the main route that connects all the settlements of the island. South of this ring road there are functions like the main hospital of Crete, the campus of University of Crete, and the industrial zone. However, what seems to be interesting regarding the contemporary settlement is that the “live centre” of the urban settlement, as this has been fully explained in the theoretical framework of this study, remains within the Venetian walls, into the old historic core of the city.

The historical evolution of Heraklion in terms of its economical activities shows that trade activities were the dominant economic resources of its population. Therefore, from 15th and until 17th century, there was a variety of people engaged with trade, including retail and wholesale. As for 20th century according to the census of 1961, 59.2% of the active population in Heraklion is employed in this

sector of the economy, which includes both trade activities and administration.⁷ Today, according two researches, which have been conducted in 1985 and 1998 the wholesale shops are a significant part of the functional pattern, located outside the “live centre” and towards the circular road, which embraces the city. On the contrary, retail shops and administrative buildings are within the old core of the city, which appears to remain its “live centre”.

In 827 the founding population of the city appears to be 15,000 citizens. Despite the fluctuating population in 1900 Heraklion has 22,501 citizens. Its population has increased significantly during the 20th century regarding all the other major cities of Crete. The bigger increase of its population took place during the years 1920-1928, when it increased up to 38%. The previous is justified by the large number of refugees from Asia Minor, who fled to Crete. Hence, after centuries of foreign domination the city found itself to be populated by Greek Orthodox and a few Jews and Armenians (Detorakis, T., 1990).⁸ The above brief description implies the socio-economic processes, which took place within the spatial framework of Heraklion in an attempt to investigate if they have been any special factors having an effect on the functional pattern of the contemporary settlement. The study turns to the second settlement-case study: Chania

5.2 Chania: Historical evolution of the settlement

Today, Chania is the main town of western Crete. It is also located on the north coast of the island and at far as its topography is concerned it has a height of 20m above sea level. According to Gergopoulou M., all the major settlements of Crete had been located in the north coast because of the topography of the terrain, the winds and the sea current (Gergopoulou M., 2001). However, what it is interesting about this settlement is that it appears to be the main economical and administrative centre in the larger area of western Crete.

The historical evolution of Chania originates from the first Byzantine Period (330-823a.C.), when the records mention the settlement Kydonia as the bishop’s headquarters. During the occupation of Crete by the Arabs (823-961 a.C.), there are records about two urban settlements in Crete: the Badh el Khandak (english: the city of the ditch), which has been already identified as being Heraklion; and the Badh elDjobu (english: the city of cheese), which is identified as Chania. One Arab geographer of 12th century, Edrizi, argues that next to the city there were fruit gardens and gold mines. However, what seems to justify its name

⁷ The details about the census of 1961 for the city of Heraklion are found in the research conducted by A. Proveggios in 1966 for Heraklion.

⁸ For more information on socio-economic and ethnographic details of Heraklion during its evolution process see Appendix.

during these centuries is the cheese-making in the surrounding countryside, which furthermore was sold to other settlements. During the second Byzantine period (961-1204a.C.), the bishop's headquarters was moved to a neighbour settlement. Thus, at this time there are not records in terms of the settlement of Chania. In 1204, as it has been mentioned above, Crete was occupied by Venetians. Until 1211, Chania despite the fact that was an existing settlement it was of minor importance, and thus there are not enough historical records about the settlement.

However, in 1252 the settlement was rebuilt and fortified. Venetians reinforced the existing fortress of Kasteli, the ancient acropolis of Kydonia. Kasteli was the first core of the Venetian settlement. Inside it, Venetians designed the main street Corso, today named Cannevaro, located on its east-west axis, dividing the whole settlement into two areas. On this main axis and close to it they built the Duomo and the palace of rector. Around it Venetians planned small streets, where they built their residences. However around the fortress the rest of population occupied the land and formed the first suburbs (burgi). Under these circumstances, in 1538 Sammicheli M, designed the new walls, which embraced the whole settlement. However, the Venetian walls of Chania did not have the intactness of these ones of Chandaka (Heraklion). The old walls of Kasteli occupied by buildings, and thus they did not have their original use as protecting the citizens. Hence, in 16th century the Venetian walls, which were developed along the coast and the southern part of the settlement, were identified as settlement's main spatial components. They encircled three identifiable areas; the central area, called Kasteli, the ancient acropolis on the top of a small hill, embraced by its own walls, the Venetian harbour and finally to the south-west and south-east, dense residential areas. Therefore, the spatial pattern of the settlement seems to have been developed around the central core of Kasteli and all the other areas were developed around it. The entrances to the walled settlement were 3, while the entrances to Kasteli were 4. Regarding the Venetian walls the three entrances were: to the south the Porta Retimniota, to the east the Sabbionara, and to the west a smaller one, the Salvatore. A ditch encircled the construction until the Sabbionara. The narrow streets of the settlement formed a pattern where there was a bunch of main streets orientated towards the harbour and a small number of disproportional squares. One main road, the Ruga Maistra, originated from the harbour and led to south to one of the main entrance-exit of the walled city, the Porta Retimniota. Being vertical to Ruga Maistra, another main road, led to the east and formed the square of St. Nikolas. The urban structure also comprised a square formed around a public fountain. in southern part of the harbour, where the street of St.Fransisco, today Halidon Street, stopped. Its north side was formed by two entrances, which led to the harbour. The northwest side of the settlement was occupied by the Jewish area, which appears to have been completely segregated (*Figs 10,11*). However, in Chania in comparison with Chandakas (Heraklion), the administrative buildings

were clearly separated, from what were the main activities of the city, that is the marketplace, the squares and one public fountain (Georgopoulou, M., 2001).

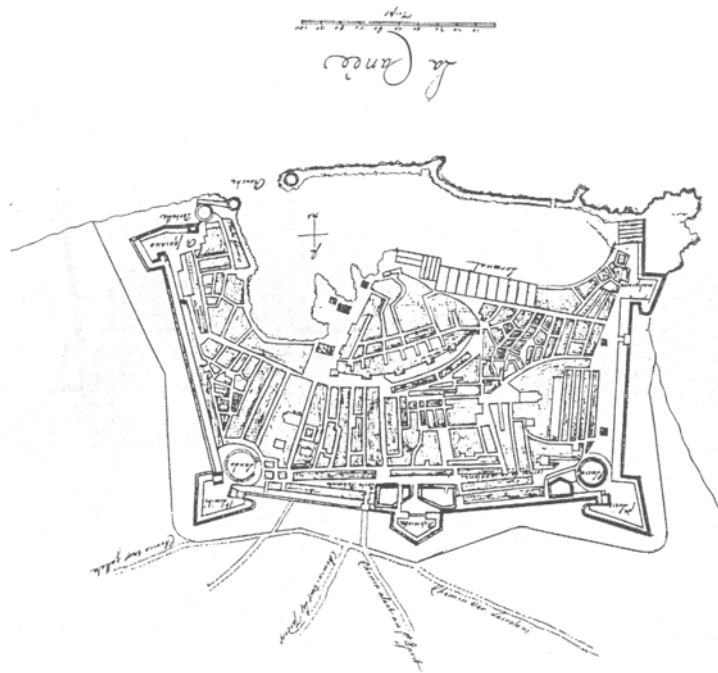


Fig. 10 Plan of Chania in 1660. Fr. Collignon: Fifteen plans of fortifications in Candia (Catalogue of the printed maps) 1660

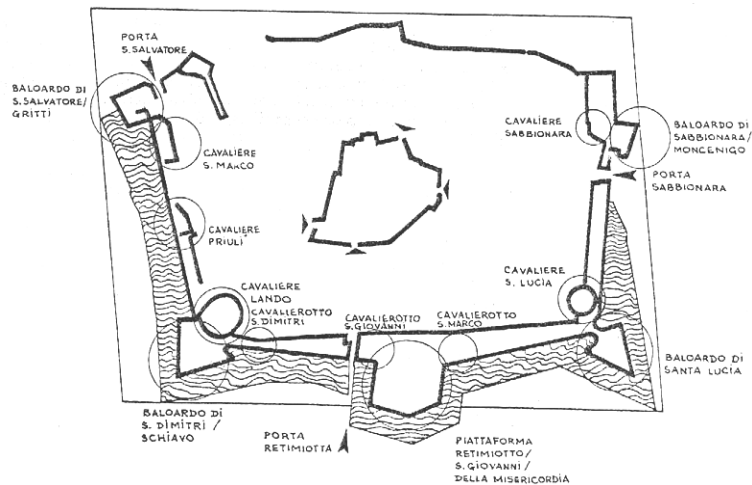


Fig. 11 In 16th century Chania, encircled by Venetian walls had three entrances: to the south the Porta Retimniota, to the east the Sabbionara, and to the west a smaller one, the Salvatore. The construction was encircled by a ditch until it reached the sea, where the Porta Sabbionara was.

In 1645 the city was occupied by Ottomans after a siege of two months. Chania's urban structure had apparently not changed apart from the intensification of its density. The formed residential areas were the Turkish one, named Splantzia, the Greek one, named Topanas, and the Jewish one, remained as one identifiable sector of the settlement, since the Venetian period. Their names still remain today. In 1898, when Chania was freed from any foreigner occupants, the authorities decided to destroy whatever reminded them any constraints, and thus they destroyed the northwestern part of the Venetians walls. In 1901 there was a new plan of the city and it was decided the expansion of the city outside the walls, and thus the demolition of the southern walls (*Fig. 12*). The new plan led to the construction of new streets, which actually connected the city inside the walls with the developing one outside of them. In 1911 the municipal food market was built just on the south edge of the old walled city, and it caused the demolition of another part of the wall. However, in 1947 there was the new plan of the city, which suggested the complete transformation of the existing urban structure. However, this new plan had not been fully applied. Apparently, from the so-far description of the evolution of Chania's urban structure, what seems to emerge is the gradual destruction of the constraints, which were applied once to enclose the settlement as a whole. When there was need for defending the sovereignty of Venetian rule the settlement followed the rules of growth and expanded outside the walls.

Today, Chania's historical old core retains only part of the original structure due to the bombing of the city in 1941 and the partly applied plan of 1947. Thus, the historical old city does not function as one identifiable walled city, due to the demolition of the greater part of the wall, encircled the city since 17th century, and of its three entrances. However, its street pattern appears to originate from this one of 17th century, although some features of the streets like the narrowness have disappeared (*Fig.13*). What seems to describe better the contemporary settlement as a whole are its main spatial elements like the gulf of Souda, a military campus just outside the city in Akrotiri, the harbour, the urban core and one valley on its west side.



Fig. 12 Chania at the beginning of 20th century. The demolition of the southern walls and of Porta Rethimniota.

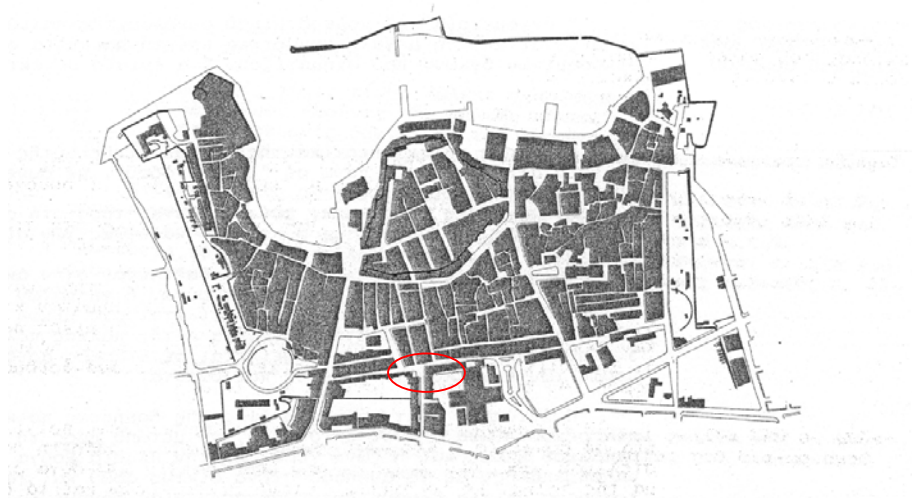


Fig. 13 Chania in 1990. The street pattern of the old historical city. The red circle indicates the area featuring in Fig. 12

The study focuses on the socio-economic process, which had taken place in Chania. Therefore, regarding the population of Chania, it emerges that during 20th century there was an increase of it, in Chania and in its larger area during 1951-1971. However, this increase appears to be significant from 1951 until 1961, which for the larger area of Chania was 21.9%, while during 1961-1971, there was a decline of the increase and the percentage went down to 4.4%. Like

every other city in Greece during these years, Chania functioned as attraction to people originated from the countryside and semi-urban settlements, whereas some of its citizens immigrated to the capital city, Athens, and other countries. Regarding the population of the settlement from 16th until 19th century, the records kept by the Venetian authorities showed that there were a lot of changes due to epidemics, famine and wars. However, a sudden increase of the population took place between 1851-53, when it appears to comprise 12,000 citizens. It is suggested that this increase was due to immigrants arriving from other parts of mainland of Greece, which at that time was occupied by Ottomans.⁹

As for the economic process, according to the research conducted in 1977 by A. S. Kalligas -A. G. Romanos, the society of Chania and its larger area was identified by its stability. The limited retail activities reinforced the image of the city as the transitional point between the surrounding countryside and larger settlements. In 1977 the old core has a similar function in terms of the city as a whole. However, since 1967, when another research for Chania had been carried out by Argiropoulos, Th. and Tritsis, A., it was suggested the maintenance of the old urban structure and the restoration of all its monuments in an attempt to develop it as tourist attraction. Thus, for most researchers and the authorities at that time the answer to the socio-economic stability, which the research conducted in 1977 pinpointed, was the development of the old core of the settlement as tourist attraction.¹⁰

Hence, Chania has followed the rules under of which other historical cities have grown. Thus, the contemporary city and all the spatio-functional elements, which are bound to it, such as the “live centre”, fully described in the theoretical framework, are completely separated from the old historical core. Thus, the latter has become a “live museum”, including all the functions such as tourist attractions or cultural events, which are bound to this concept.

5.3 Findings

The previous historical review of the two settlements aimed at dealing with the historical factors, which possibly affected the contemporary functional patterns of both cities. The study also investigated the socio-economic forces, which had been developed in every settlement. Hence, regarding the initial research question what appears to be significant for the evolution process of Heraklion is

⁹ The details of the historic statistics are introduced into Appendix 3 of the research conducted for it by A. S. Kalligas -A. G. Romanos in 1977, by the Maurakaki, M., archaeologist.

¹⁰ For more information on socio-economic and ethnographic details of Chania during its evolution process see Appendix.

the new plan of the city in 1936, which focused on the increase of the density of the old core in which all the central functions would be located. On the contrary Chania's plan in 1947 suggested the complete transformation of the old core. Furthermore, since 1967 different researches suggested the revitalising of the old city by transforming it into a tourist attraction. Apparently the previous constitute possible historical factors, which could have led to the different functional patterns of the contemporary settlements.

However, the study's initial hypothesis suggests that Heraklion and Chania differ in terms of its spatial structure, that is the morphology of the grid. This difference related with what is known about the distribution of land uses appears to be more powerful reason for their contemporary different functional pattern. Hence, the axial analysis of the grid for each city will reveal its spatial pattern.

6. Axial analysis

6.1 Heraklion

The axial models for the study were made using maps provided by the local authorities. However, the axial map of Heraklion in 1666-68 was made using the map designed by Hans Rudolf Werdmuller in the Library of Zurich¹¹. In the case of Heraklion in 1990 the axial map was made in terms of the settlement as a whole. However, the city is encircled by a ring road, which part of the main motorway that connects all the main settlements of Crete. Thus, the area, which is on the south of this motorway, appears to be very separated from the rest of the city. Due to this aspect, the study of the axial map of Heraklion in 1990 has been limited until the ring road. In *Plate 1* one can notice the evolution of the grid of Heraklion from the old historical town of 1666-68 until Heraklion of 1990.

6.2 Chania

The axial models for this study were also made using maps provided by the local authorities. However, the axial model of Chania in 1660 was made using the map designed by Fr. Collignon, while the axial model of Chania in 1905 was based on the map surveyed by W. Chapman.¹² *Plate 2* illustrates the evolution of the grid of Chania from 1660 until 1990.

¹¹ For the details of the map see footnote 1

¹² Fr Collignon: Fifteen plans of fortifications in Candia (Catalogue of the printed map) 1660, map surveyed by W. Chapman, Chanea, or Khania; both found in A. S. Kalligas -A. G. Romanos (1977), *The Medieval City of Chania, Chania*

6.3 Comparative analysis

All the axial maps have similar scale in order to be comparable. Comparing the axial maps of Heraklion and Chania throughout their evolution process, it emerges immediately that these differ geometrically, especially regarding these ones of 20th century, that is 1936 and 1947, or 1960 and 1963 and lastly 1990. Considering that axial maps are sets of lines, the geometrical difference between the two cities is expressed in terms of the length of the lines and the kind or angle of intersection. Hence, all the axial maps of Heraklion comprise short lines, which end on other lines, and this is found both locally and globally. The longest lines are these ones, which begin from the historic core and heading outwards. What it is interesting about this settlement is that the city seems to have grown under the same rules, which the old city has formed. Thus, the axial lines of the city outside the old core have similar geometrical features with these ones of the old core. However, the old core has a weak connection with the grid outside of it. Thus, the “old” and the “new” grid are mainly connected through three different lines. Comparing the axial maps of Heraklion themselves one can notice that between 1960 and 1990 the grid is intensified in almost all the areas.

The axial maps of Chania consist of a certain number of parallel long lines, passing through each other. These lines are mainly forming the grid just outside the historical core. This area of the grid has a strict right angle of intersection. The historical core of Chania maintains some of its structural elements throughout the historical process of evolution. It comprises shorter lines than the grid just outside of it, with a less right angle of intersection. However the grid of this old core appears to be well connected with the grid of the new city, through two strong lines that practically cross the structure of the old core, having a north-south orientation.

Apparently, Heraklion appears to be more radial, while Chania appears to be more giddy. The geometric difference between the axial maps of Heraklion and Chania, as it has been described above reflects the syntactic differences as they emerge from the syntactic analysis, which will be described further on, referring to the axial maps of each city through its evolution process.

7. Syntactic Analysis

The compared syntactic analysis of Heraklion and Chania shows the syntactic differences between the cities, and thus it pinpoints the differences in the morphology of their grid, regarding the initial hypothesis of this study. For this study the analysis has included the integration rad_n and rad_3 analysis of the axial maps, that is a global and a local analysis of the grid. The latter has been also applied in an attempt to find the local grid conditions. However, the true to life picture has been given by the radius-radius analysis, since this is a global analysis without the edge effect, as it has been already described in Data and methodology. Because the study focuses on the different functional patterns of the historical centres of the cities, the old core of both cities was analysed as closed system, clearly separated from its surroundings. Plates 3,4,5,6,7 illustrate the integration analysis rad_n (global integration) and rad_3(local integration) of Heraklion in 1666-68, 1936,1960,1990,1990(until the main ring road), accordingly. Plate 8 illustrates the rad -rad analysis of Heraklion in 1990, that is rad_8 analysis, compared with the rad_n one. Plates 9 and 10 show the rad_n and rad_3 analysis of the old core of Chania in 1666-68,1936,1960,1990. Plates 11,12,13, 14,15 illustrate the integration analysis rad_n (global integration) and rad_3(local integration) of Chania in 1660, 1905, 1947, 1963,1990, accordingly. Plate 16 shows the rad -rad analysis of Chania in 1990, that is rad_9 analysis, compared with the analysis rad_n. Finally, plates 17 and 18 illustrate the rad_n and rad_3 analysis of the old core of Chania in 1660, 1905,1947,1963,1990.

The results of all the previous analysis showing the syntactic parameters of both cities can be seen in the following tables:

TABLE 1: SYNTACTIC PARAMETERS OF HERAKLION

Heraklion	Mean global Integration	Mean local Integration	Mean Depth	Mean Conn	R ² local/global	R ² conn/global
1666-68	0.853	2.202	9.831	3.959	0.363	0.265
1936	1.208	2.792	7.080	5.251	0.258	0.166
1960	1.032	2.855	10.322	5.457	0.262	0.148
1990	1.020	2.856	8.349	5.413	0.192	0.126

TABLE 2: SYNTACTIC PARAMETERS OF CHANIA

Chania	Mean global Integration	Mean local Integration	Mean Depth	Mean Conn	R ² local/global	R ² conn/global
1660	1.188	2.135	5.629	3.604	0.558	0.334
1905	0.892	1.843	16.101	3.143	0.449	0.288
1947	1.226	2.828	10.567	5.539	0.478	0.336
1963	1.090	2.695	10.594	5.136	0.477	0.279
1990	1.203	2.747	9.045	5.192	0.356	0.249

TABLE 3: SYNTACTIC PARAMETERS OF THE OLD CORE OF HERAKLION

Heraklion /old core	Mean global Integration	Mean local Integration	Mean Depth	Mean Conn	R ² local/global	R ² conn/global
1666-68	0.853	2.202	9.831	3.959	0.363	0.265
1936	1.356	2.674	6.892	4.987	0.463	0.328
1960	1.329	2.715	1.917	2.636	0.533	0.363
1990	1.608	2.953	10.178	5.910	0.724	0.537

TABLE 4: SYNTACTIC PARAMETERS OF THE OLD CORE OF CHANIA

Chania/ old core	Mean global Integration	Mean local Integration	Mean Depth	Mean Conn	R ² local/global	R ² conn/global
1660	1.188	2.135	5.629	3.604	0.558	0.334
1905	0.892	1.843	16.101	3.143	0.449	0.288
1947	1.501	2.526	7.533	4.803	0.759	0.625
1963	1.222	2.423	4.228	4.474	0.658	0.467
1990	1.131	2.172	12.175	3.837	0.455	0.322

TABLE 5: SYNTACTIC PARAMETERS OF THE RADIUS- RADIUS ANALYSIS

Settlement	Mean global Integration	Mean local Integration	Mean Depth	Mean Conn	R ² local/global	R ² conn/global
Heraklion (1990)	1.020	1.515 (rad_8)	8.349	5.416	0.534(rad_8/ rad_n)	0.126
Chania (1990)	1.203	1.422 (rad_9)	9.045	5.210	0.877(rad_9/ rad_n)	0.249

7.1 Heraklion

What emerges from Plate 3 is the pattern of the *deformed wheel*, as a deep structure common to many small towns, which occurs independent of any topographic aspects (Hillier, B., 1990). The *deformed wheel* pattern is described by the integration core (patterns formed by the red, orange and yellow lines), which located at the heart of the city, link it to the edges through quasi-radial lines. Within the interstices of this overall pattern are found greener and bluer areas. The analysis of rad_3 integration shows that these green or blue areas have as a local focus, yellow lines. The main integrator of the system is today's Idis Str. (integration rad_n: 1.40), and it starts from the geometrical centre and the focus of the integration core, forming with the other integrators the boundary of the first settlement, that is what it was before 17th century and the expanded city during its Venetian occupation. *Figs. 14 and 15* show the synergy and the intelligibility of the first mapped formation of the settlement that is Heraklion in 1666-68. The local structure of the system is described by the synergy, which in 1666-68 its R^2 has a value .363 that is a poor correlation. From *Fig.14* it emerges that despite the poor correlation the points are forming almost a tight shape around the regression line. Regarding intelligibility, this has a R^2 value of .265, which implies an unintelligible system, where the measure of integration is not a good guide for this one of integration.

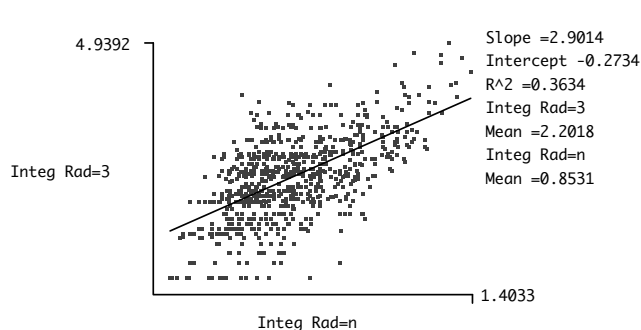


Fig.14 Scattergram showing the synergy for the axial map of Heraklion in 1666-68

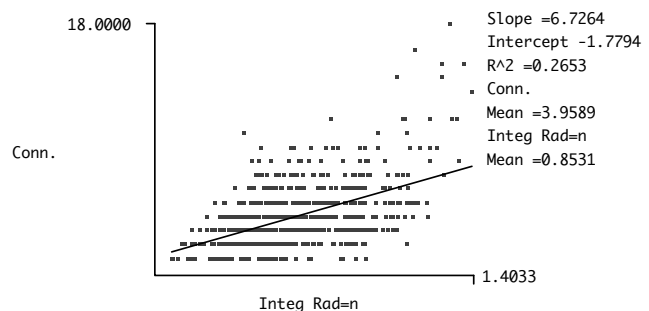


Fig.15 Scattergram showing the intelligibility for the axial map of Heraklion in 1666-68

The historical review of the evolution of the urban structure of Heraklion focused on the plan of 1936. It was when there was the most significant attempt to plan the city as this had begun to expand outside of the historical core, that is outside the walls. The expansion seems to be oriented to the eastern part of the city. In terms of the integration core, one can notice that this shift towards the east and outside the old core (Plate 4). The integration analysis both of rad_n and rad_3 shows that there are streets that have remained as integrators for almost three

centuries. These streets are mainly the Minoos Avenue, today renamed as Dikaiosinis Avenue and 1821 Avenue, that is a street that originates from the central public square, and the geometrical focus of the city known as square of N. Fokas, The main integrator of the system is Minoos Avenue (integration rad_n: 1.86).

As it emerges from Plate 5, the integration core of Heraklion in 1960 has been displaced outside the old historical town. However, from Plates 4,5 and 6 it emerges that it has been always located in the eastern part of the city. In 1960 the main integrator of the system is G. Papandreou Avenue (integration rad_n: 1.64). This street belongs to the orthogonal integration core, unlike the grid in most areas of Heraklion, which appears to be more radial. This part of the city was fully developed in the 50s and formed a significant part of the new settlement as it has been since late 30s. Furthermore, this area is oriented outwards towards other settlements in south. What is interesting about Heraklion in 1960 and its syntactic analysis is that the main global integrators of the system also function as local integrators, as easily one can notice in the integration rad_3 analysis. However, in Table 1 the R^2 value of the correlation between the local and global integration is .258, showing that local integration is not an indicator of the global integration of the system. According to the results in Table 1 in 1960 the system has become much deeper (M.D.: 10.322), than what it was in 1936 (M.D.: 7.080), and the deepest of all the systems during the years, 1666-68, 1936, 1960 and 1990.

As for the axial map of Heraklion in 1990, the integration analysis rad_n, which is illustrated in Plate 6, has shown that the part of the city, being south of the main ring road is separated from the rest of the city and thus segregated. Due to this aspect the study focuses on the syntactic analysis of the settlement until the main ring road. In Plate 7 one can notice that the integration core remains almost the same as was it in 1960, although, it seems to be more compact. The main global integrator of the system is Kapodistria Str (integration rad_n: 1.60). The integration rad_3 analysis of the map has marked the local centres being spread throughout the settlement. Thus, what was the integration core of Heraklion in 1666-68 has been transformed into a local centre. in 1990's system. In 1990 the system becomes shallower than this one of 1960 ((M.D.: 8.349 comparing with M.D.: 10.322), as one can see in Table 1. The latter can be explained from the intensification of the grid, as it has been mentioned above, which led to alternative different routes inside this urban system.

The correlation between the integration rad_3 (local integration) and integration rad_n (global integration) describes the local structure of the city (*Fig. 16*). The red dots in the scattegram represent the old core. This correlation, which represents the synergy for the whole system, gives a R^2 : .192. However, in the case of the old city, that is the city inside the walls the correlation has a value of

.314. This number is very close to .363, which is the correlation between the local and global integration of Heraklion in 1666-68, shown in Fig. 14.(Table 1) The latter justifies what it has already been mentioned about the maintenance of structure of the old core, and thus the almost unchangeable syntactic parameters. As far as the intelligibility of the system is concerned, Heraklion in 1990 gives R^2 :.126, while for Heraklion in 1666-68, R^2 has a value of .265.(Figs. 15,17). However, the intelligibility of every city, is related with the size of the settlement, and thus the more the settlement grows, the more unintelligible it becomes. (Hillier, B, 2001). Regarding Heraklion's old core, in 1990, which is represented by the red dots in the scattegram of Fig. 17, the R^2 is .193, being less intelligible than this one of 1666-68. The latter constitutes a syntactic difference between the two structures.

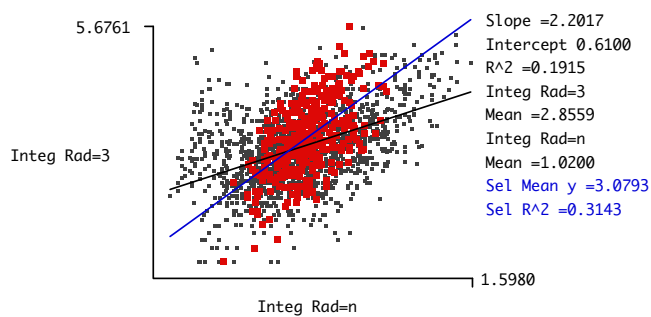


Fig .16 Scattegram showing the synergy for the axial map of Heraklion in 1990

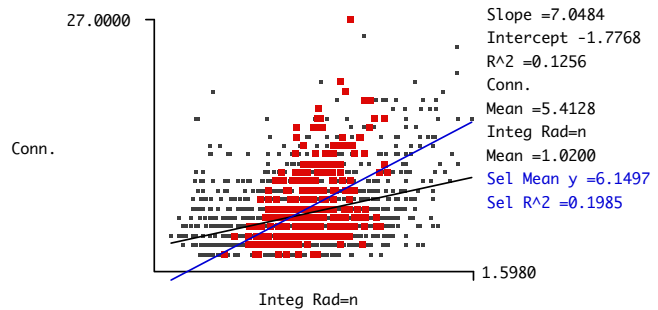


Fig. 17 Scattegram showing the intelligibility for the axial map of Heraklion in 1990

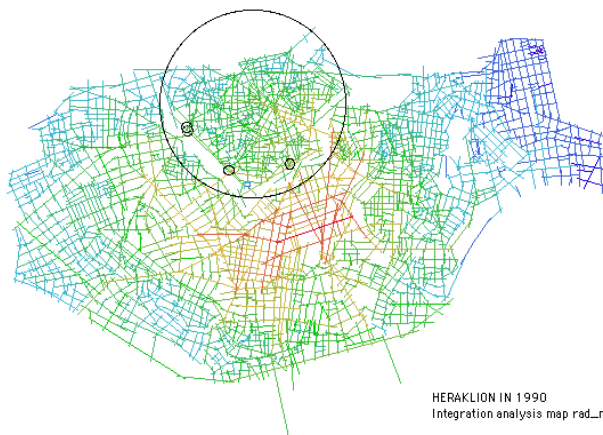


Fig .19 Integration analysis rad_n of Heraklion in 1990. The circle indicates the red dots in scattegrams in Fig .6 and Fig. 7

However, in an attempt to have a true to life picture of Heraklion in 1990 the study focuses on the radius-radius analysis of it in which it is set at the integration analysis rad_8 (Plate 8), that is at the mean depth of the whole system from its main integrator (Table 1). The advantages of the radius -radius analysis have been described in the paragraph Data and Methodology. For the sake of clarity, it can be mentioned that the radius -radius analysis gives results, which describe better the reality of the configurational system, since all the lines are analysed to the same radius. Therefore, the integration analysis rad_8 of Heraklion in 1990 could be indicator of the main streets in and out of the historical core, where the urban buzz of the contemporary city is located. This analysis has shown that the old city is part of the expanded rad_8 integration core. The same analysis has highlighted the radius_8 integrators the same axial lines, which used to be the dominant integrators 54 years ago. Thus, Dikaosinis Av. (former Minoos Av) or the 1821 Str, which were significant integrators during three centuries, in 1990 function both as rad_8 integrators and local integrators. The results of this analysis can be seen in Table 5.

Considering the initial research question, which focuses on the old historical centre of both cities and their functional patterns, the study goes further by separating the structure of the old city and analyse it syntactically as a closed system throughout its evolution process. As for this one in 1936,1960 and 1990 the study includes the three radial lines that connect the old with the new city. Plates 9 and 10 mark what the previous integration analysis has already shown. The old city maintains its structure and as it has been expected during the last 30 years, that is between 1960-1990 there is a noticeable intensification of the grid. The argument about the maintenance of the old structure is further reinforced by the aspect that the 1821 Str. remains as the main global integrator of the system for 1936, 1960 and 1990. Thus, in 1666-68 as it has already mentioned the main integrator is the Idis Str. (integration rad_n: 1.40). However, in this system 1821 Str. has a value of 1.376, which is very close to this of the main integrator. In 1936 the main integrator is 1821 Str. (integration rad_n: 2.259), while in the following years 1960 and 1990 1821 Str remains as the main integrator giving the following results integration rad_n: 2.235, and 2.537, correspondingly. According to the results of the analysis shown on Table 3, the correlation between the local and global integration for the closed system of the old core has become gradually stronger giving in 1990 R² value: .724. The previous could be compared with the .192 of Heraklion as whole in 1990, shown in Table 1. The latter describes that the old core separated from the extended contemporary settlement constitutes a self -contained system with different syntactic features that the rest of the city.

Hence, it emerges that the urban structure of the old core is consisted of streets, which for more than 300 years have been the dominant integrators both of the global and local structure (1666--1936). As the settlement has grown the

significance of the structure of the old core has lost its global effects. However, the dominant integrators for more than 300 years have been transformed into local centres. What has been so far described, is marked on Plates 3,4 5 and 7. Thus, the previous syntactic analysis manifests what Hillier B. claims about the distribution of integration in an urban system as not being a static picture of the current state of the system but a structural record of the historical evolution of the system.(Hillier, B.,1996,p.344). Therefore, the syntactic analysis of Heraklion through its evolution process, can be summarised in the fact that the city, as it has grown maintained the main structure of the old core, along with the expected intensification of the grid within this old core (Hillier, B.,2000). This structure is consisted of lines which functions through this evolution process either as the dominant integrators, both global and local, or only as local integrators.

7.2 Chania

Plate 11 illustrates the *deformed wheel* pattern regarding the axial map of Chania in 1660. The main integrator of the system is Halidon Str., (Integration rad_n: 1.881), being on the periphery of the earliest formation of the settlement, that is before 17th century. This integration core appears to be sparser than this one of Heraklion in 1666-68. Since the size of the settlement is apparently smaller than this one of Heraklion, the local structure is developed mainly on a 2-step logic from the global integrators, apart from the more dense area located in west, that is the area where the Jews had been located, being separated from the rest of the city. The correlation between the local and global integration can be seen in Fig. 19. The Fig. 20 illustrates the intelligibility of the settlement.

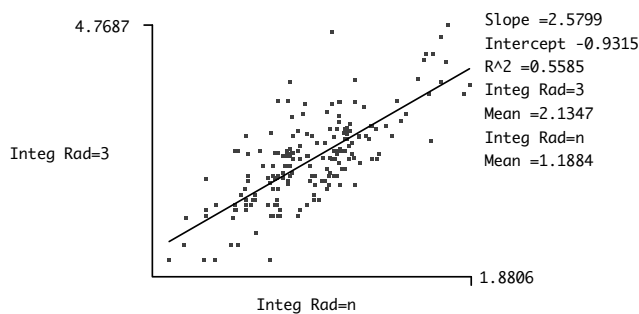


Fig .19 Scattegram showing the synergy for the axial map of Chania in 1660

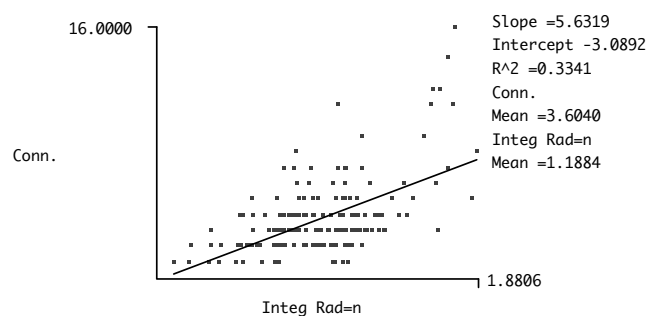


Fig .20 Scattegram showing the intelligibility for the axial map of Chania in 1660

The correlation between the local and the global integration is poor (R^2 : .558), however it is better than this one of Heraklion in 1666-68 (R^2 : .363). From the shape of the scattergram it emerges that the system is apparently smaller than this of Heraklion in 17th century, having although a comparable tight shape around the regression line. Thus, the better correlation between the local and global integration could be credit to the size of the system. As for the intelligibility, Chania is also an unintelligible system, giving R^2 : .334.

In 1905 the settlement appears to be sparse (Plate 12). The sparsity of the system and the local area structure has formed a significant deep system (M.D.(1905) 16.101 versus M.D.(1660) 5.629). However the elements of the structure has remained almost the same. The integration core has been sparser, without being dislocated, since the settlement has not grown. The main integrator of this system is one part of today's Halidon Str.(Integration rad_n: 1.373). However, the results of this system as one can see in Table 2 could be related with the way that the system had been mapped.

However, in 1947 the city has a significant growth. It has been expanded outside the historic core, being larger on its eastern side towards the other settlements of Crete. The structure of the old city appears to be significantly transformed. Plate 13 shows that the integration core has clearly displaced outside the old city towards its southern edge. However, it is sparse and less compact than the integration core of Heraklion in 1936, and furthermore it extends until it reaches the strong line, which connects the old with the new city. The main structure of the old city around this line, functions as a local centre. The main integrator of the system is today's Hegoumenou Gavril Str. (Integration rad_n: 1..997), located on the edge of city. In 1963 the city has not expanded further. However, Plate 14 marks the expansion of the integration core. In 1963, the main integrator is Giamboudaki Str(Integration rad_n: 1..752), being parallel to the previous main integrator.

Plate 15 illustrating the integration analysis, rad_n and rad_3 of Chania in 1990, shows that the city has significantly grown. Although its growth, the integration core has not been displaced, but it has been clearly expanded. In 1990, the main integrator of the system remains Giamboudaki Str(Integration rad_n: 2.023).The connection between the old and the new city is realised through two strong lines, which cross the structure of the old city on a north-south axis. These lines comprise part of the integration core. However, what describes the spatial structure of the settlement in 1990 is the fact that the structure of the old city has ceased to function as a local centre, apart from the strong lines-connections with the old city and some other streets 1-step away from them. The latter is marked on the true to life radius-radius analysis, (for Chania in 1990 it is set at analysis radius _9), shown in Plate 16. The radius-radius analysis, as being the most

effective global analysis manifests that the integration core of Chania in 1990 is fully developed outside the old city. The syntactic parameters of the rad-rad analysis of Chania are shown in Table 5

It is interesting to compare the correlation between the local and global integration of Chania in 1990 and this of the first settlement that are shown in *Fig. 19*. The synergy for Chania in 1990 is shown in *Fig. 21*. According to the results of the analysis shown in Table 3, the correlation gives R^2 :.376, which is far away from the .556 of the first settlement in 1660. The synergy of Chania in 1990 is better than this one of Heraklion in 1990(R^2 : 0.126); however, its low value does not suggest that in this system the local integrators are indicators of global integrators. The same correlation as far as the old core is concerned, represented by the red dots, (*Figs. 21,23*), gives a value of .342, very similar to the R^2 of the whole settlement, but very different of the R^2 of Chania in 1660. The latter indicates the integration of the old core into the new settlement, and the transformation of the structure of the old city. As for of the intelligibility of the city, which features in *Fig. 22*, this has the small value of .249. The latter indicates that Chania in 1990 as is unintelligible as it was also the settlement in 1660 (R^2 : .334)

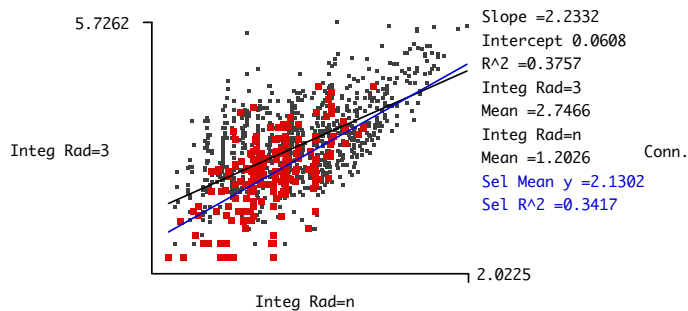


Fig. 21 Scattegram showing the synergy for the axial map of Chania in 1990

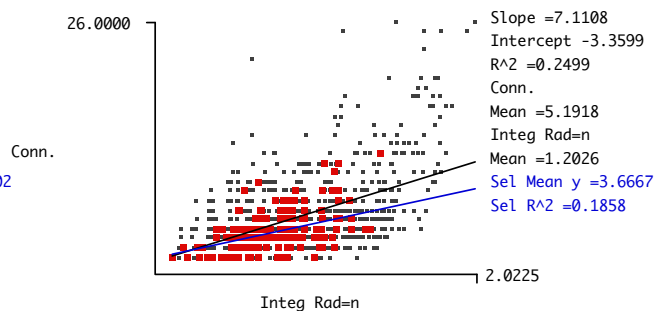


Fig. 22 Scattegram showing the intelligibility for the axial map of Chania in 1990



Fig. 23 Integration analysis rad_n of Chania in 1990. The circle indicates the red dots in scattegrams in Fig. 15 and Fig. 16

The study has also analysed the old core of Chania as closed system. The structure of the old city has been separated from the rest of the city, leaving only the edge zone, which has been developed, on the trace of Venetian walls. The syntactic analysis of the old core manifests what it has already been mentioned, that the structure of the old city has been transformed (Plate 17 and 18). However, there were some streets like Halidon Str. or Cannevaro Str, the backbone of the first settlement before 17th century, which have not been transformed. The structure of the old core in 1947, as one can notice from Plates 17 and 18, became a more orthogonal grid, which has been intensified during its evolution process, mapped in the axial map of 1990. The main integrator of the old core in 1660 is Halidon Str.(Integration rad_n: 1.881), which in 1905 remains as the main integrator (Integration rad_n: 1.373), although it has a different orientation. The same street appears to be the main integrator also in 1947(Integration rad_n: 2.484).In 1963 the main integrator is Karaoli Dimitriou Str. (Integration rad_n: 1.914), while in 1990 the main integrator displaced to Daskalogianni Str. (Integration rad_n: 1.967). What it is interesting about this analysis is that the street, which seems to dominate the integrators, is Halidon Str. one of the two strong connections between the old and the new city. The results in Table 4 show that the synergy of the old core analysed as closed system in 1990 is poor (R^2 : .455) comparing with this one of the old core of Heraklion in 1990 (R^2 : .724). The previous syntactic parameters manifest one of the syntactic differences between the old city of Heraklion and this one of Chania.

7.3 Findings

The syntactic analysis of both cities has shown that there are syntactic differences between these cities, which are better described by the rad-rad analysis of the contemporary settlement and the measure of synergy. Hence, it emerges that the old historical centre of Heraklion in 1990 is a very integrated area of the city, shown by the rad_8 analysis.(Plate 8). Analysed on its own, the old core gave a good correlation between the local and the global integration (R^2 : .724), which means that the distribution of local integration is indicator of this one of global integration. Embedded in the surrounding new city, the old core, as one sees in *Fig. 17* forms a regression line which cross the line of the city as a whole at a steep angle. The slope across the line implies that the most integrated lines within the old core are more locally than globally integrated. On the contrary, the rad-rad analysis of Chania in 1990 showed that the old core is a more segregated area despite the strong line, which connects the old and the new city. The same old core, analysed on its own has a poor correlation between the local and the global integration (R^2 : .455). The same old core embedded in the city as whole, as one sees in *Fig. 21* forms a series of layers, with poor correlation between the local and global integration, which according to Hillier, B. suggesting an area which freezes the natural movement. (Hillier, B, 1996, p.135). Thus, regarding the research question the study has investigated if this syntactic analysis of both cities revealing syntactic differences which are mostly related with how the new settlements are connected to the old historical centres, reflects these differences in their functional patterns.

8. Functional Analysis

Having analysed the spatial structure of both cities during their evolution process, the study focuses on their functional pattern, which emerges from the distribution of land uses during their evolution process. This analysis has been limited because of lack of historical data. However, whenever historical data regarding the land uses have been available, the study focuses on retail and administrative activities, since these two activities are related with the concept of “live centre”, as it has been fully described in the theoretical framework of this study. Thus, in an attempt to trace the “live centrality” and its functional aspect the study maps the location of retail shops, food shops, tourist shops, usually related to where the tourist attractions are located and finally where buildings like banks or administrative ones are located in terms of structures of both cities.

8.1 Heraklion: Functional patterns

Heraklion, as it has emerged from the syntactic analysis retains the significance of the old core. Hence, it is interesting by analysing the functional pattern of the city to investigate the impact of this tendency of its structure on the distribution of land uses. The study mapped only the land uses distributed in the city during 1666-68, 1960 and 1990, since there was no clear evidence of the functional pattern during 1936.

Thus, there are records for Heraklion's economical, social and trade centre in 17th century. This appears to be located in the geometrical centre of the city, in today's El. Venizelou Square, called at that time Piazza delle Bianda (english: The square of Cereals). Its name originates from the state cereal warehouses, located on the southwest side of the square, on the trace of the old Byzantine wall. Its significance in the social life of the city can be traced in Plate 19, which illustrates the distribution of land uses imposed on the integration rad_3 analysed axial map of Heraklion in 1666-68. The line passing through this square, today's 1821 Str. is a very strong integrator. However, the food market, which at that time were shops providing fish (Pescaria) and butcher shops (Bescaria) were located 1-step and 2-step away from this main integrator. However, along this integrator and in its sequence of lines towards north, that is on Ruga Maistra, today's 25th Avgoustou, there were all the administrative buildings, the Loggia, the Palazzi of Capitano generale and of governatore. (Tzobanaki, C, 1996). One can easily see that the "live centre" of the city co-exists with the administrative centre and both are developed along lines(Figs. 24,25,26).

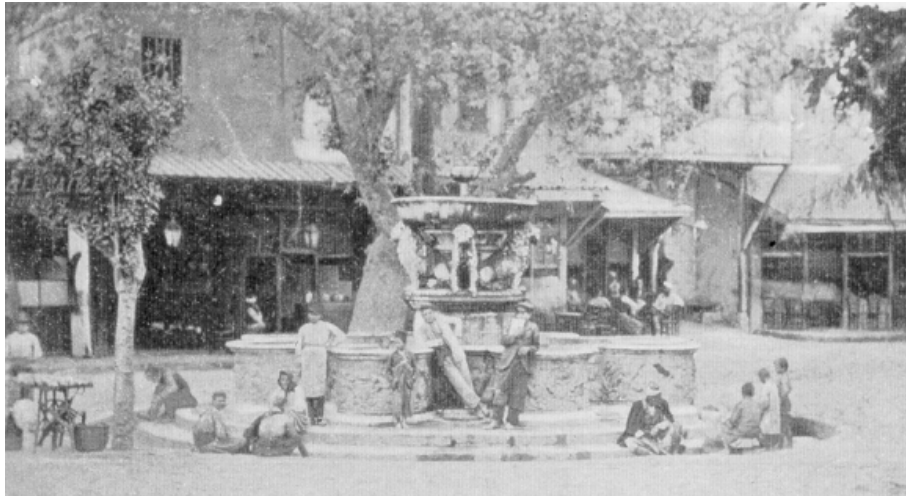


Fig. 24 Heraklion at the beginning of 20th century. Square of El.Venizelou, renamed as "Liontaria" due to the public fountain.



Fig. 25 Heraklion at the beginning of 20th century. 25th Avgoustou Street just before the Second World War.



Fig. 26 Heraklion at the beginning of 20th century. Square of N. Fokas, which is close to food market, just before the Second World War.

In 1960 the distribution of land uses is similar to this one of 17th century, mapped in Plate 19. Thus, in Plate 20, which illustrates the distribution of land uses of Heraklion in 1960,¹³ one can easily see that 1821 Str. retains its significance as a local centre along which boutiques are distributed. The food market has been displaced 1-step away from 1821 Str, that is on 1866 Str. Boutiques have been also located on 2-step away from 1821 Str., on lines which are also local integrators of the system, such as Kalokairinou Str. or Evans Str. Furthermore, 1-step away from 1821 Str., there are special bronze-handicraft shops. Mainly, the banks have been located on 25th Avgoustou Str., where in 17th century were located the administrative buildings. In 1960 the administration is found on a local integrator, Dikaiosinis Str. Apparently, the “live centre” of Heraklion in 1960, as it emerges from the distribution of land uses, appears to be located inside the old core. It is developed around the focal point of 17th century, where it appears to be compact. However, the dominant pattern as a whole is formed of lines.

In 1990 the functional pattern is intensified. Thus, the distribution of land uses as they have been mapped on Plate 21, imposed on the integration rad_3 analysed axial map of Heraklion in 1990 manifests that the location of land uses has not significantly changed during these 30 years.¹⁴ Kalokairinou and Evans are still main shopping streets. However, there are some areas, where the functional pattern has become more convex, because of the intensification of the grid known as local grid conditions (Hillier, B.,2000). Thus, the areas around the food market, 1866 Str, or around 1821 Str, where boutiques are located, or even the area around Averof Str are convex areas of the “live centre”. The latter convex area is formed as a result of the intensified “2-deep” grid from the central lines, that are the streets 1821, 1866 and Averof. This 2-deep grid logic is described as local grid conditions. The latter seems to be a distinctive spatial property of live centre lines (Hillier, B.,2000).

Banks are still located on 25th Avgoustou Str. along with some tourist shops, due to its feature as the main axis that connects the “live centre” of the city and its “entrance” from the sea. However, there are some other tourist shops on Xanthoudidou Str., located just opposite the Archaeological museum. Hence, it emerges that the pattern of tourist shops is not developed according to the theories of “natural movement” or “movement economy”, but it is strongly and mainly related with the location of the tourist attractions in the city. In Heraklion in 1990 administrative buildings are located close to the “live centre”, mainly on Dikaiosinis Str.

¹³ The main resource has been the research conducted in 1966 for Heraklion by architect A. Proveleggios.

¹⁴ The main resource has been the complete report conducted by the Ministry of Environment of Greece in 1998 for Heraklion, provided by the local authorities and enriched with observations by the researcher.

However, what constitutes the functional pattern of Heraklion in 1990 significant, is the fact that despite the tendency to become more convex, due to the intensification of the grid that occurs to the centre of the settlement during their evolution process, there are still lines along which the functions related with the centre are developed. Hence, the latter opposed to what Akkelies van Nes argues about the pattern of shops of Birmingham in 1997. She argues that during the evolution process this pattern had changed from a linear structure to a compact and convex structure and thus most of linear shopping streets leading towards the city centre disappeared (Akkelies van Nes, 2002,p.181). On the contrary, in Heraklion in 1990 the linear shopping streets retain their significance in terms of the functional pattern. However, around the central lines there are convex areas of shopping streets described by local grid conditions. Thus, the overall functional pattern comprises a convex shape with spikes. This “live centre” is still located into the old core of the city.

8.2 Chania: Functional patterns

The syntactic spatial analysis of Chania has shown that the city functions as a uniform system. The old core of the city has been lost its early structure, although it retains some of its spatial elements. The connection between the old and the new city is better than this one of Heraklion. Thus, the old core appears to be part of an entire system, what Chania has been in 1990. For the sake of the argument, it is interesting to investigate the functional pattern of the city, as this emerges from the distribution of land uses. The study mapped the functional pattern of the city during 1905 and 1990 since there has been no evidence of land uses in Chania during 1660, 1947 and 1963.

In 1905 Chania has not expanded towards any direction outside the first recorded settlement. Plate 22 which features the land uses in the city during 1905, shows Cannevaro Str., as the backbone of the first settlement before 17th century, which appears to be the administrative centre of the settlement, where all the buildings of the governors are located. This line, which functions both as global and local integrator ends to the square, where was recorded as the social centre of the Greek community of the city. The Turkish community was gathered on a different square, clearly separated from this one of Greeks, related to other integrators. In contrast to the functional pattern of Heraklion in 1666-68 (Plate 19), in Chania the social centres of the city are separated from the food market, which was located on the edge of the city (*Figs. 27,28,29*).

In 1990 the city has apparently enlarged and it has been expanded outside its old core. The functional pattern emerges from the distribution of land uses, mapped

in Plate 23¹⁵. Within the old core the shops, which dominate the retail uses are the tourist shops. These tourist shops are distributed along Halidon Str, and Zambeliou Str., 1-step away from Halidon Str. The syntactic analysis has shown that Halidon Str is one of the two strong lines which connects the old and the new city and both local and global integrator. 1-step away from this dominant integrator, that is along Sifaka Str. there are handicraft shops making and selling traditional knives. These shops used to function as local manufacturers, but in 1990 they seem to be addressed to tourists. Hence, the “live centre” of the city is found on the edge of the old core, while the old core houses all the functions bound up with tourism.

The food market, a building of 1911 is located on Tsouderon Str, just outside the old city. It has a similar location with the open food market of 1905. All the boutiques are located along local integrators of the system such as Giannari Str, Dimokratias Str, Tzanakaki Str., Kidonias Str, Kriari Str., on other streets 2-steps away from them, and in some cases 3-step away from them (Ch. Episkopou Str.) The convexity of these shopping areas can be explained by the spatial property of the “live centre”, known as local grid conditions, described above. In Chania banks are distributed unevenly, along the same lines which comprise the “live centre”. The plotting of land uses in Plate 23, clearly shows that the compact and convex “live centre” of the city lies on the edge of the old core. Thus, the functional pattern of Chania in 1990 manifests what has been already mentioned about the functional separation of the old core from the urban buzz. The old core is the spatial framework for the tourist functions, which are developed along lines.



Fig. 27 Chania at the beginning of 20th century. Canevaro Str. at the time of First World War.



Fig. 28 Chania at the beginning of 20th century. The market place at the time of First World War.

¹⁵ The main source of these data has been a research conducted in 1977 by A. S. Kalligas -A. G. Romanos for the medieval town of Chania, provided from the local authorities, enriched with observations by the researcher.

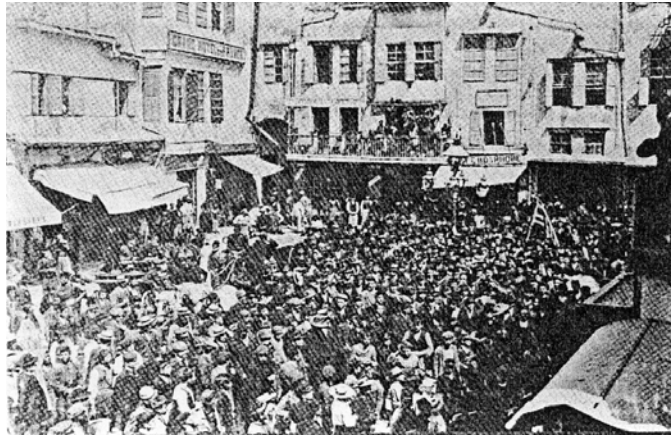


Fig. 29 Chania at the beginning of 20th century. Square of "Sintrivani" at the time of First World War.

8.3 Findings

The findings of the previous functional analysis are limited because of the lack of some historical data. The functional analysis of Heraklion has shown that the old city retains its significance in terms of its urban life. The old core appears to be the main location of the urban buzz for three centuries (17th -20th century). The dominant functional pattern of its "live centre" between 1960-1990 is formed by strong lines around of which convex shopping areas are formed particularly marked in the functional pattern in 1990 (Plate 21). Regarding Chania the analysis has shown that in 1990 the "live centre" is found on the edge of the old city. The pattern that emerges is a convex shape with a strong line, Halidon Str. along which the tourist shops are located. This line is the strong line, which connects the old with the new city. However, due to lack of data the study has not traced the possible transformation of Chania's functional pattern throughout its evolution process, especially during the recent years.

9 Discussion

Looking at both cities in terms of their different functional pattern within their historical core the study has pinpointed differences in their evolution process. The spatial analysis emerged that Heraklion and Chania followed different rules of growth. The latter reflected in the morphology of their grid. In the light of the specific hypothesis of the study, which presumed that the different functional

patterns were due to differences of the grid, the syntactic analysis showed different syntactic parameters between Heraklion and Chania. These differences have been clearly described by the rad-rad analysis of the grid of both contemporary settlements. Hence, the rad-rad analysis of Heraklion in 1990 showed that its old city has retained its significance as focal point of the city. The grid inside the walls is part of the extensive integration core of the city as a whole. In 1990 the geometrical focus of the old city and the integration core of the city in 17th century, is consisted of lines, which function as local centres (Plate 7,8). On the other hand, Chania followed the rules of growth according to which other historical cities have evolved. Thus, as the settlement had grown its integration core had been displaced from the historical core towards the edge and finally outside of it. The rad-rad analysis of the city in 1990 showed the segregation of the old core. The historic core retains its significance partly as having local centres. This old city as local area is easily accessible to strangers by strong lines from the edge of the area, like other European historic cities. (Hillier, B., 2001). In this particular city, these strong lines, the streets Halidon and Daskalogianni. are the connections between the old historical part of the city and the new settlement and both cross the whole old core in north-south axis. (Plate 15,16).

These different spatial patterns, best described by the rad-rad analysis of the settlements have been suggestive for the different functional patterns, mapped in Plates 21 and 23. The functional pattern of Heraklion during the decades 60s and 90s describes the old core as the place where the urban buzz is located (Plate 20,21). Hence, in 1990 the main shopping streets are found inside the walled city, forming a convex shape with strong lines. Unlike other historical cities, Heraklion retains its historical core as its main functional core that is its “live centre”. The latter that is strongly bound with the natural movement has been described by the rad_8 analysis of Heraklion in 1990, which has showed the main grid of the old city as comprising dominant integrators (Plate 8). Unlike Heraklion, Chania’s functional pattern, mapped in Plate 23 showed that its “live centre” is located on the edge of the old core. The old core having an historical significance functions as an attraction for visitors. The tourist shops along Halidon Str and 1-step away from it justify old core’s spatio-functional features. The rad_9 analysis of the city showed that the old core is clearly separated from the integration core, having one strong connector with it. This true- to life spatial pattern seems to have been very suggestive for the functional and current movement patterns of the city.

Therefore, the study having explored the relation between the spatial and functional pattern of both cities, as they have been emerged from the syntactic and functional analysis suggests that the morphology of the grid of a city can be informative about the urban system and how it works. Considering the limited historical data, this study revealed a problematic upon two apparently similar

urban systems which function differently. Finally, regarding the research question which is about the reasons of their different functional pattern, the study has shown that syntactic analysis of the grid, especially the radius-radius analysis related with the evolution of land uses is a promising line for further research with more complete data.

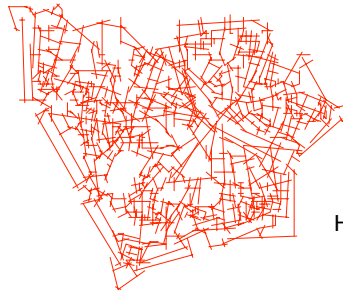
10 Conclusions

Despite the similar historical process that these two cities were formed, their evolution process appears to have led to different spatial and functional patterns. Heraklion and Chania differ in terms of the size of their first core. Heraklion's old core comprises a substantial part of the settlement as a whole. Its significant in terms of the function of the whole city, can be traced on the intensification and density of its grid, which have taken place during the last decades. However, despite its size and density, the historical old core is not well connected with the settlement as a whole. The latter reaches the old city through four lines, which are not very strong. On the contrary Chania's historical city is a small part of the contemporary settlement, which has been expanded significantly during 20th century. Old core's morphology of the grid is clearly different of this one of the new part of the city. This old historical city is connected to the new city through two strong lines, which practically cross the old core on the north-south axis. As a conclusion, this study suggests that it is its size, its density, and its connections to the new city that enabled Heraklion's historical core to function as a "city into the city". For the same reasons Chania's historical core is a local area of the city, which because of its significance in terms of its historical evolution, functions as an attraction both for the inhabitants and the strangers.

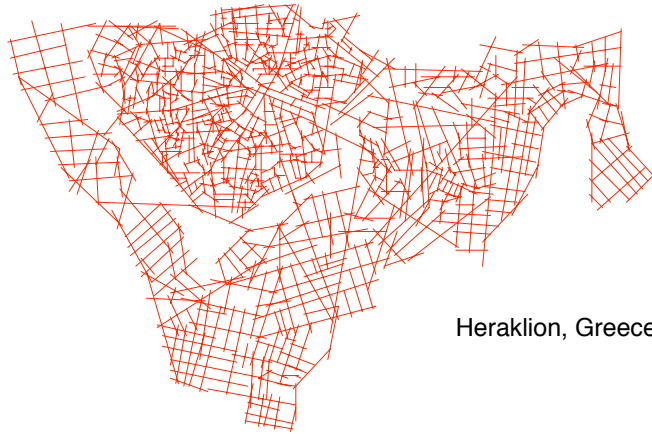
Heraklion - Chania:

A study of the evolution of its spatial and functional patterns

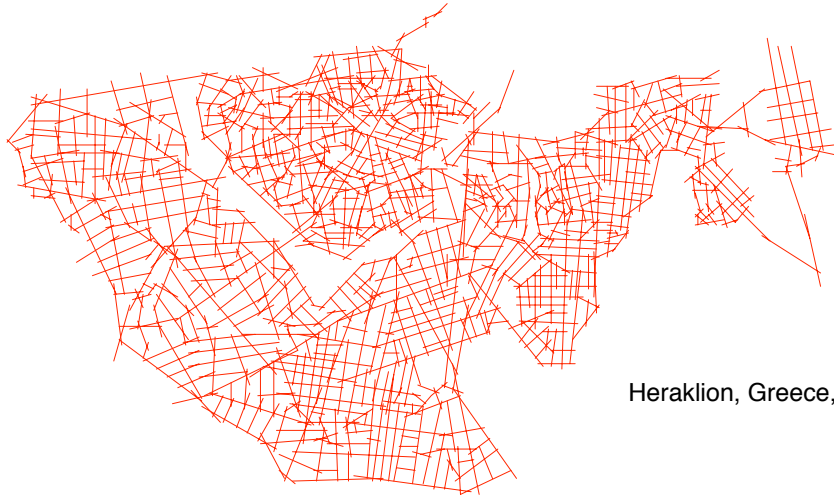
PLATES



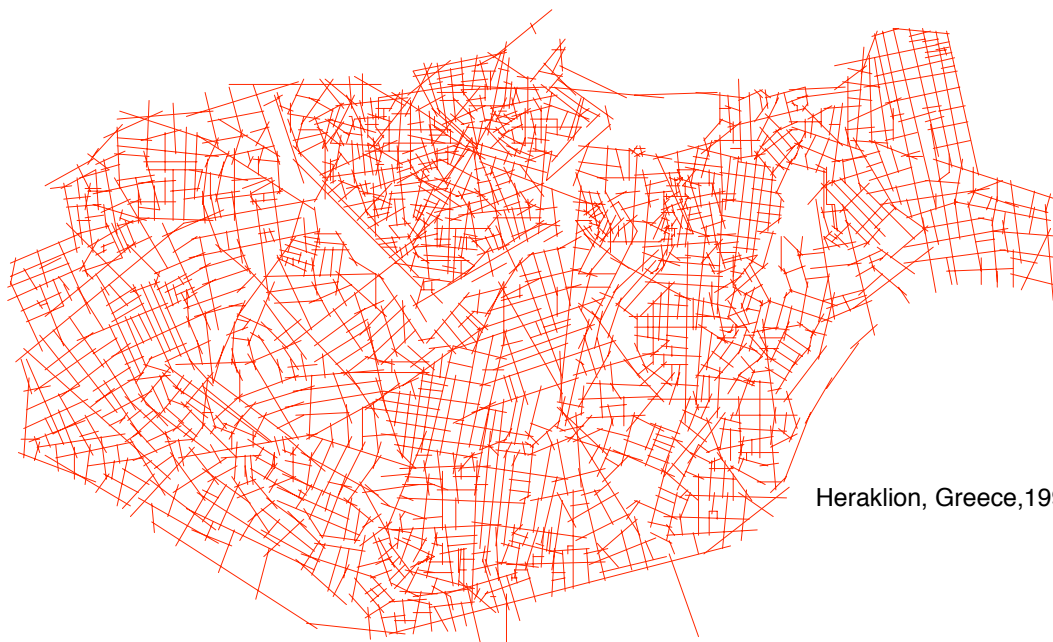
Heraklion, Greece, 1666-68



Heraklion, Greece, 1936



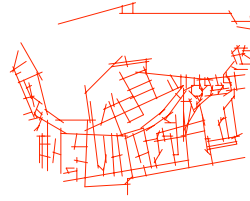
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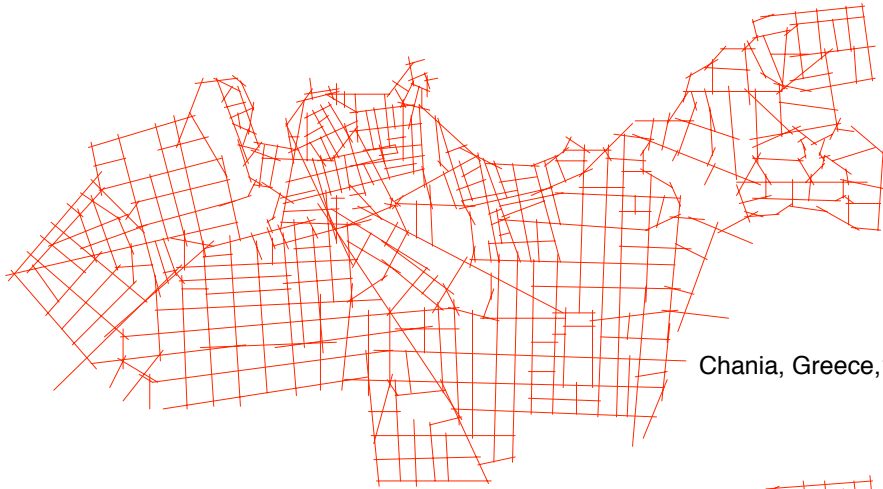
Heraklion, Greece, 1990



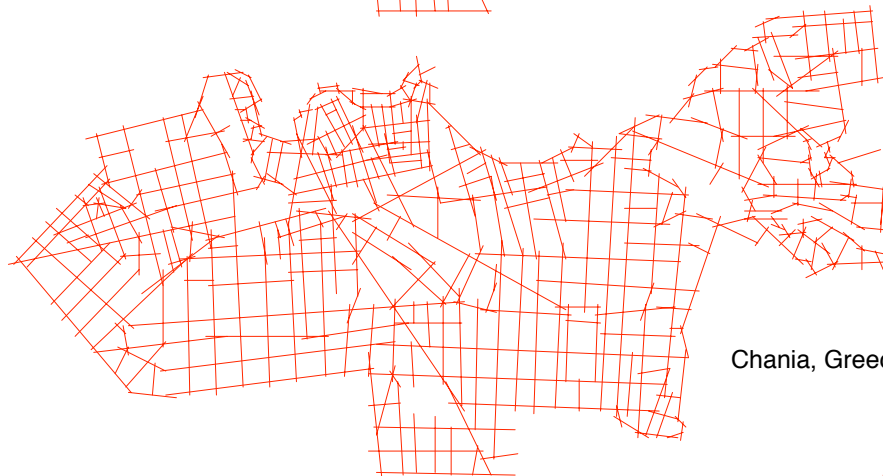
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Chania, Greece, 1905



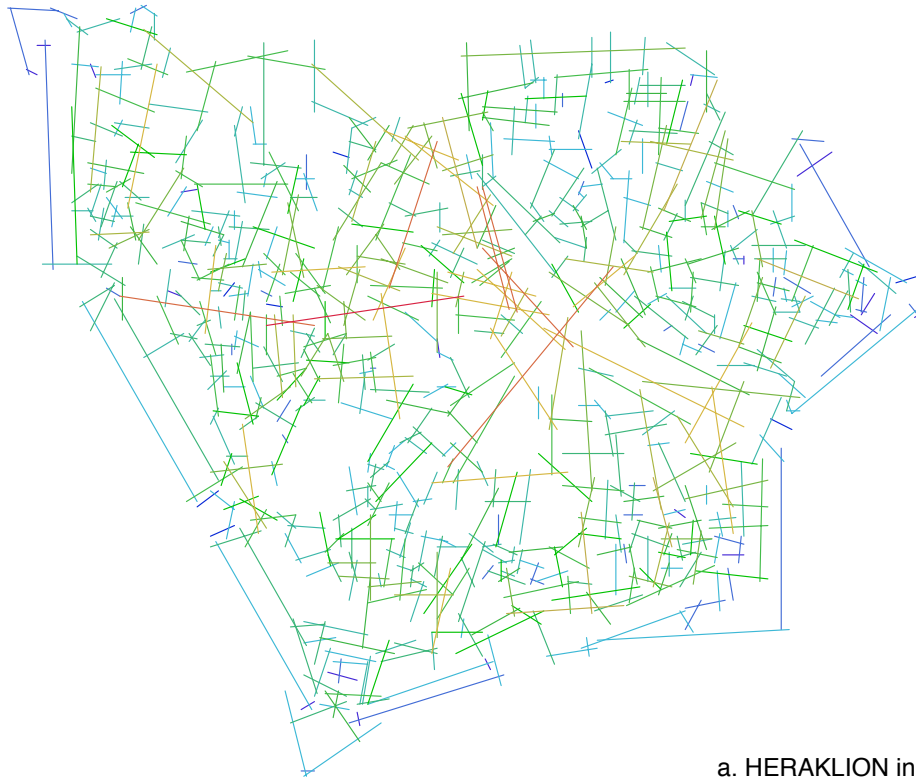
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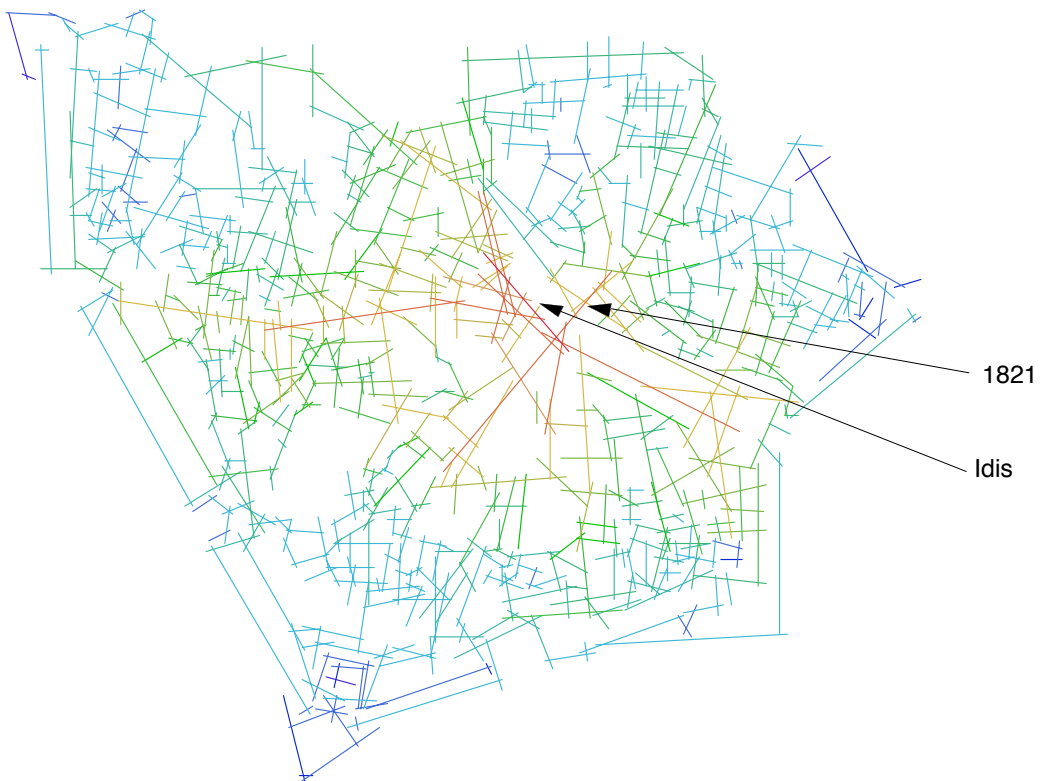
Chania, Greece, 1963



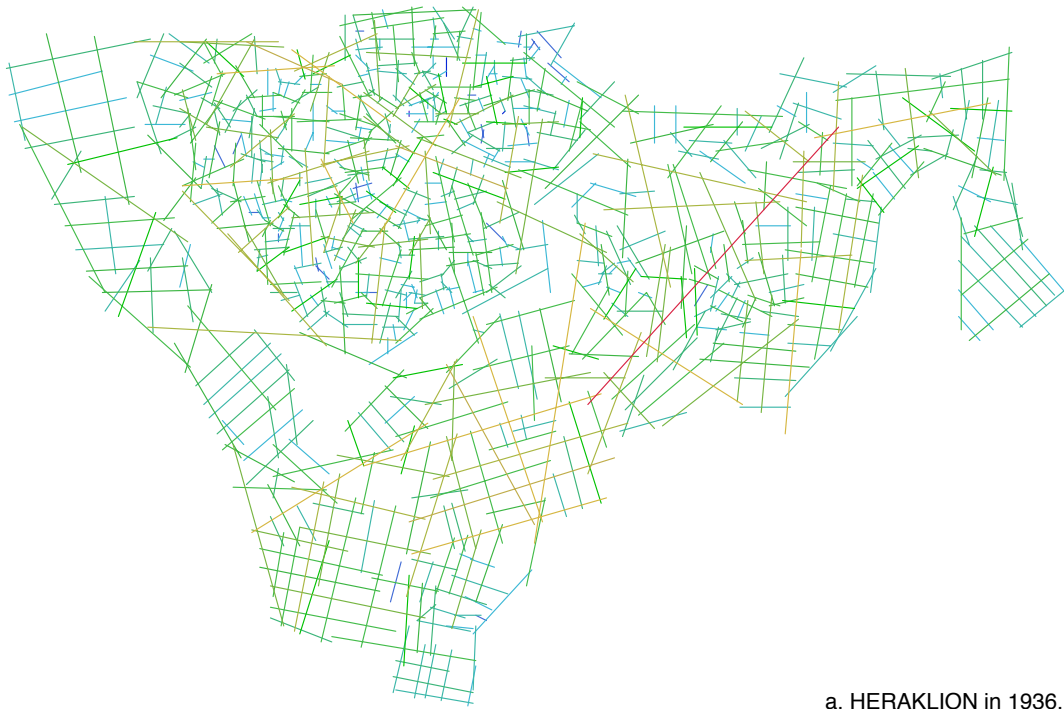
Chania, Greece, 1990



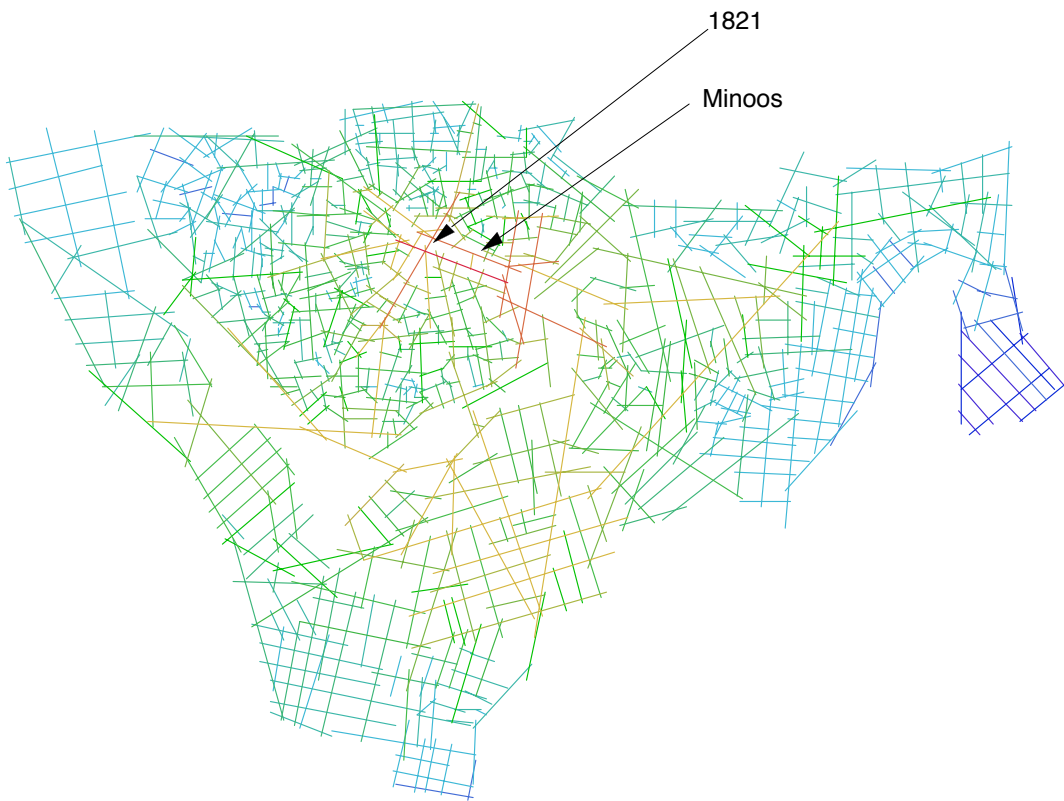
a. HERAKLION in 1666-68.
Integration analysis rad_3



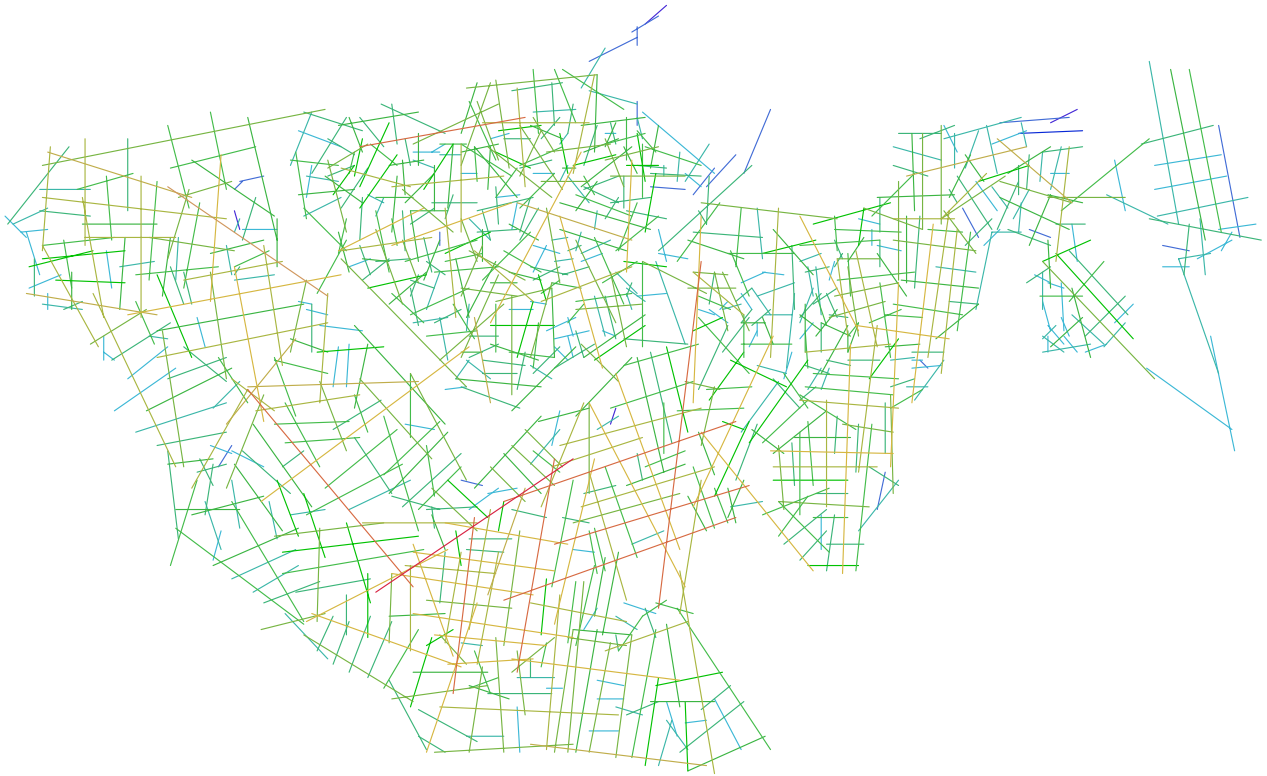
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Integration analysis rad_n



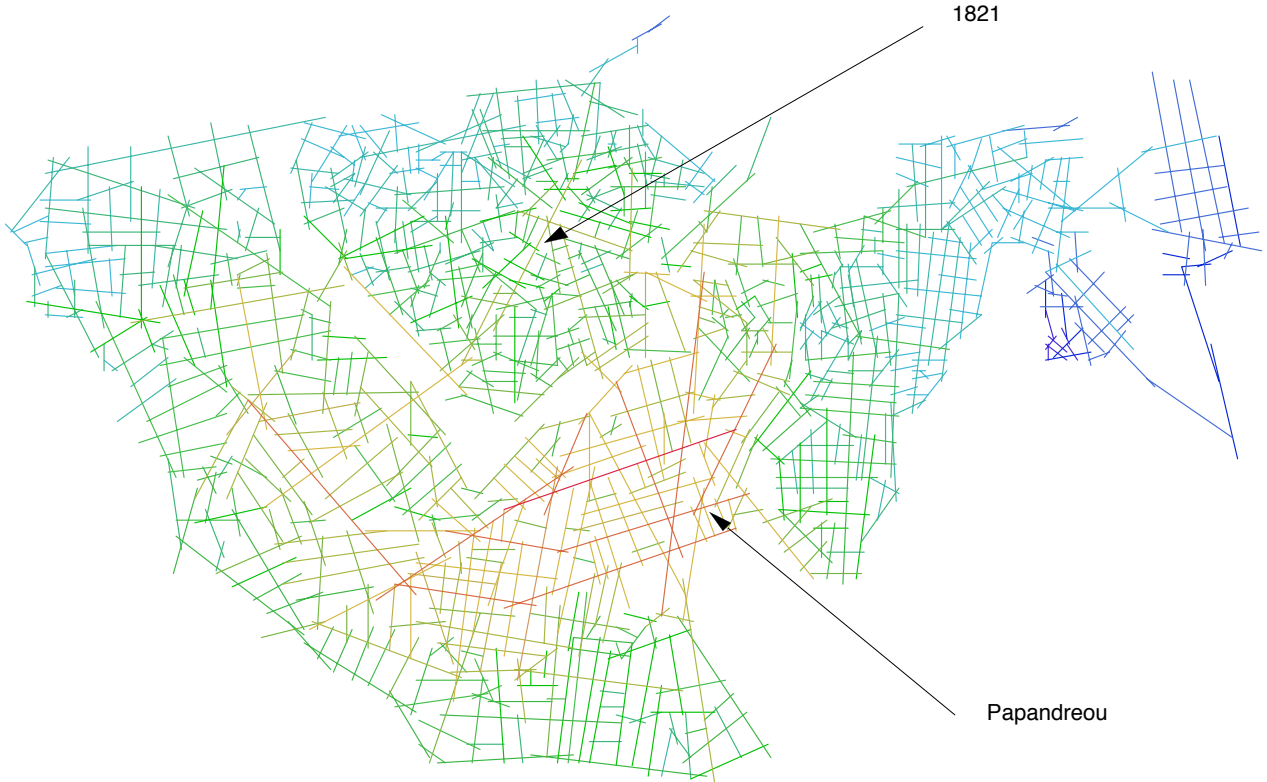
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Integration analysis rad_3



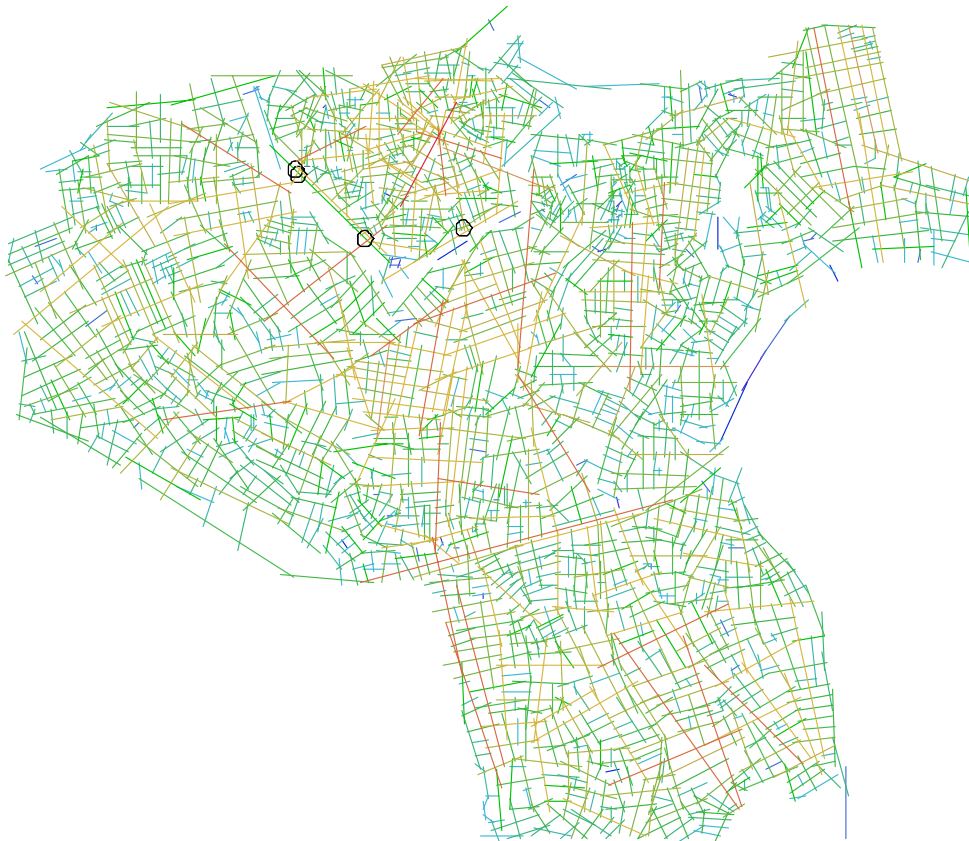
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Integration analysis rad_n



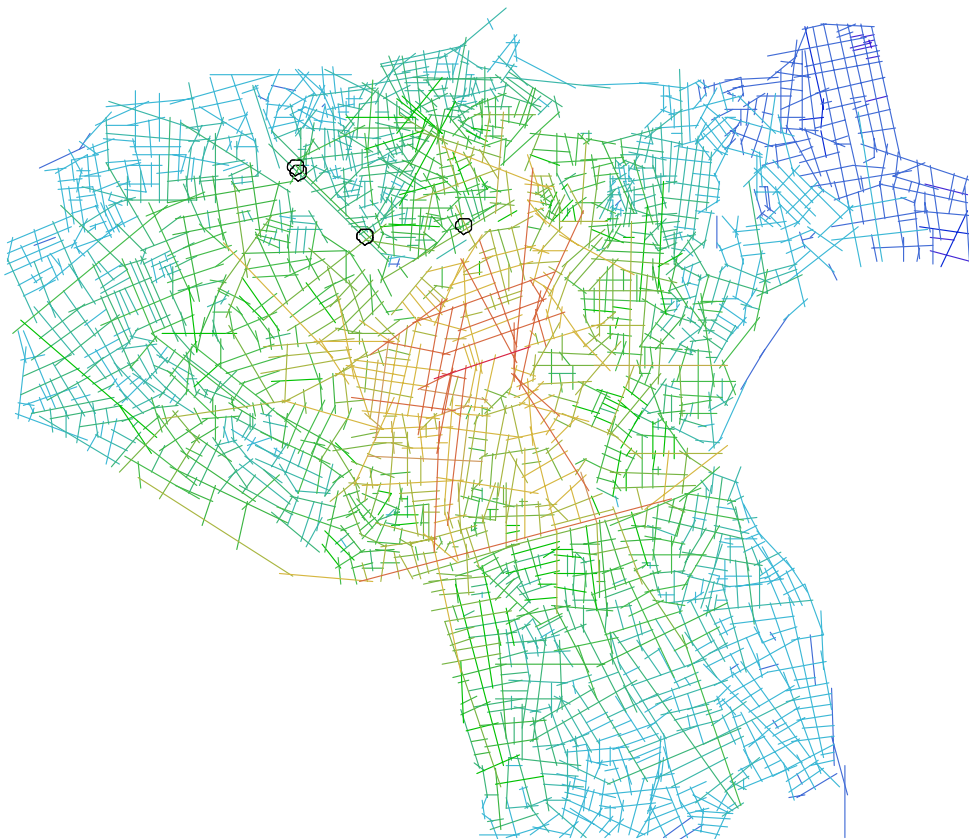
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Integration analysis rad_3



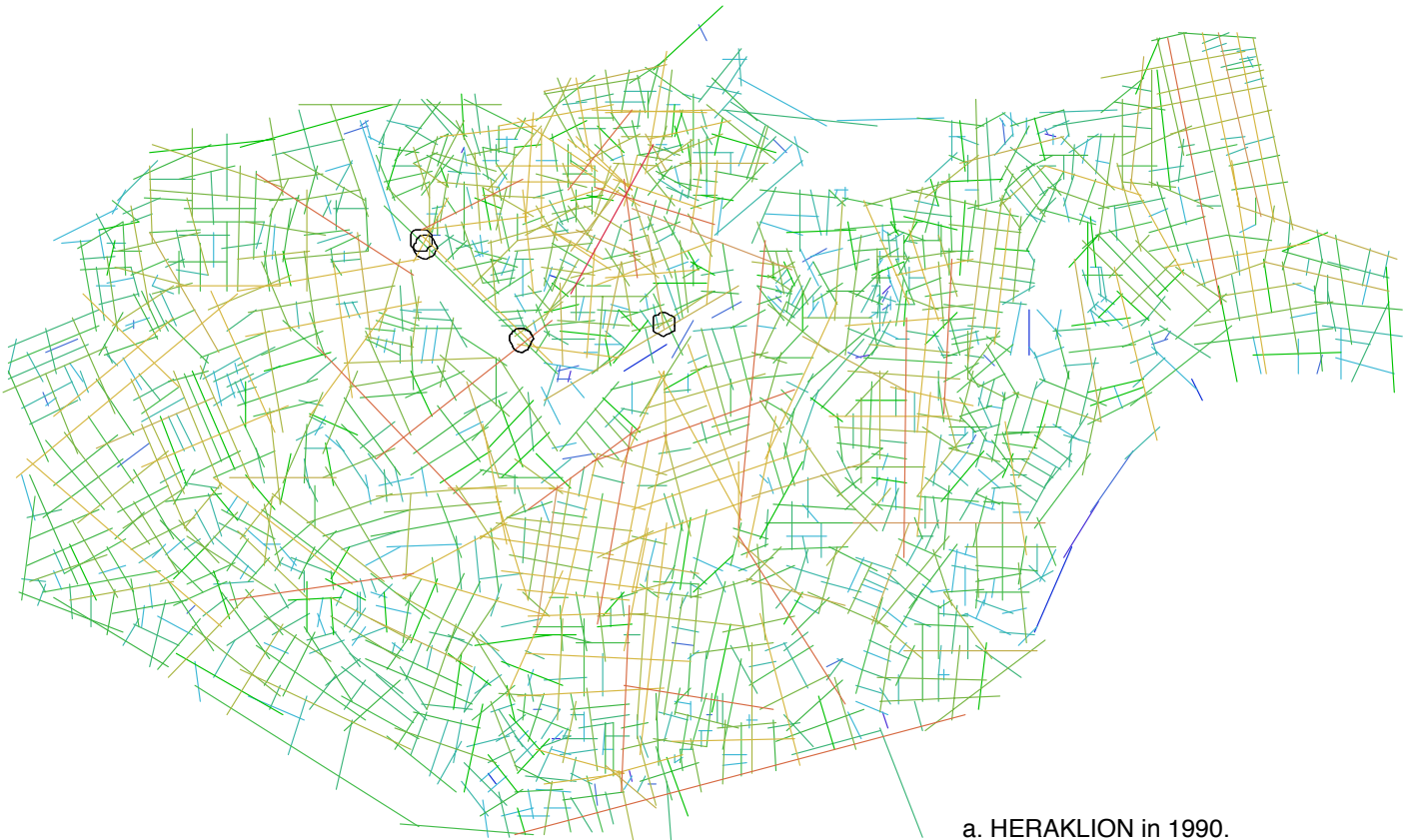
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Integration analysis rad_n



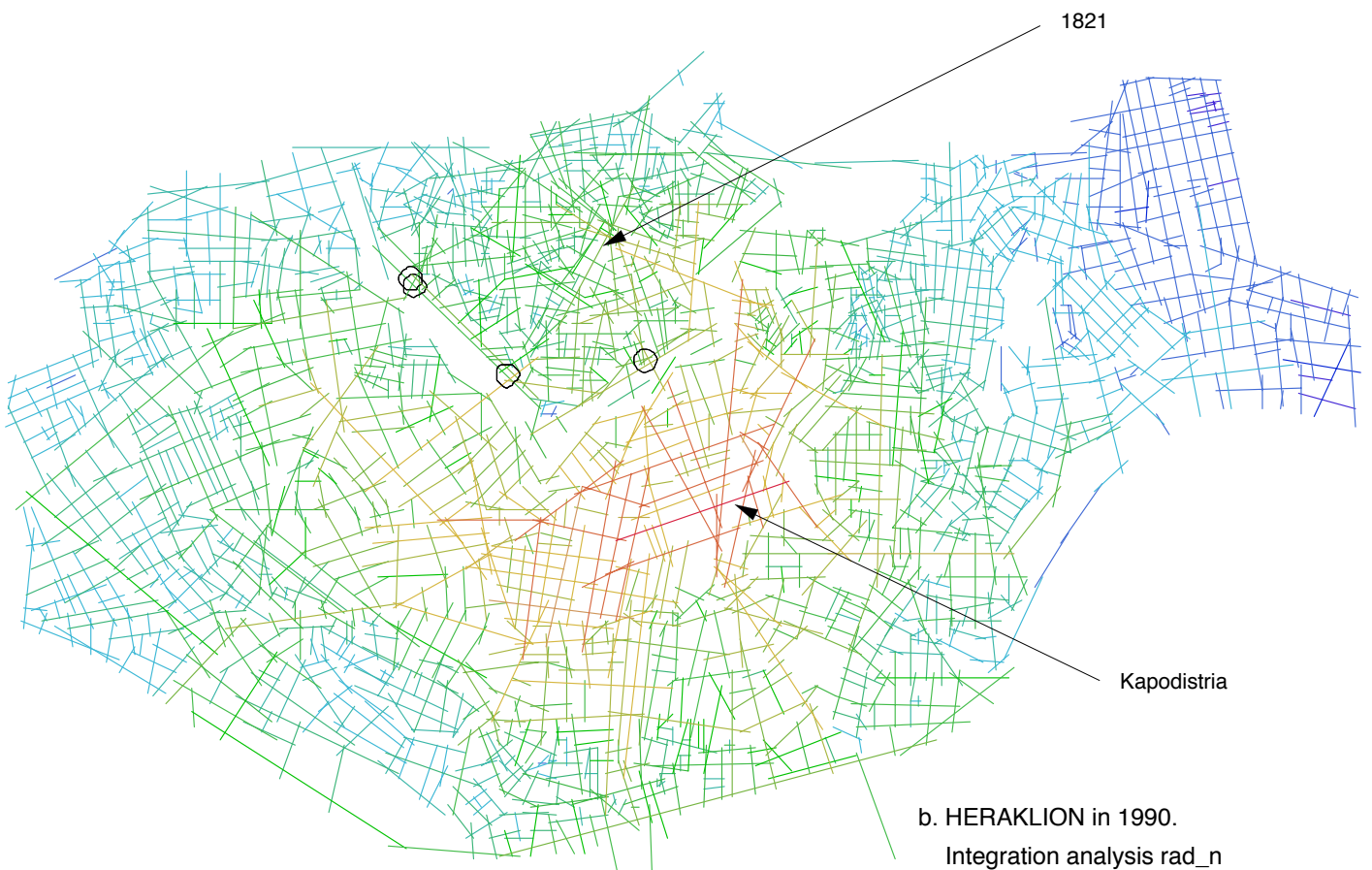
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Integration analysis rad_3



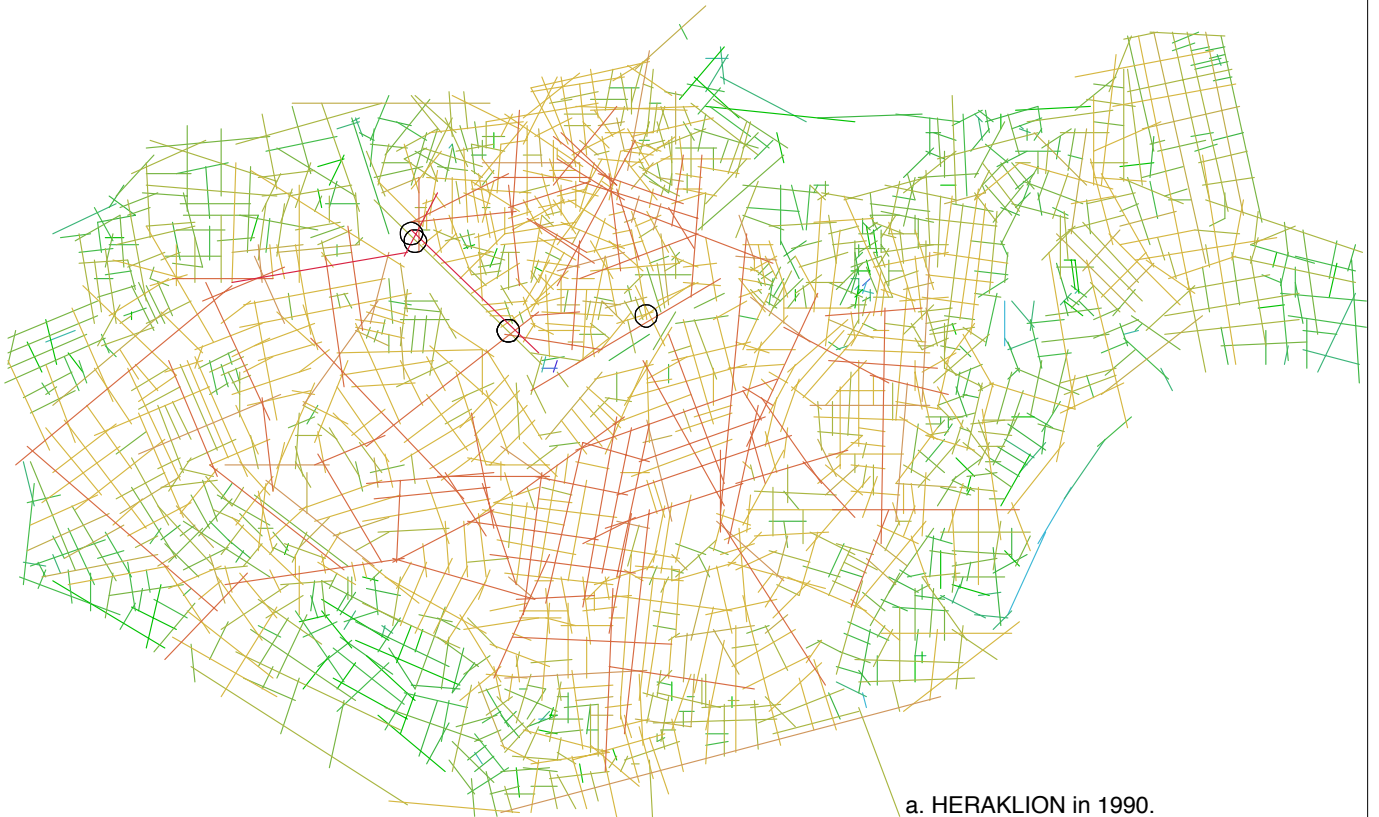
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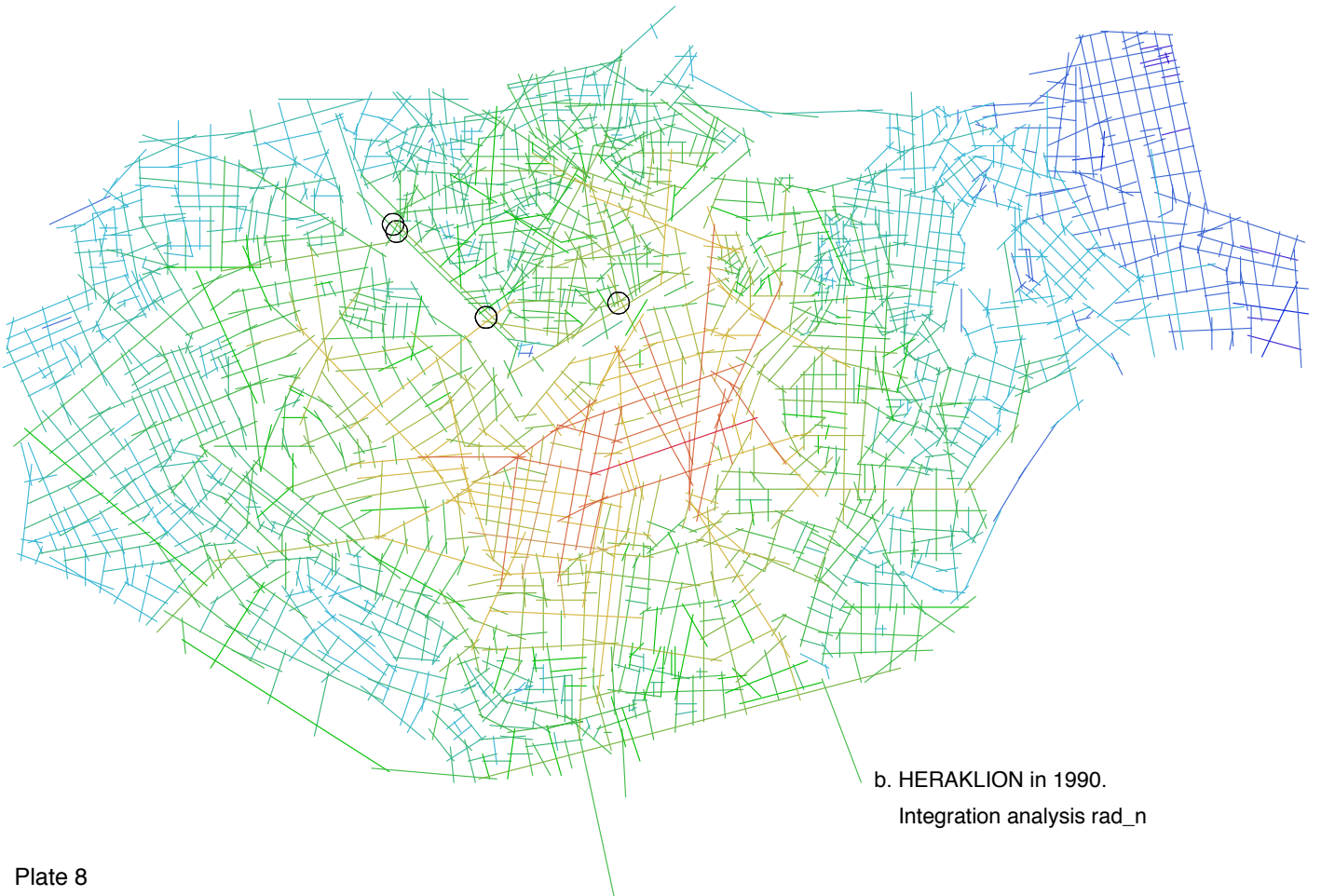
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Integration analysis rad_3



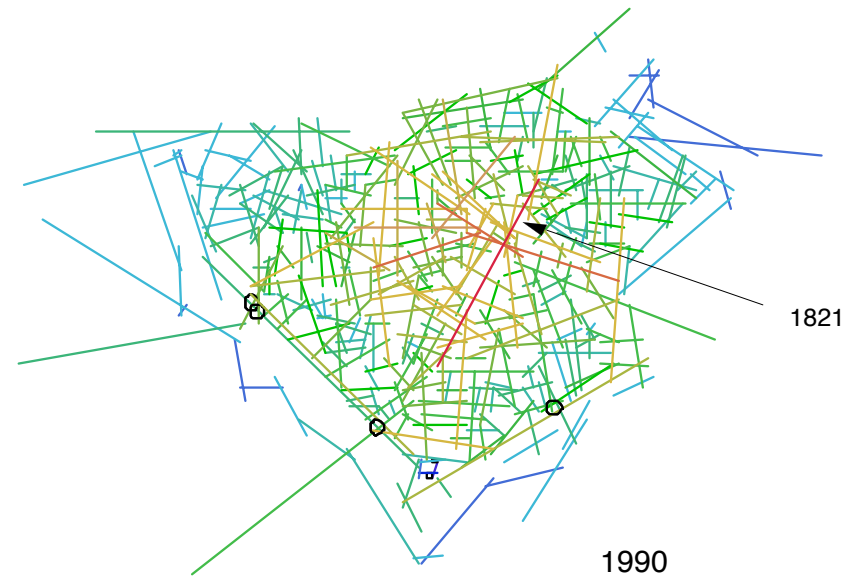
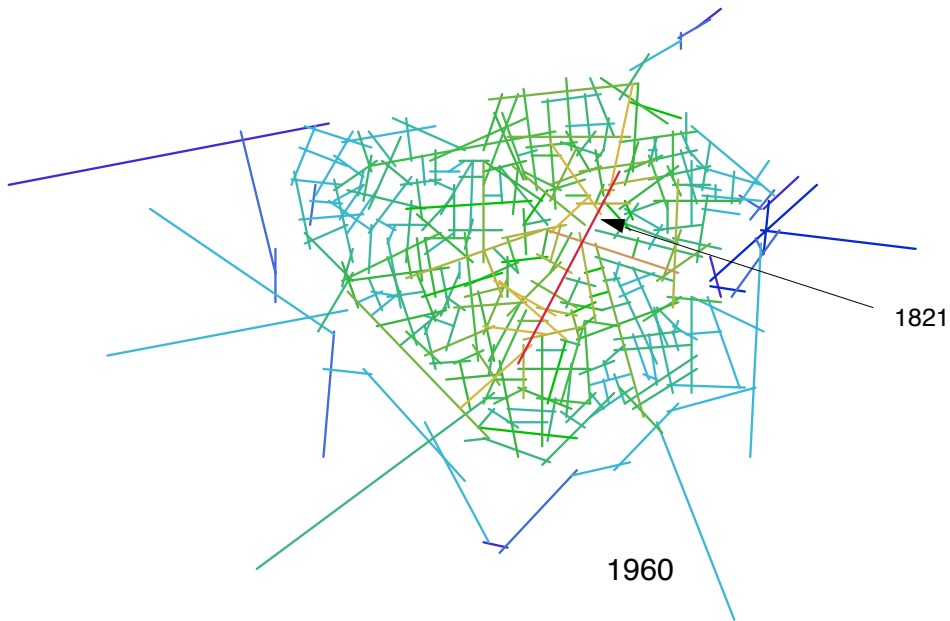
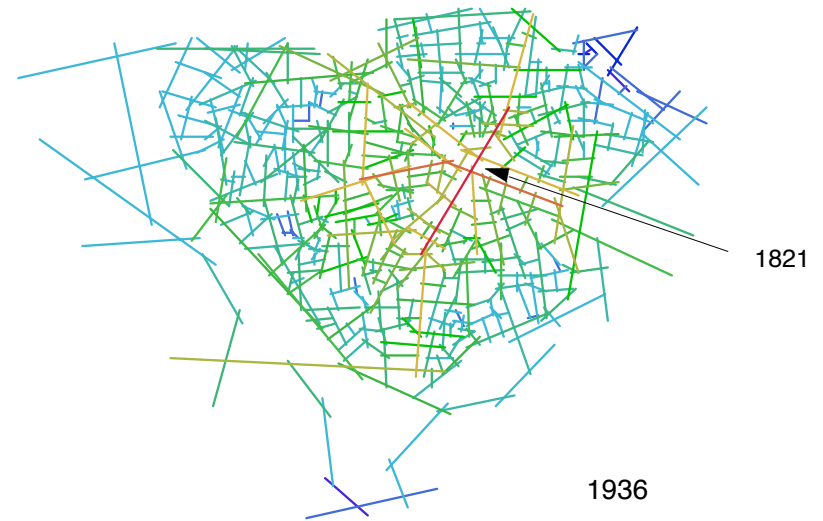
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Integration analysis rad_n

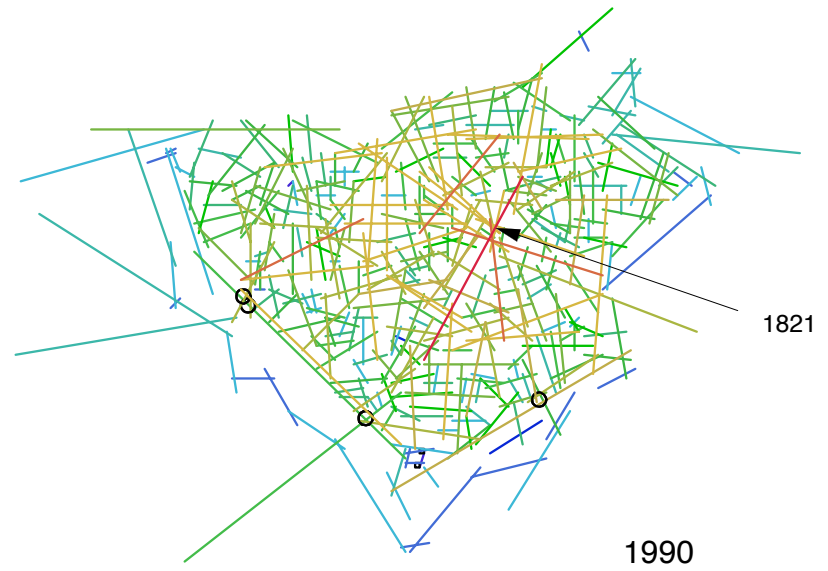
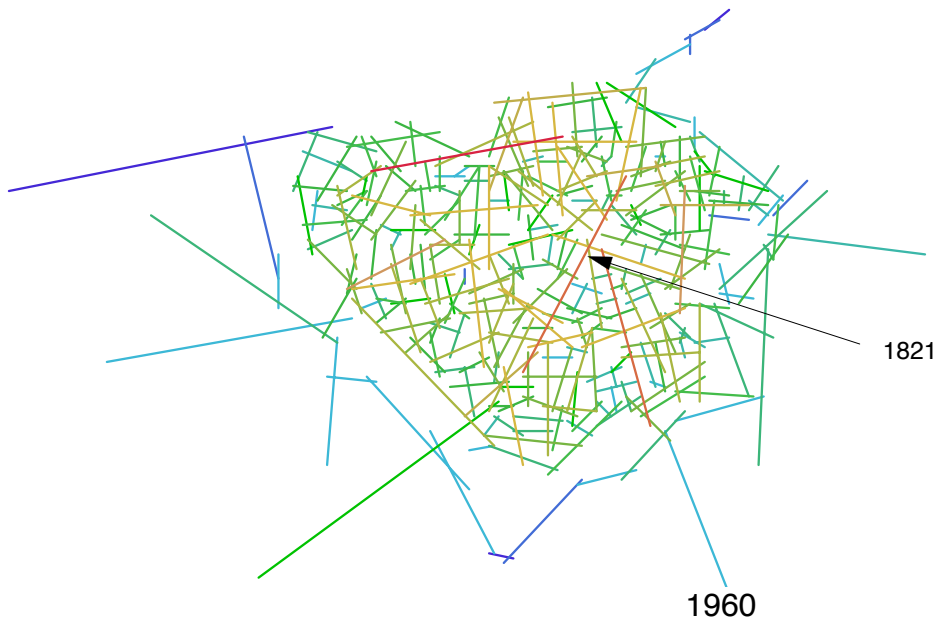
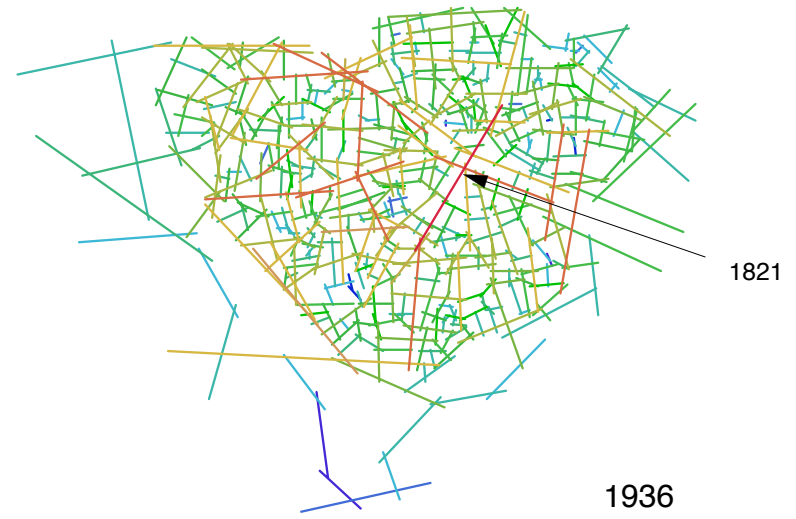
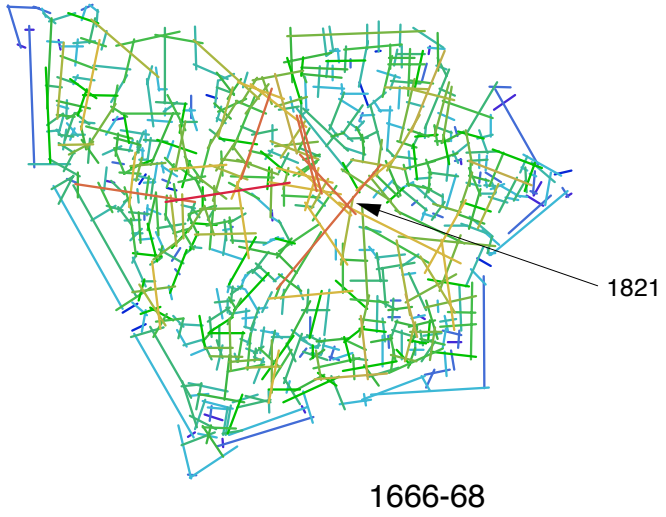


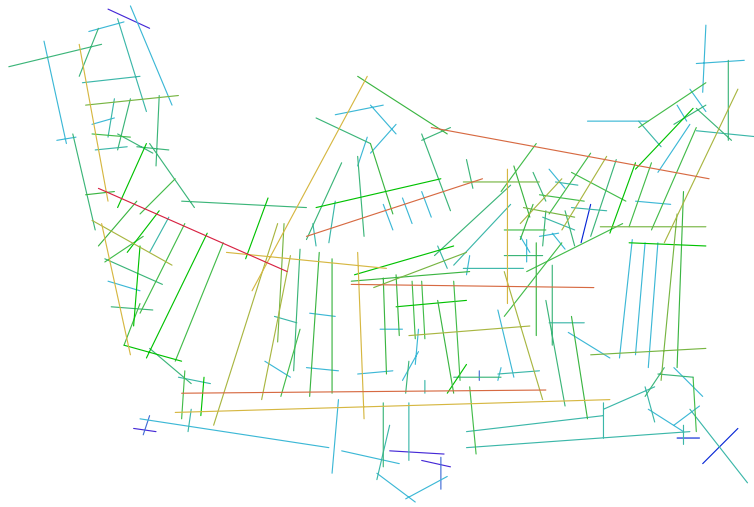
a. HERAKLION in 1990.
Radius-radius integration analysis
(radius=8).



b. HERAKLION in 1990.
Integration analysis rad_n

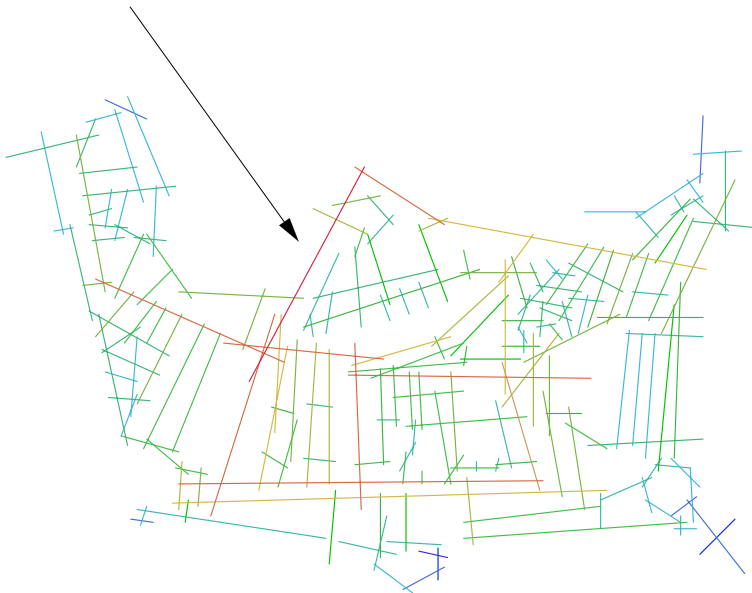






a. CHANIA in 1660.
Integration analysis rad_3

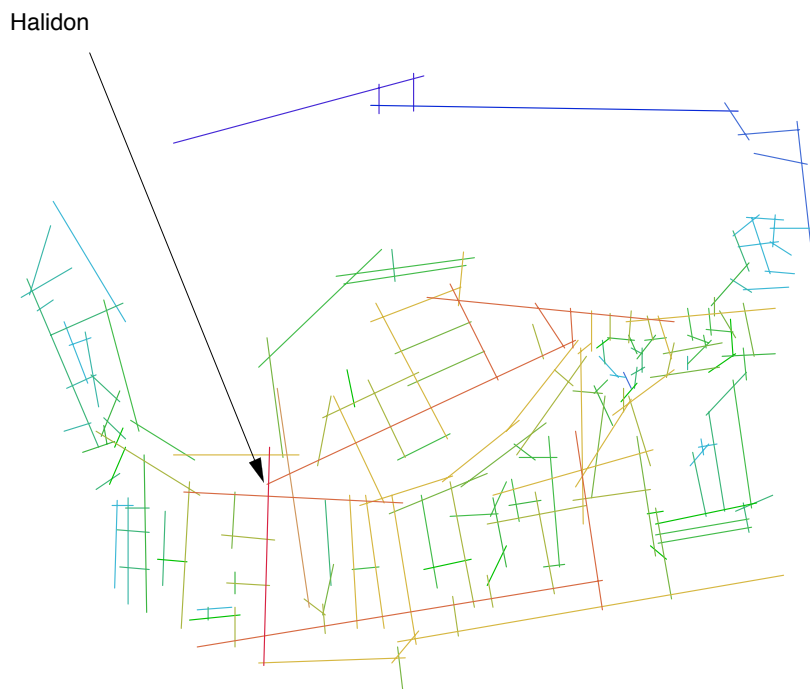
Halidon



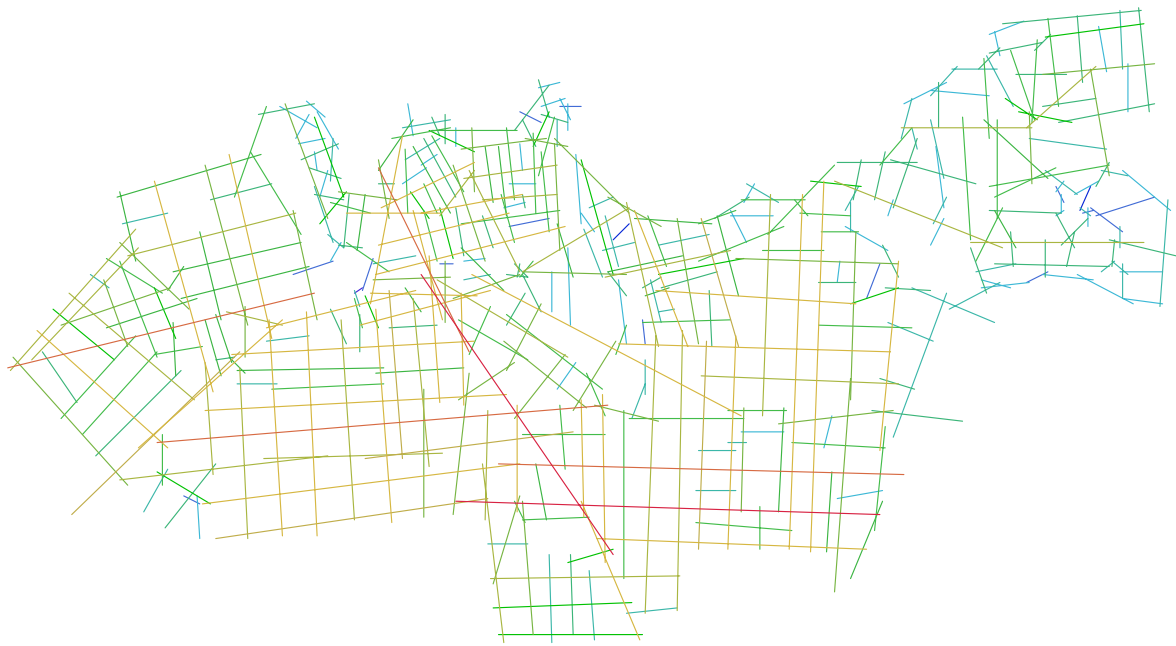
b. CHANIA in 1660.
Integration analysis rad_n



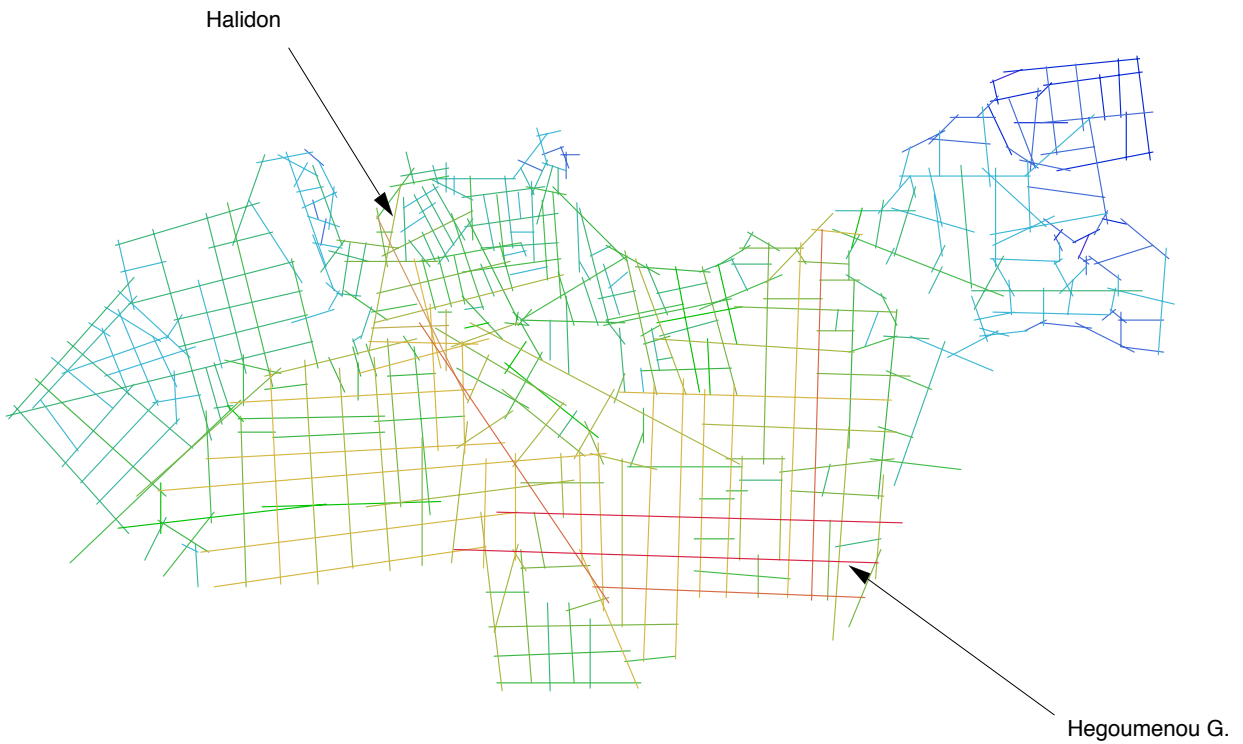
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Integration analysis rad_3



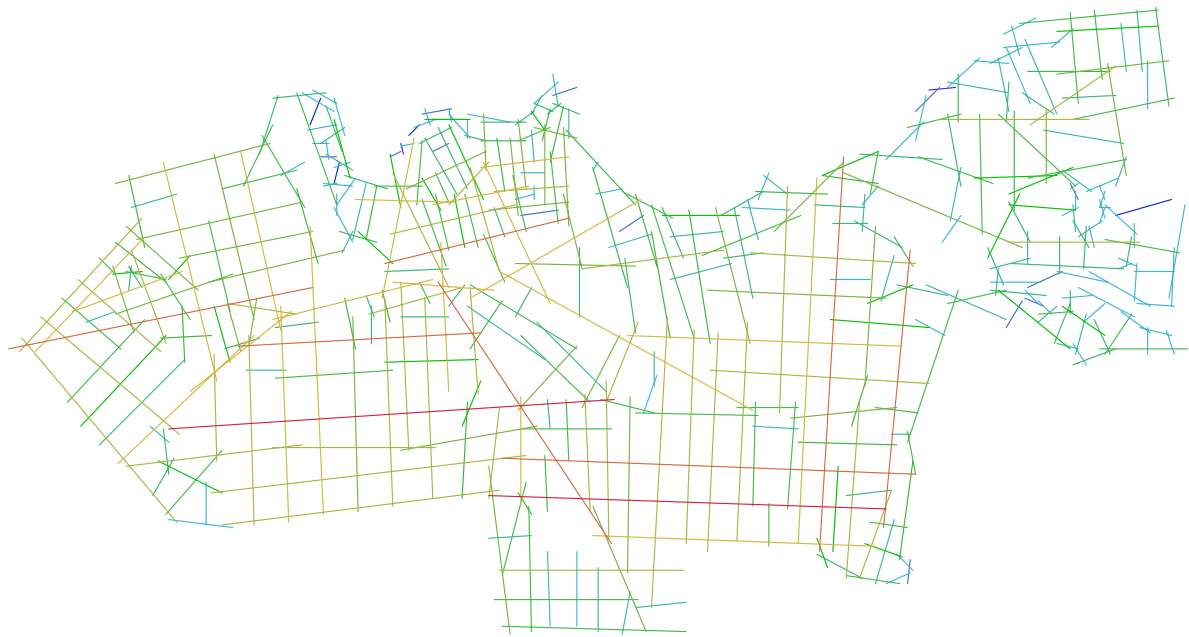
b. CHANIA in 1905.
Integration analysis rad_n



a. CHANIA in 1947.
Integration analysis rad_3



b. CHANIA in 1947.
Integration analysis rad_n



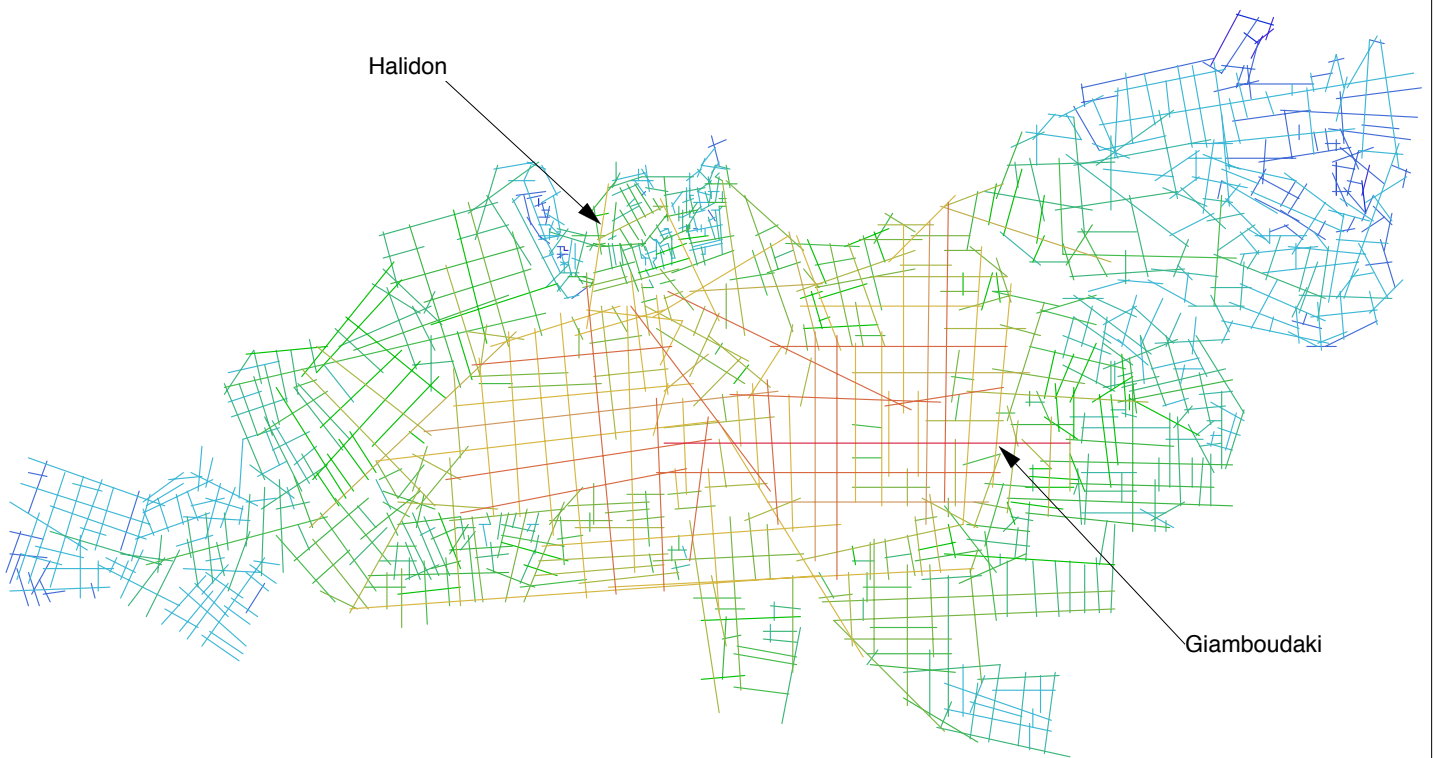
a. CHANIA in 1963.
Integration analysis rad_3



b. CHANIA in 1963.
Integration analysis rad_n



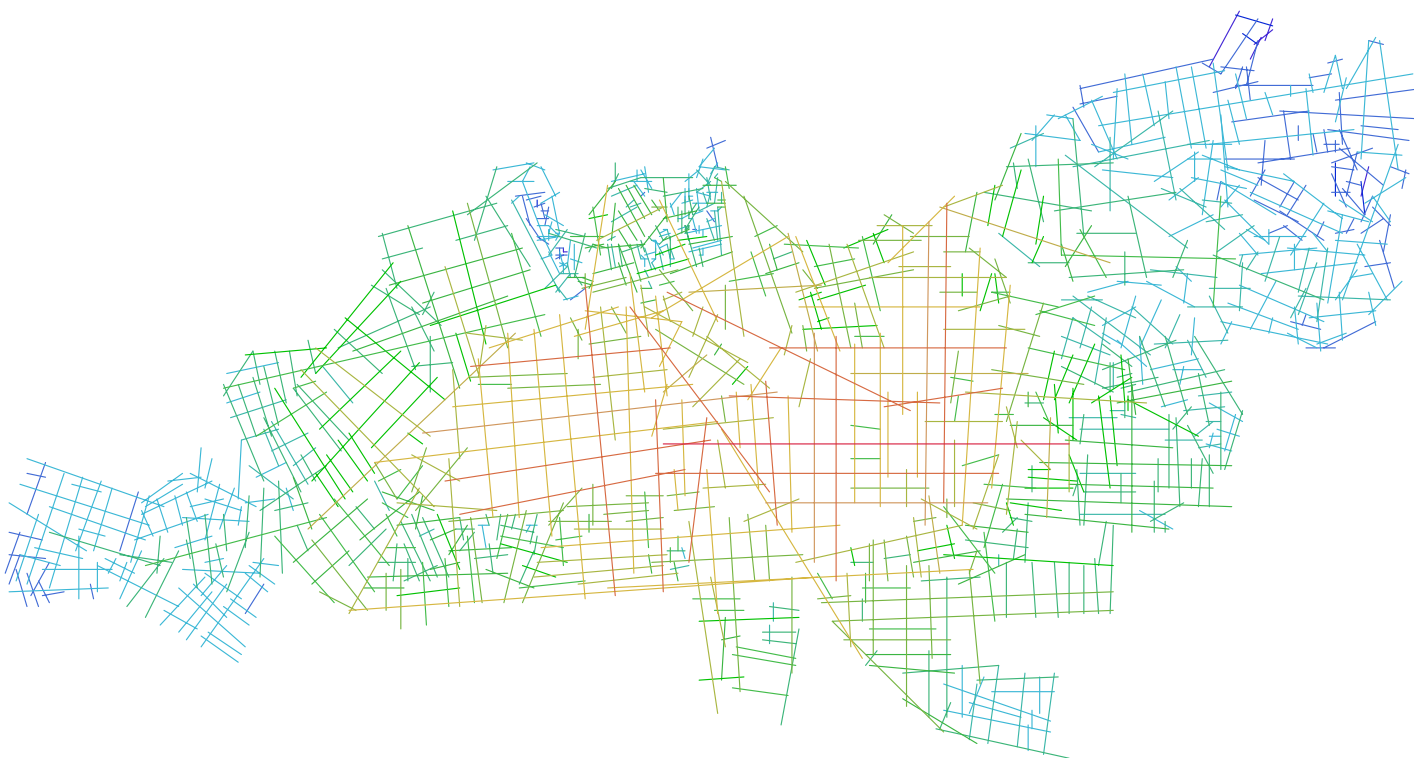
a. CHANIA in 1990.
Integration analysis rad_3



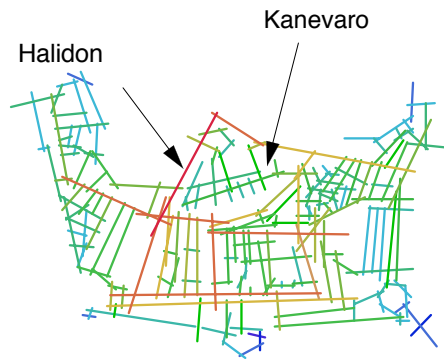
b. CHANIA in 1990.
Integration analysis rad_n



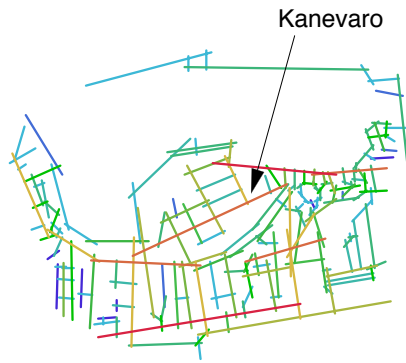
a. CHANIA in 1990.
Radius-radius integration map
(radius=9).



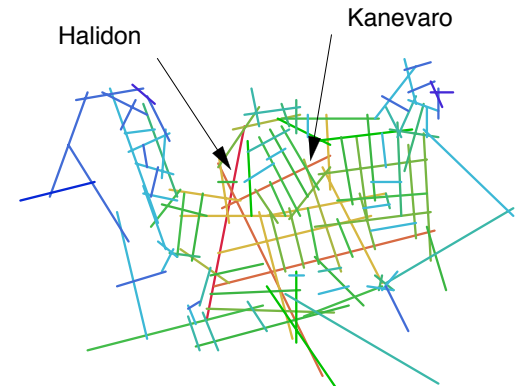
b. CHANIA in 1990.
Integration analysis rad_n



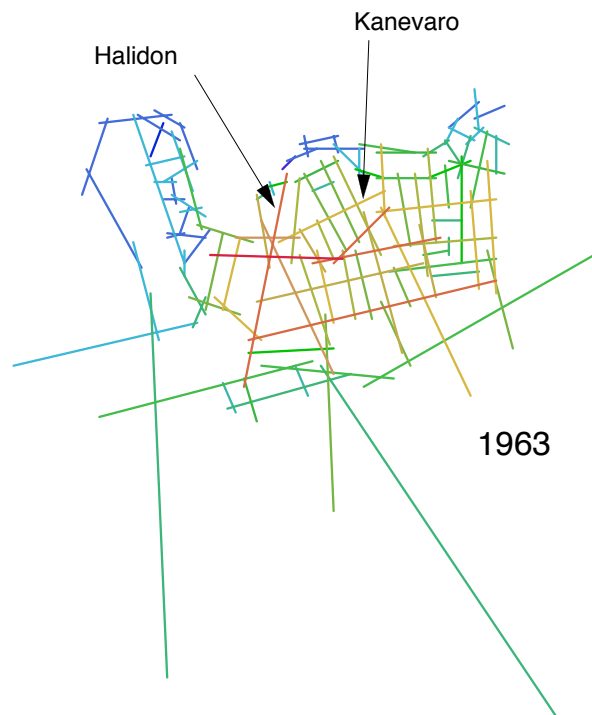
1660



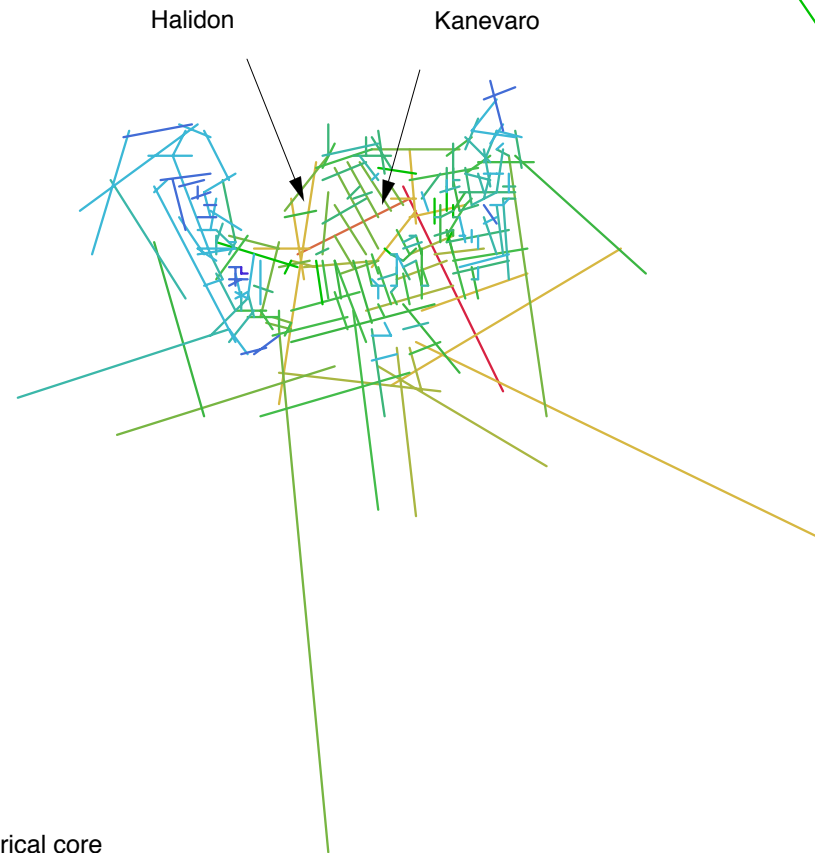
1905



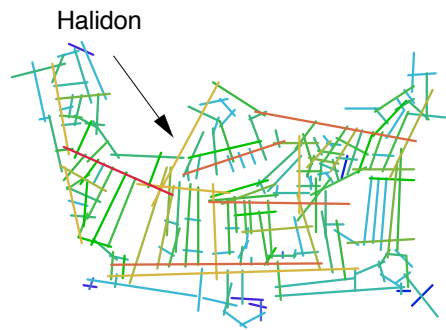
1947



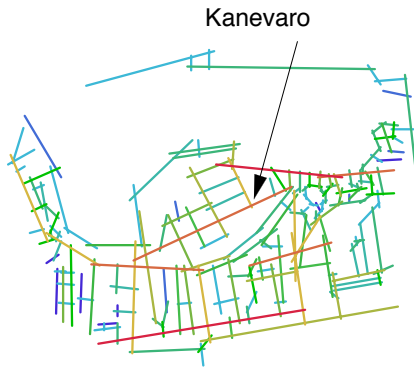
1963



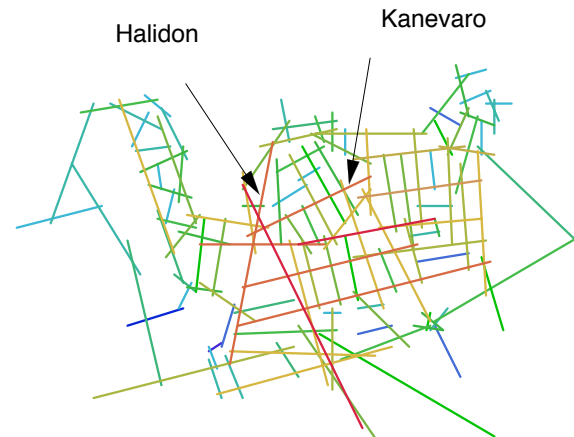
1990



1660



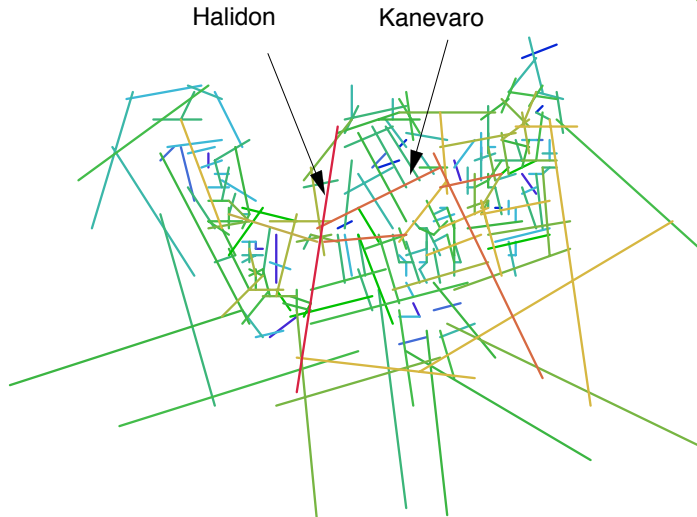
1905



1947



1963



1990

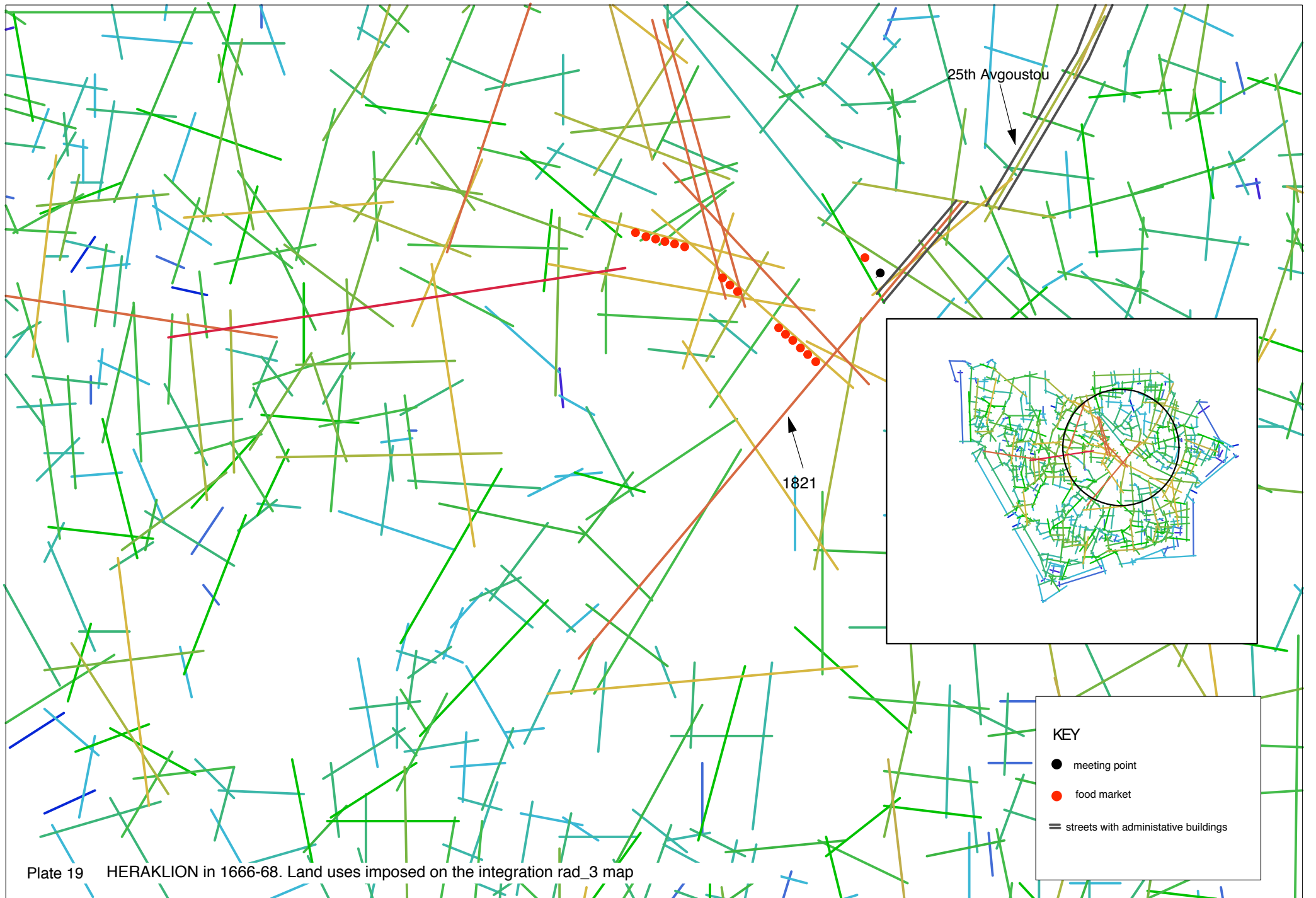


Plate 19 HERAKLION in 1666-68. Land uses imposed on the integration rad_3 map

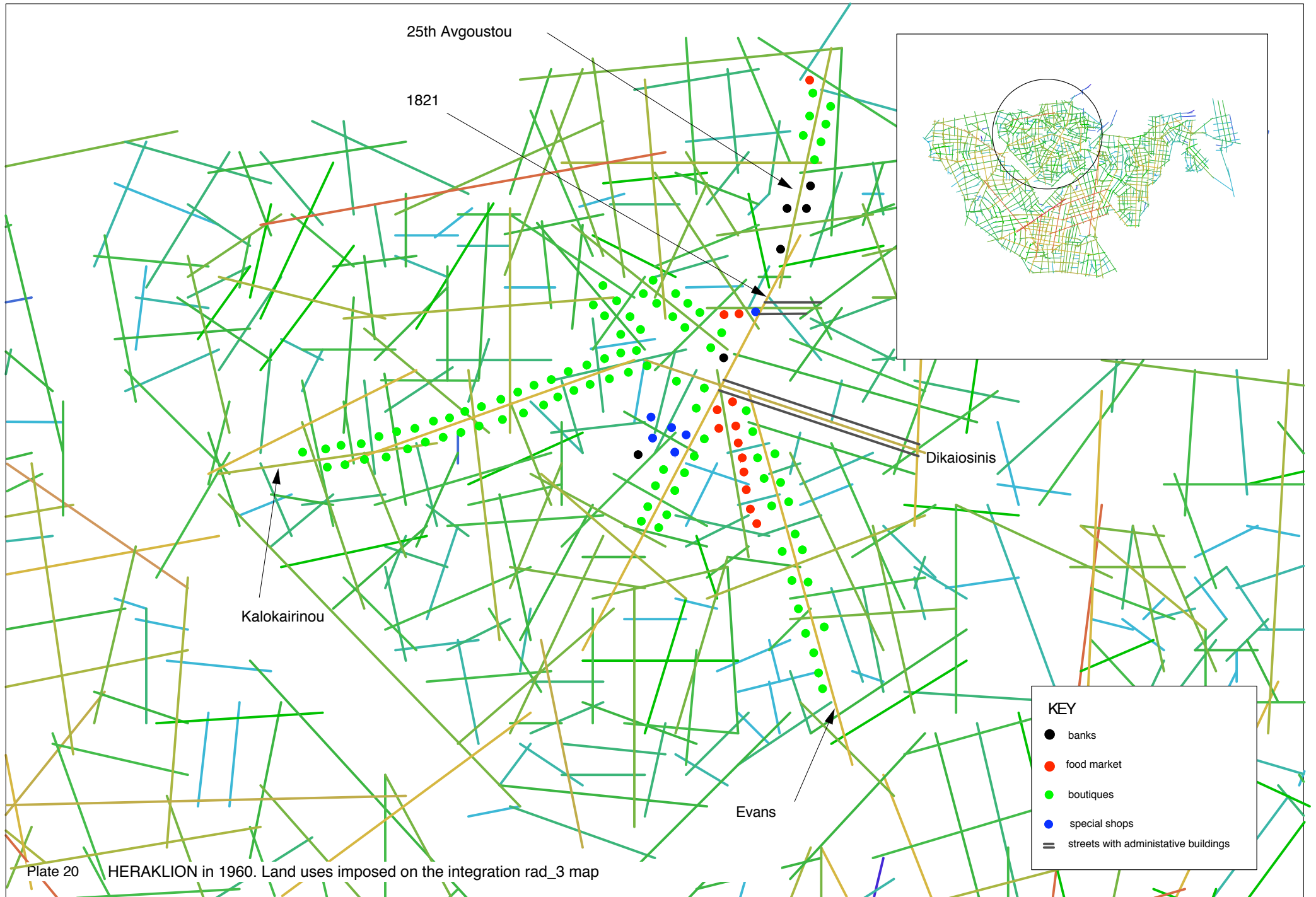
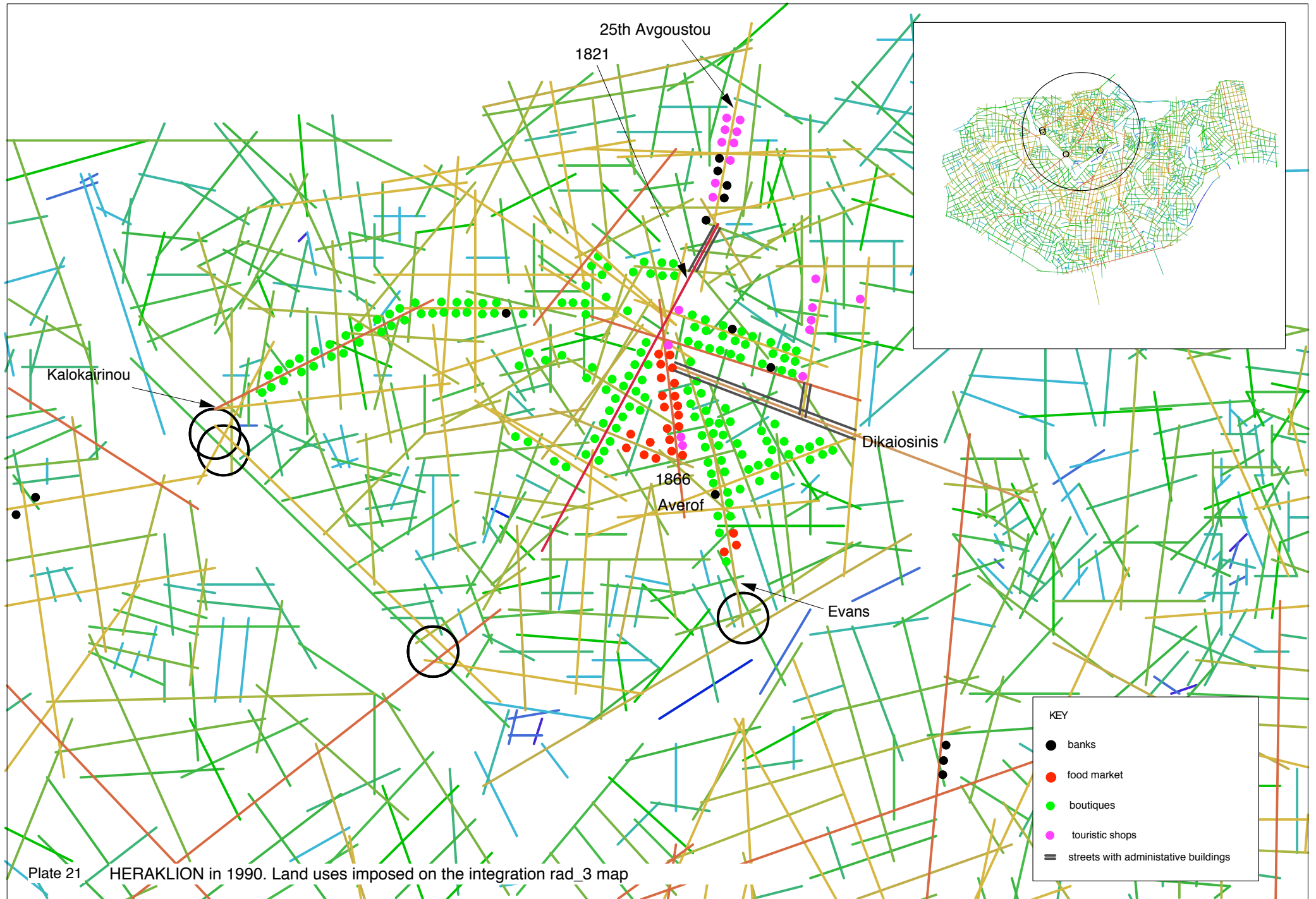


Plate 20 HERAKLION in 1960. Land uses imposed on the integration rad_3 map



25th Avgoustou
1821

Kalokairinou

Dikaiosinis

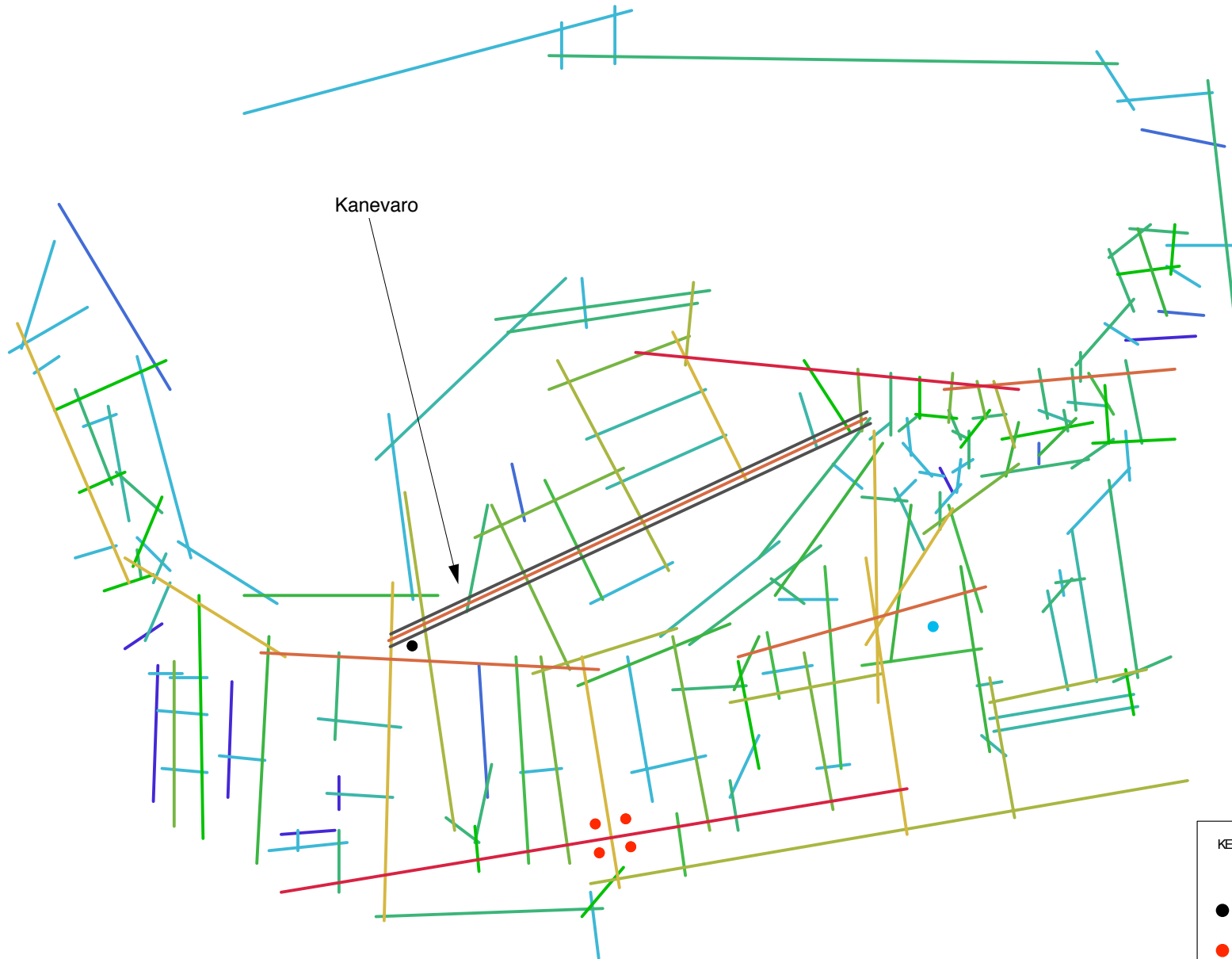
1866
Averof

Evans

KEY

- banks
- food market
- boutiques
- touristic shops
- streets with administrative buildings

Plate 21 HERAKLION in 1990. Land uses imposed on the integration rad_3 map



Kanevaro

KEY

- greek meeting point
- food market
- turkish meeting point
- == streets with administrative buildings

Plate 22 CHANIA in 1905. Land uses imposed on the integration rad_3 map

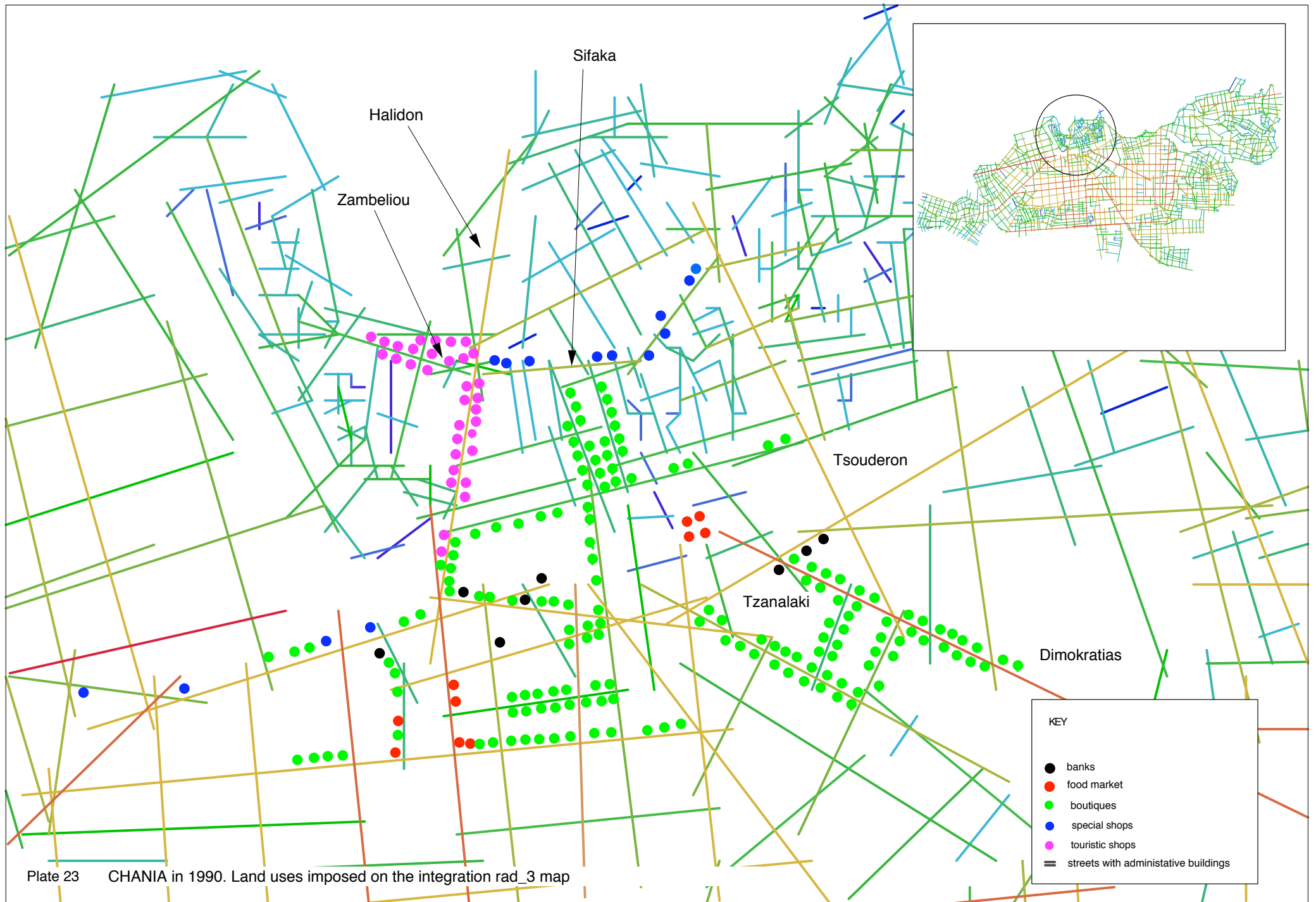


Plate 23 CHANIA in 1990. Land uses imposed on the integration rad_3 map

KEY

- banks
- food market
- boutiques
- special shops
- touristic shops
- streets with administrative buildings

Appendix

Heraklion

According to the census of 1991 the city of Heraklion had a population of 129,345 citizens, while the authorities anticipate that this population will expand to 218,841 citizens in 2013.¹⁶ Considering all the statistics, it reveals that during the 20th century the population of Heraklion has increased mostly, regarding the population of all the other major towns of Crete, including the town of Chania. This significant increase has remained almost the same throughout Heraklion's historical process. In terms of the 20th century the bigger increase of its population took place during the years 1920-1928, when it increased up to 38%. An important aspect of Cretan social and demographic history during this period was the large number of refugees from Asia Minor that were resettled on Crete, mainly in the area around Heraklion. In September 1922, according to the new reports and descriptions in the newspapers of the day, more than 20.000 refugees were in the harbour and roads of Heraklion. In January 1923 the Treaty of Lausanne was signed by Turkey and Greece, whereby an exchange of populations was agreed upon. The homes and property of the Muslims were handed over to the Greek refugees from Asia Minor. Thus, most of the refugees settled in the towns or their outlying districts where the Muslims had largely confined themselves since the beginning of the century. The previous argument is reinforced by the fact that in the census of 1928 the proportion of the citizens of Heraklion being refugees appears to be up to 39.30% of the whole population. However, the percentage of the increase of population during the years 1940-1951 was 30.5%, which appears to be the bigger increase among all the settlements in Crete during the after the Second World war era.¹⁷ To the previous statistics can be added the fact that a small percentage of the population of Crete immigrated to more developed countries like the United States of America and this proportion is described as 0.78‰ of the population of the county of Heraklion. The statistics in terms of the population of the larger area of Heraklion between the years 1951-2013 according to the census can be seen in the scattegram and the table below¹⁸:

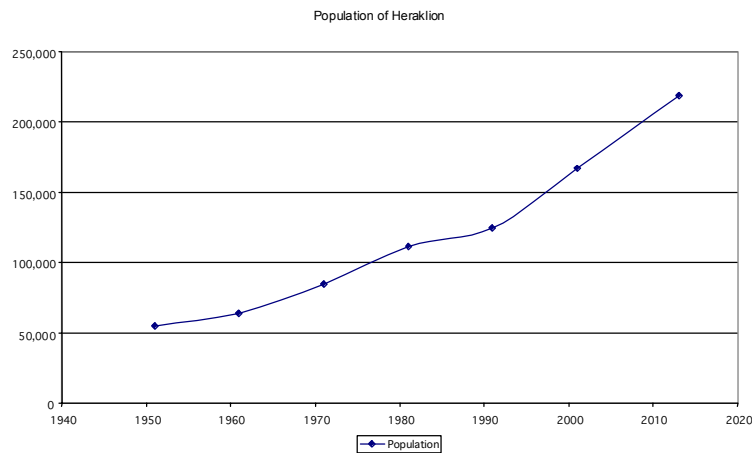
¹⁶ The population statistics are mentioned in the report conducted by The Ministry of Environment of Greece, in 1998 for the city of Heraklion.

¹⁷ The details about the percentage of the increase of population in Heraklion are found in the research conducted by A.Proveleggios in 1966 for Heraklion.

¹⁸ The details of the statistics for the larger area of Heraklion are found in the research conducted by the Ministry of Environment in 1998 for the city of Heraklion.

larger area of Heraklion

Year	Population
1951(Census)	54,878
1961(Census)	63,765
1971(Census)	84,354
1981(Census)	111,335
1991(Census)	124,345
2001(anticipation)	166,617
20013(anticipation)	218,841



The statistics relating the population of Heraklion during the 20th century can be completed by the statistics of the population of Candia, the former name of the city, from its formation until 1913. Thus, in 827 the founding population of the city appears to be 15,000 citizens. However, there is a decrease of this amount between the years 1300-1669. The population between these years has been recorded as 11,474 people. In the year 1669 when Candia was occupied by Ottomans 7,700 soldiers and 4,000 citizens fled. The next years the city of Candia was gradually repopulated. However, in 1800 Candia appears to have 15,000 citizens, while in 1850 there is a significant increase of the population when the city appears to have 18,910 citizens (Chandler, T., 1974,p.172). Furthermore, according to the census in 1900 its population is 22,501 citizens, which in 1913, when Crete became part of Greece, increased to 25,000 people. Consequently, in terms of the evolution of the population of Heraklion, it emerges that there is a significance increase of it from the 18th century until today.

As far as the economy of the city is concerned, this appears to be mainly based on trade activities, although there are also a large number of administrative services. The latter is justified from the census of 1961, which describes that 59.2% of the active population in Heraklion is employed in this sector of the economy, which includes both the trade activities and this one of the

administration.¹⁹ The latter proportion is split into 24% of it that it is related with the trade and the 28.5% of it, which are related with the administration. The previous describes Heraklion's significance in terms of the services that the city provides to all the other settlements, manifesting its significance for the economy and its evolution of Crete. However, what seems to describe better the reality in terms of the trade activities, is the fact that the majority of them are related with the retail and there is also a proportion that is related with the wholesale. According to a research conducted in 1958 the number of shops, located within the city were 1562. This number is divided as follows: 402 (25.7%) of them were wholesale shops and 1160 (74.3%) of them were retail shops. The shops were mainly located into the "centre", that is into the part of the city inside the Venetian walls. Today, according two researches, which have been conducted in 1985 and 1998, the trade activities remain almost the same as they have been described above.

What seems to describe the socio-economic features of Candia (Heraklion) until 17th century is the fact that trade activities dominated the economy of the society. Hence, during the period of Venetian rule artisans and professionally trained individuals were particularly active in all urban centres of Crete. Over 50 crafts, divided into various specialities, are recorded: masons, carpenters, cobblers, barbers, tailors, saddle makers, bridle makers, hatters, cap makers, sword smiths, bow makers, arrow makers, furriers, goldsmiths, locksmiths, ditchers, farm wall makers, chandlers, rope-yard makers, turners, pewterers, coopers, tanners, sausage makers and others. The artisans and the workers they employed in these various trades and professions were organised into guilds or schools the same as in Italian cities, in order to secure the solidarity of their trade, their protection of their rights, improvements in living and working conditions and mutual aid of their members (Detorakis, T., 1990,p.194). Their membership was reinforced into spaces, which had been identified as belonging to every different guild; every guild had its own church.

However, during the 15th century and until the 19th century the trade activities were the main economic source for the population of Heraklion. Therefore, during the 15th, 16th and 17th century, there were a variety of people engaged with trade, retail and wholesale. However, there was a large proportion of its population that had been members of what today is called administration. The identified division of the population between these who were engaged into trade activities and those who were part of administration also implies the division of the population into social classes. Thus, bourgeois were usually doctors or pharmacists or even notaries, while the middle social class was this one who was related with all trade activities. In terms of the guilds that have been mentioned above, doctors,

¹⁹ The details about the census of 1961 for the city of Heraklion are found in the research conducted by A.Proveleggios in 1966 for Heraklion.

perfumers, pharmacists, painters, haberdashers and retailers constituted special categories of their own. Due to trade, the economy of Heraklion during the 15th and until 17th century had been very well developed. Therefore, the arts like painting or sculpture was part of its social life. In 14th century there is a record of at least 25 painters who lived and worked into the larger area of Heraklion (Candia). While in 16th century the number increased up to 200 painters (Tzobanaki,C.,1996, p.60).

However, the 18th century when Heraklion (Chandakas) was part of what is known as Ottoman Empire there was a significant decline of what was related with intellectual activities. Hence, arts were not anymore one of the activities in which the population had been engaged. However, what it seems to have remained unchangeable is that trade activities were the main economic resource for the society of Chandakas. At the beginning of 20th century, what it seems to have been the developing economic activity, apart from trade, was actually light manufacture. Hence, in Heraklion, at that time, there were some small factories, especially soap factories, but also raisin processing plants.

Chania

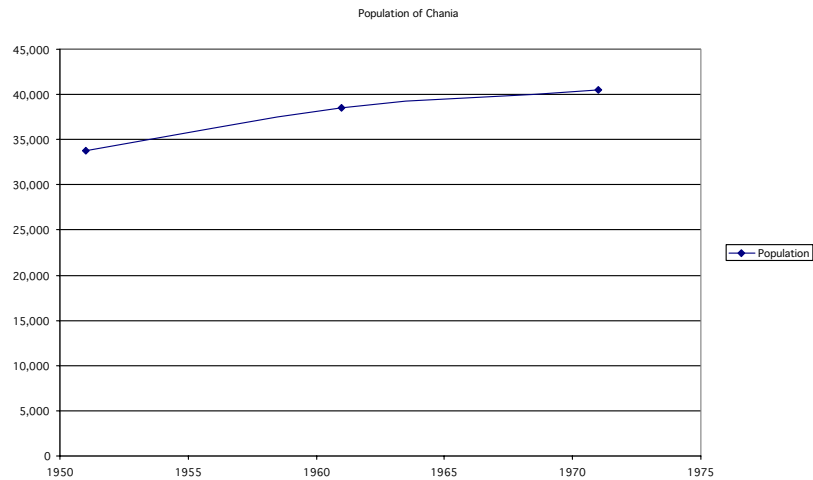
Since the details about the population statistics are based on the research conducted in 1977 by A. S. Kalligas -A. G.Romanos for the old city of Chania, the numbers are provided until 1977. Furthermore, the statistics refer both to the city of Chania and to a larger area of, consisted of the city of Chania and five other smaller settlements next to it. Thus, the population for the city itself and the larger area of Chania in 1951,1961 and 1971 are shown in the tables and scattegrams below:

Chania

Year	Population
1951(Census)	33,780
1961(Census)	38,467
1971(Census)	40,564

Larger area of Chania

Year	Population
1951(Census)	41,668
1961(Census)	50,789
1971(Census)	53,026



From the statistics just above it emerges that there was an increase of the population both of Chania and of its larger area during 1951-1971. However, this increase appears to be significant during 1951-1961, which for the larger area of Chania is 21.9%, while during 1961-1971, there was a decline of the increase and the percentage went down to 4.4%. However this increase of the population appears to be more significant in terms of the population statistics of the county of Chania. Thus, despite the fact that during 1951-1961 there was a decline of the population of the county of 5.32%, the population of the larger area of the city grew. Like every other city in Greece during these years, Chania functioned as attraction to people originated from the countryside and semi-urban settlements,

whereas some of its citizens immigrated to the capital city, Athens and other countries.

However, what seems to be interesting in terms of the evolution of the settlement are the statistics of the population from 16th and until 19th century. The statistics are based on records that were kept by Venetian authorities and during following centuries by the travellers, who visited Crete. The details are rough and sometimes there is a diversity of the sources, which provides the researcher with different numbers.²⁰ However, from the records one can notice the fluctuation of population. The statistics can be seen in the table below:

Chania

Year	Population
1549	9,902
1554	10,000
1575	8,911
1583	7,500
1583	8,200
1590	5,802
1598	6,711
1603	4,319
1608	5,000
1628	4,340
1636	6,787
1644	10,401
1700	5-6,000
1770	12,016
1813	13,000
1834	5,800
1851-53	12,000
1861	16,000
1881	12,000
1894	14,610
1900	12,016

The declining population was declined; this was due to epidemics, famine and wars. Regarding the sudden increase of population, it is suggested that it is due to immigrants from other parts of mainland of Greece, which at that time was occupied by Ottomans.

In terms of the old historical city of Chania the population of it in 1977 was 4,193 residents. Comparing with the population of Chania in 1971, as one can see in the table above, the population of the old core constitutes the 10.3% of it, while the same number is the 8% of the population of the larger area of Chania. As far

²⁰ The details of the historic statistics are introduced into Appendix 3 of the research conducted for it by A. S. Kalligas -A. G. Romanos in 1977, by the Maurakaki, M., archaeologist.

as the density is concerned, the old core appears to have 8.50 people/1000m² against 8.14 people/1000m² of the city of Chania as a whole. However this number increases dramatically when it refers to the old core without including the area around the walls; and thus, it becomes 13.5 people/1000m².²¹ However, despite the increase of population of the settlement as a whole, the population of the old core remains almost stable, which from time to time is consisted of temporary residents on their way to Athens or other countries.

The previous statements justify the fact that at that time in the historical old core of Chania were located people as temporal residents and furthermore people of the lower socio-economic class. The latter explains the small percentage of the employed residents, which was 28% of all the residents within the city inside the walls. This percentage is distributed into different activities. What seems to be significant is the fact that the 73.2% of the active citizens were employed in the administration and only the 5.9% of it are engaged with retail. The previous statistics are compatible with the statistics regarding the county of Chania since according with the census of 1971 from the employed people, who were forming the 39% of all the citizens within the area, the 25% of it were employed in the administration. What it has been mentioned so far in terms of the ethnographic details manifests the stability of the society of Chania and its larger area. The limited retail activities reinforce the image of the city as the transitional point between the surrounding countryside and larger settlements.

²¹ The details on the statistics in terms of the old historical core are based on the research conducted for it by A. S .Kalligas -A. G .Romanos in 1977.

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