Identifying ‘crisis-proof’ places. An assessment of public space accessibility using Space Syntax and GIS in the Municipality of Kalamaria, Greece.

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Abstract
The provision of easily accessible high quality open spaces in cities is essential in times of socioeconomic crisis. The study presents methods and spatial analysis tools that can be used to locate and assess easily accessible open spaces within the urban fabric. The local authorities can then focus their planning and landscaping efforts on the designated areas in times of increased fiscal insecurity. To locate and assess such spaces the study implements a Space Syntax approach, which unlike traditional ‘fixed radius’ or ‘shortest path’ analyses, models the natural human movement which is influenced by the configuration of the urban network. Space Syntax results are post-processed in a GIS environment in order to relate the syntactic measures to the open spaces and cartographically visualise the outcome. The produced maps can inform the actions of the local authorities towards creating ‘crisis-proof’ public open spaces. The proposed method is applied to Kalamaria, which is an important municipality within Thessaloniki's conurbation.

Keywords: Space Syntax, GIS, public spaces, accessibility, crisis, green infrastructure

1. Introduction
The aim of the study is to assess the accessibility of open spaces within a Municipality and to locate those that have the potential to function as local attractors of human movement and social interaction. To meet this aim the study initially implements a Space Syntax approach. In contrast to traditional ‘fixed radius’ or ‘shortest path’ methods, Space Syntax relates the human movement to the spatial configuration of the urban fabric (Jiang et al. 2000). The Space Syntax results are integrated in a GIS analysis in order to relate them to the open spaces and cartographically visualise the findings.

Space Syntax research in the field of pedestrian movement modelling within urban space has been extensive over the last decades (Hillier et al.. 2007). There are several relatively recent examples of studies that focus on the pedestrian accessibility of public spaces in a number of cities around the world (Önder and Gigi 2010; Talavera 2012; Koohsari et al. 2013; Khan 2014). The common research aim of these studies is to provide a spatial interpretation of the social function of existing public spaces according to the configuration of the urban fabric and propose possible ways of improving their accessibility.

In this study the preparation of data for analysis, as well as the post-processing and cartographic visualization of the space syntax results is conducted within a GIS environment. Extending the modelling capabilities of GIS with Space Syntax theory has been highlighted by a number of researchers (Jiang et al. 1999; Jiang and Claramunt 2002; Gil et al.. 2007; Jones et al.. 2009), as modern GIS packages are able to handle and visualize multiple types of data and provide an extensive arsenal of spatial analysis tools. This combination is essential in bridging the gaps between Space Syntax experts and other scientific disciplines (Jones et al. 2009).

The proposed methodology is applied to the Municipality of Kalamaria in Thessaloniki, Greece (Fig. 1, Fig. 2). Kalamaria, constituting the largest Southeastern part of Thessaloniki's conurbation, contains several formal public spaces but also a large number of informal open spaces. This combination allows us to study the accessibility of both formal and informal open spaces within a Municipality. The method applied in this case study can then be used to inform similar studies in other Municipalities that face a shortage of formal public spaces, have several informal spaces and are on a tight budget.

The present research utilizes UCL's Depthmap application, along with ArcGIS 10. Depthmap, a Windows application originally developed by Alasdair Turner at University College London, can conduct visibility, space syntax and agent-based analyses (Space Syntax Network 2014).

2. Public spaces in times of crisis

Public spaces have an integral multifaceted role in shaping socially and environmentally sustainable cities. From providing thermal comfort during heat waves and encouraging people of all ages to walk, play and cycle to improving health, wellbeing and stimulating human interaction, public spaces constitute vital focal points that establish a sense of community (Shaftoe 2008; Carmona et al. 2010).

Accessibility is one of the key characteristics of successful public spaces that function as both destinations and thoroughfares of pedestrian movement (Lynch 1981; Bentley et al. 1985; Jacobs and Appleyard 1987). According to Gehl (1987) the dramatic increase of demand for high quality urban recreation is connected to the social changes of our era. In times of economic crisis easily accessible spaces where people interact with each other and with nature become essential as free time and movement choice are limited and socioeconomic insecurities arise.

Public space provision in Greek cities is inadequate in general terms. This is not only a matter of quantity but also of spatial configuration and quality. Uneven distribution and fragmentation of open spaces, as well as the mismanagement or absence of adequate vegetation, are main reasons for the underuse of many public spaces in Greece during hot or cold periods (Vartholomaios et al. 2013).

Furthermore the impact of the Greek economic crisis on society is reflected on public spaces, which have become the theatre of increasing poverty and social insurgence (Athanassiou 2013). Simultaneously, there is an increasing struggle to retain the public nature of Greek open spaces. Reinvented urban communities seek to reinforce their public character through collective activism and experimental initiatives such as urban agriculture projects. On the contrary there are cases of open spaces whose public character has been undermined by local government strategies and actions (Athanassiou 2013).

Meanwhile many Municipalities contain a number of unused and neglected spaces, of often obscure property status, identity and function. These urban 'cracks', as Loukaitou-Sideris (1996) calls them, are in many cases leftovers of development and are often left in a deteriorating state. These informal open spaces may disrupt the continuity of urban form and physically separate social worlds.

Despite their current condition, some urban 'cracks' may have a central location within the urban fabric. Perhaps a solution to the public space inadequacy of Greek cities can be found in improving those urban 'cracks' that are highly accessible and linking them, if possible, to the existing network of open spaces. With low-cost interventions from the local Municipality

and the active involvement of urban communities ‘crisis-proof’ public spaces that support social resilience could become a reality. Thus, there is a need to assess the accessibility of both formal and informal spaces in order prioritise local action.

3. Space Syntax Analysis of open spaces in Municipality of Kalamaria, Greece

3.1 Site Description

Our case study is the Municipality of Kalamaria, which lies southeast of the city centre of Thessaloniki (Fig. 1). The main characteristic of Kalamaria is its coastline that surrounds almost two thirds of the total site perimeter. In total there are 20,4 hectares of characterised green space. Adding to this the areas that are characterized as forests, Kodra and Ntalipi military camps that are scheduled to become public spaces, the area of the Forestry School of Aristotle University of Thessaloniki and the planted traffic islands, the total green area can reach 80 hectares. This corresponds to approximately 7,28m^2 of green space per inhabitant, which is well above the average of 2.19m^2 for the conurbation of Thessaloniki (Ganatsas et al. 2002) but still below the official Greek Planning Standards of 8m^2 (Ministerial Decree 10788/5-3-04).

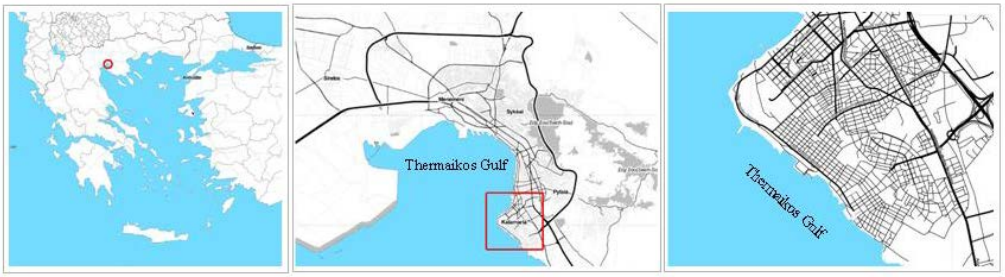


Figure 1: Location of the Municipality of Kalamaria

Kalamaria is fully urbanized and natural vegetation is mostly found on steep slopes along the coastline, in the Kodra camp (Fig. 2) and in small wooded spaces. These wooded spaces are scattered in the urban tissue and often include playgrounds and sitting areas. Perhaps the most important open space is the waterfront, characterized by its steep topography. The waterfront includes the rocky 'Mikro Emvolo', which is mostly used for watersports and Aretsou beach which includes numerous small parks, playgrounds, cafeterias and a summer cinema (Fig. 2).

Kalamaria lacks a city-wide park and for this reason the statutory General Urban Plan has suggested using the large open spaces of Kodra and Ntalipi military camps (Fig.2). Moreover, according to the Revision Study of the General Urban Plan (Giannakou et al. 2011), some parts of the waterfront have accessibility issues, which need to be resolved. Other important focal points are Skra Square, Ulov Palme park and the pedestrianized Komninon Street (Fig. 2).

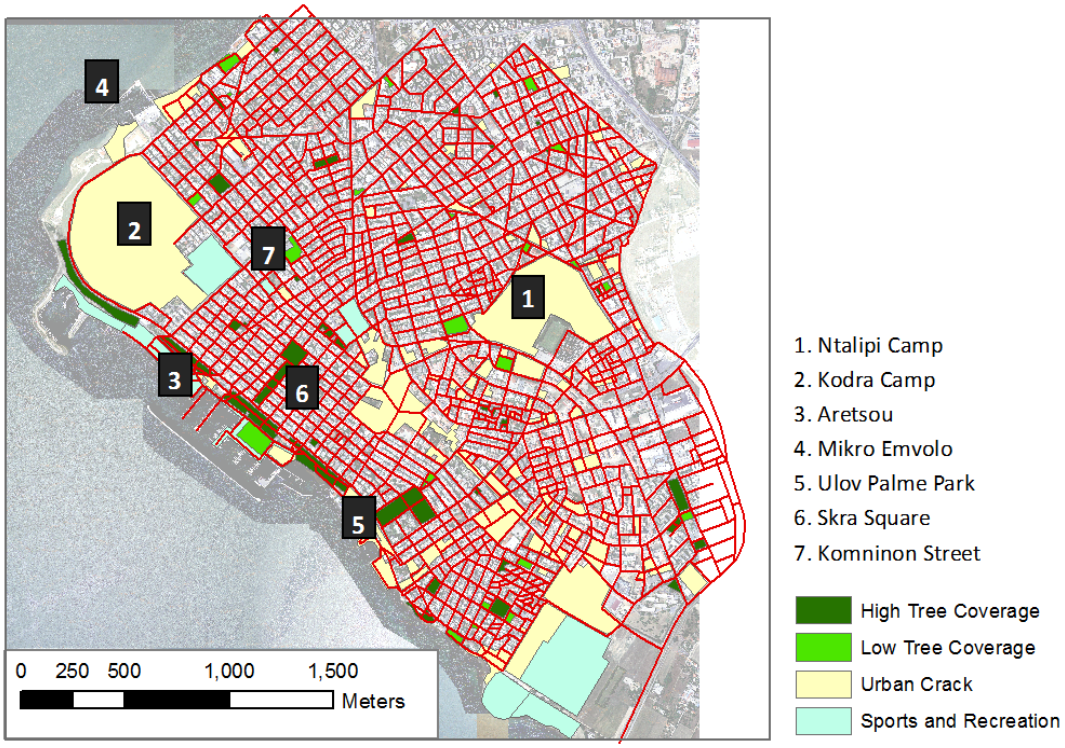


Figure 2. Map of the examined area exhibiting the street network and the open spaces of Kalamaria. It can be observed that the northernwestern part of Kalamaria has considerably fewer public spaces and urban 'cracks' as well, as a result of being more densely built.

3.2 Methodology

The methodology suggested in this study is a relatively simple process, where a GIS is used in the data preparation and post processing phases. The steps are the following:

1) Collect and prepare data in the GIS environment
2) Perform Space Syntax analysis in Depthmap software
3) Import space syntax results in GIS and link them to the geometry of open space polygons using overlay techniques (see e.g. Longley et al. 2005)
4) Classify and cartographically visualize the results

3.2.1 Collection and preparation of data

The segment map used in the Space Syntax analysis was derived from the street network shapefile provided by the Municipality of Kalamaria (2014). Numerous pedestrian paths were added to the street network which was topologically validated for inconsistencies (e.g. network segments overlapping or fragmented). The location an characterization of open spaces (excluding streets) in the Municipality was conducted using an orthophoto map provided by the online service of the National Cadastre and Mapping Agency (2009). This allowed the classification of open spaces not by their statutory land use or ownership status, but by their current state and apparent function. Both the orthophoto map and the street network were georeferenced to the Greek Geodetic Reference System (GGRS) of 1987 (see e.g. Fotiou 2007) to allow a seamless overlay and visualisation of spatial data as seen in Figure 2. The classification of open spaces was done in ArcGIS using nominal categories of information (see e.g. Papadopoulou 2010):

1) Formal public space with high tree coverage
2) Formal public space with low or no tree coverage
3) Urban 'crack' (informal space of no specific function or identity)
4) Sports and general recreation facilities

The first two classes emphasize the presence or absence of trees in characterized public spaces which is crucial for a thermally comfortable and enjoyable environment. The third class is used to locate the spaces that have no specific function or identity but might have the potential to constitute new public spaces. Finally the last class deals with spaces that accommodate sports or recreational facilities.

3.2.2 Space Syntax Analysis in Depthmap

The street map was exported to Depthmap software to conduct a segment analysis. Traditionally, Space Syntax analyses are conducted using axial maps which contain the fewest amount of possible axial lines; or in other words straight lines-of-site. An alternative to this approach is the segment map which approximates the centerline of the street network. For an assessment of the segment map analysis and comparison with the use of axial maps the reader can refer to Turner (2007) and Medeiros and Holanda (2007).

The concepts of accessibility and spatial configuration are important in Space Syntax theory. Accessibility expresses the ease of reaching certain locations from other points of space and is related to the spatial configuration of a place which influences the 'natural movement' of the pedestrian (Hillier et al. 1993). Accessibility can be determined through a number of space syntax measures, such as Connectivity, Depth, Integration, Control and Choice. For more detailed information on these measures the reader can refer to Peponis and Wineman (2002), Bafna (2003), Hillier (2007) and Hillier and Vaughan (2007).

This study uses the syntactic measures of Choice and Integration to describe movement flow and centrality within the street network. Choice expresses the flow in the network. When multiple shortest path routes pass through a network segment, its choice value is high. Integration describes the average depth of a space in relation to all other spaces. Depth is defined as the least number of syntactic steps (changes of direction from one segment to another) that are needed to reach one part of the network from the other. Consequently, spaces of high Integration are easy to get to from any point of the network. Both syntactic measures can be calculated by Depthmap at a global and a local scale. Global calculations involve all segments of the network and provide an idea of how each part relates to the whole. Local calculations are limited by a maximum metric or angular radius and unveil the spatial importance of each space at the local scale.

For this study a maximum metric radius of 400m was specified, which corresponds to a five minute walk to the closest open space. The distance covered by a five to ten minute walk is often associated to the optimal neighbourhood size and the distribution of communal services and spaces (Carmona et al. 2010).

The analysis results (Fig. 3) provide an insight on the network structure of Kalamaria. It can be observed that street segments receiving high global Choice values correspond to major traffic arteries of Kalamaria, while the dense Hippodameian grid leads to a relative local uniformity in Integration values.

Figure 3. Results of the Space Syntax analysis in Depthmap.

3.3.3 Processing the results in a GIS environment

The Space Syntax results were imported in ArcGIS as a line shapefile containing all the attributes calculated by Depthmap. This step was essential to relate the open space polygons with the Space Syntax results, which are currently linked to the street network. It can be observed that multiple street segments may pass through or at a short distance from an open space. This issue was addressed by using the spatial analysis capabilities of GIS.

Buffer zones around all open spaces were created at a distance of 50m which corresponds to the mean street segment length. It is indicatively assumed that this distance represents the average urban block dimensions and that street segments intersected by the buffer zone are spatially related to the corresponding open space. Yet this approach has some limitations, as it doesn't take into account the possibility of nearby streets not providing direct access to the open space.

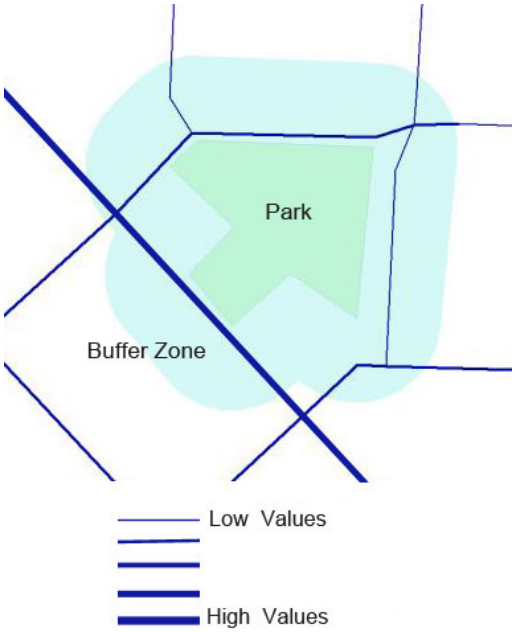


Figure 4. Schematic representation of the spatial relation of open space polygons to street network segments using a buffer zone of 50m.

Another problem is that the values of the syntactic measures may vary significantly within the buffer zone, as shown in Figure 4 and Table 1. Calculating the mean value of any syntactic measure seems like an obvious, albeit unsuitable choice. Firstly, the examined Space Syntax measures are expressed in an ordinal and not in a quantitative scale. This means that individual values cannot describe the accessibility potential in an absolute way but their comparison does. Secondly, the mean value cannot be considered as a representative index of accessibility of the open spaces as the calculated standard deviations in most of them are high due to an uneven frequency distribution (Tab. 1).

In real-world terms this is attributed to the fact that one open space may be linked with one highly accessible street segment and several poorly accessible local streets or paths. Applying an arbitrary weight, such as the segment length, to the calculation of the mean value may lead to a misinterpretation of the results if an important street is broken down to smaller segments. The same problem occurs if the sum of values is used.

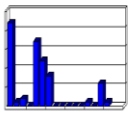
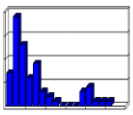
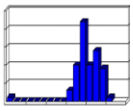
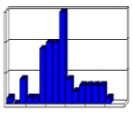
	Global Choice	Local Choice	Global Integration	Local Integration
mean	130031	182	813	52
standard deviation	118668	173	135	21
sum	9102206	12764	56931	3666
minimum	0	0	0	0
maximum	430507	671	1017	99
frequency distribution				

Table 1. Statistical indices of the syntactic measures produced for Kodra ex-military camp. The standard deviation approaches the mean value.

We propose using the maximum value for each open space considering that it allows a direct comparison of the results and is not affected by the number or the length of street segments. This means that an open space that is accessed by a highly accessible street is also considered as highly accessible regardless of the number of nearby low priority streets.

3.3.4 Classification and cartographic visualization of the results

The classification and cartographic visualization of the results was conducted using the GIS software. According to Jones et al. (2009) space syntax graphs are traditionally visualised using a 'complex full spectral colour scheme', which uses cold (blue) and hot (red) colours. However, this classification implies the existence of a midpoint value from where values deviate which does not correspond to any value of the examined syntactic measures. In order to accurately portray the results and make the important elements stand out we use the following approach:

1) Classify the results using the 'natural breaks' technique (see e.g. Jenks 1977; Aza 2012), that provides a suitable basis for cartographic representation of space syntax maps (Jones et al. 2009).
2) Make small manual adjustments where the 'natural breaks' classification marginally downgrades important open spaces to lower classes.
3) Use a single colour scale and five classes to make distinction of different colours easy.
The use of five single colour classes in cartography is considered ideal for an easy interpretation of the results (see e.g. Robinson et al. 1984).
The results of the classification and cartographic visualisation can be seen in Figures 5 and 6.

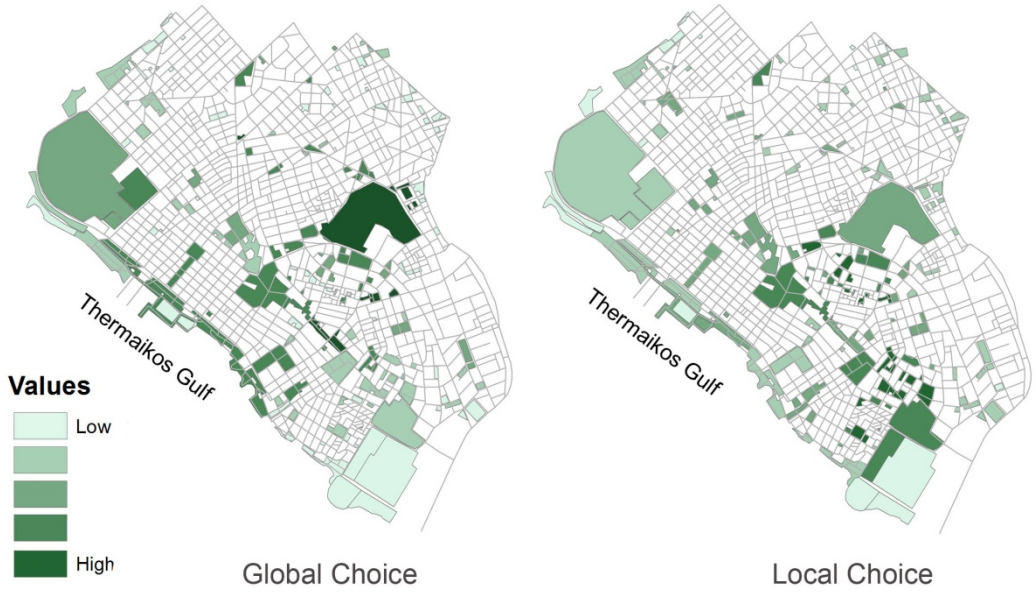


Figure 5. Global and Local Choice.

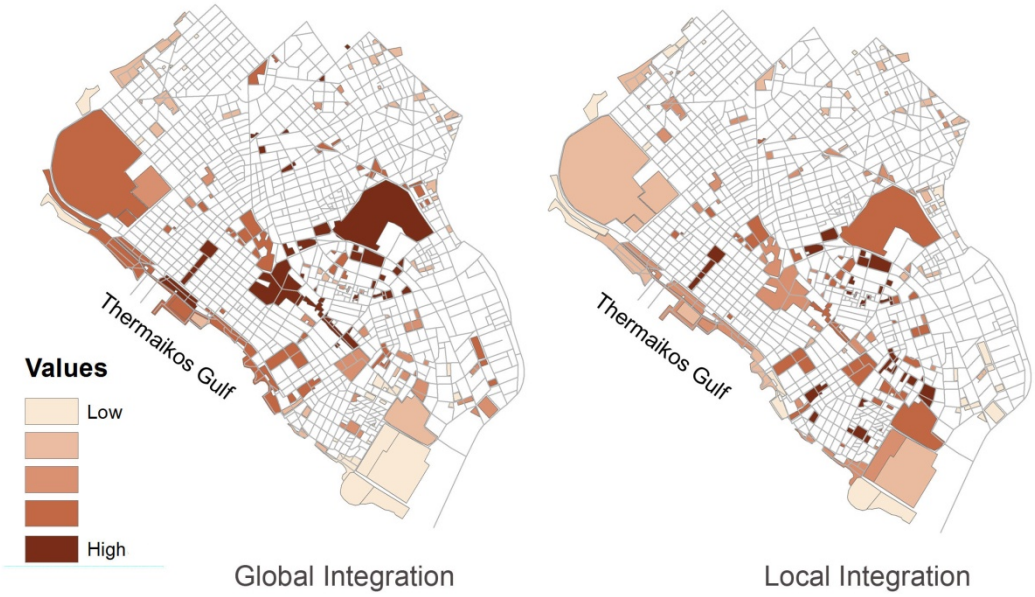


Figure 6. Global and Local Integration.

3.4 Interpretation of findings

The relative lack of spaces in the northern part of Kalamaria is further worsened by their poor global accessibility potential. Especially parts of the shoreline along Sofouli Street (northwestern side) are fragmented and poorly accessible at both global and local scales. The same is observed at Aretsou beach which is physically segregated by the rest of the urban tissue by a steep slope (Fig. 2). The analysis confirms the findings of the Revision Study of the General Urban Plan, according to which the linkage of these spaces to the rest of the urban fabric should be increased.

Both Kodra and Ntalipi camps have a considerable municipal-wide role as both attractors and corridors of movement. This means that they are excellent destinations for long walks and for cycling. However apart from those who live in the immediate vicinity, few will take short trips to Kodra and Ntalipi. The same situation is present and more accentuated at the large sports infrastructure area to the Southeast. Ulov Palme Park and Skra Square appear to be well integrated in the urban tissue both locally and globally. The linear parks along Plastira Street and the pedestrianized Komninon Street are used both as corridors and destinations of movement (Fig. 2). Furthermore, several small formal and informal open spaces are important destinations of local movement.

Thus a public space strategy for Kalamaria would require locating large public spaces where axes of natural movement and placing small squares and pocket parks in a way that they intermingle with the surrounding urban fabric.

Finally the space syntax analysis detects a large network of centrally located urban 'cracks'. The Municipality could focus its urban regeneration efforts on this area (Fig. 7) which due to its centrality has the potential to serve multiple neighbourhoods.

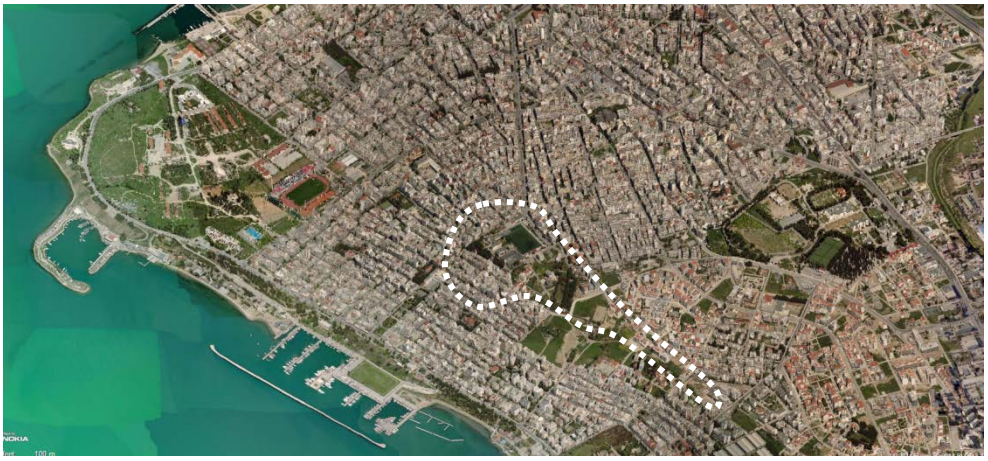


Figure 7. The Space Syntax analysis detects a large network of highly accessible but unused open spaces (Microsoft 2014).

4. Conclusions

The aim of the study was to present the tools used and the procedures followed to assess the accessibility potential of open spaces with a view to locating those that have the potential to constitute important 'crisis-proof' public spaces for the local community. To meet this aim we combined a Space Syntax approach with the spatial analytical capabilities of GIS. The combination of Space Syntax theory with the spatial analysis and visualisation abilities of GIS has been successful in producing maps and meaningful results that can inform local actions and policies at the Municipal level. The pilot study of the proposed methodology has allowed us to address a number of issues arising during the post-processing and interpretation of Space Syntax results within a GIS environment.

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References

Athanassiou E., 2013. Public space in Thessaloniki in times of crisis: from urban competitiveness to urban agriculture, Conference Proceedings Shrinking cities/Expanding Landscapes, Edinburgh.

Aza M., 2012. Classification methods for choroplethic mapping and the creation of an appropriate tool in a GIS environment, Diploma Thesis, Dept. of Cadastre Photogrammetry and Cartography, AUTh (in Greek).

Bafna S., 2003. Space syntax. Environment and Behavior, 35, 17-29.

Bentley I., Alcock A., Murrain P., McGlynn S. and Smith G.,1985. Responsive Environments a Manual For Designers, Architectural Press, London.

Carmona M., Heath T., Oc T. and Tiesdell S., 2010. Public Places, Urban Spaces: The Dimensions of Urban Design, Architectural Press, Oxford.

Deniz Erinsel Önder D.E. and Gigi Y., 2010. Reading urban spaces by the space-syntax method: A proposal for the South Haliç Region. Cities, 27, 4, 260-271.

Gehl J., 1987. Life between Buildings: Using Public Space. Van Nostrand Reinhold, New York.

Giannakou A., Diktyo SA, Geochoros Meletitiki Ltd, Valioulis Iraklis and Partners LLP, Nagkoulis A. and Natsinas T., 2011. Revision Study of the General Urban Plan of the Municipality of Kalamaria, Municipality of Kalamaria, Thessaloniki (in Greek).

Gil J., Stutz C. and Charadia A., 2007. Confeego: Tool Set for Spatial Configurational Studies. In: Turner A. (ed.) New Developments in Space Syntax Software, 6th International Space Syntax Symposium, Istanbul.

Jones, C.E., Griffiths S., Haklay M. and Vaughan L., 2009. A multi-disciplinary perspective on the built environment: Space Syntax and cartography – the communication challenge. Proceedings of the 7th International Space Syntax Symposium, Stockholm.

Ganatsas P., Tsitsoni T., Zagkas T., Tsakaldimi M., 2002. Evaluation of urban green in the conurbation of Thessaloniki. Proceedings of the 10th Panhellenic Congress of the Hellenic Forestry Society, Tripoli (in Greek).

Hillier B. and Vaughan L., 2007. The city as one thing. Progress in Planning, 67, 3, 205-230.

Hillier B., 2007. Space is the machine a configurational theory of architecture. Space Syntax, London.

Hillier B., Penn A., Hanson J., Grajewski T. and Xu J., 1993, Natural movement: or configuration and attraction in urban pedestrian movement, Environment & Planning B: Planning & Design, 19, 29-66.

Hillier B., Turner A., Yang T., Park H.T., 2007 Metric and topo-geometric properties of urban street networks: some convergences, divergences and new results. Proceedings of the 6th International Space Syntax Symposium, Istanbul.

Jacobs A. and Appleyard D., 1987. Towards an urban design manifesto: a prologue, Journal of the American Planning Association, 53, 112-120.

Jenks G.F., 1977. Optimal data classification for choropleth maps, Occasional Paper No, Dept. of Geography, University of Kansas.

Jiang B., Claramunt C. and Klarqvist B., 2000. An Integration of Space Syntax into GIS for Modelling Urban Spaces. International Journal of Applied Earth Observation and Geoinformation, 2, 3–4, 161–171.

Jiang B., Claramunt C., 2002. Integration of space syntax into GIS: new perspectives for urban morphology. Transactions in GIS, 6, 3, 295-309.

Jiang B., Claramunt C., Klarqvist B., 2000. Integration of space syntax into GIS for modelling urban spaces. International Journal of Applied Earth Observation and Geoinformation, 2, 3, 161-171.

Khan M., 2014. Study of Open Spaces in the Context of Dhaka City for Sustainable Use: A Syntactic Approach. IACSIT International Journal of Engineering and Technology, 6, 3, 238-243.

Koohsari M.J., Kaczynski A.T., Giles-Corti B. and Karakiewicz J.A., 2013. Effects of access to public open spaces on walking: Is proximity enough? Landscape and Urban Planning, 117, 92-99.

Longley P.A., Goodchild M.F., Maguire D. and Rhind D.W., 2005. Geographical Information Systems of Science, John Wiley and Sons, West Sussex, England.

Loukaitou-Sideris A., 1996. Cracks in the city: Addressing the constraints and potentials of urban design, Journal of Urban Design, 1, 1, 91–106.

Lynch K., 1984. Good City Form, MIT Press, Massachusetts.

Microsoft, 2014. Bing Maps (internet) available from http://maps.bing.com (last accessed 17/06/2014).

Ministerial Decree 10788/5-3-04, Government Gazette 285Δ, Greece (in Greek).

Municipality of Kalamaria, 2014. Geographic System (GIS) of Municipality of Kalamaria (internet), available from http://gisadmin.kalamaria.gr (last accessed 17/06/2014).

National Cadastre and Mapping Agency, 2009. Orthophoto Viewing Service (internet), available from https://www.ktimanet.gr (last accessed 17/06/2014).

Papadopoulou M., 2010. Introductory cartography lecture notes, available from http://e-topo.web.auth.gr/index_gr.html?reload (last accessed 02/07/2014), Dept. of Cadastre Photogrammetry and Cartography, AUTh (in Greek).

Peponis J. and Wineman J., 2002. Spatial structure of environment and behavior. In. Bechtel R.B. and Churchman A. (Eds.), Handbook of environmental psychology. John Wiley, New York.

Robinson A.H, Sale R., Morrison I. and Muehrcke P., 1984. Elements of Cartography (5th ed.), John Wiley and Sons, USA.

Shaftoe H., 2008. Convivial Urban Spaces: Creating Effective Public Places, Earthscan, London.

Space Syntax Network, 2014. UCL Depthmap (internet), available from http://www.spacesyntax.net/software/ucl-depthmap (last accessed 17/06/2014).

studies. Proceedings of the 6th International Space Syntax Symposium, İstanbul, 2007.

Talavera R., 2012. Improving pedestrian accessibility to public space through space syntax analysis, Proceedings of the 8th International Space Syntax Symposium, Santiago.

Turner A., 2007. From axial to road-centre lines: a new representation for space syntax and a new model of route choice for transport network analysis, Environment and Planning B: Planning and Design, 34, 3, 539–555.

Medeiros V.A.S. and Holanda F.R.B, A step further: segment analysis for comparative urban

Vartholomaios A., Kalogirou N., Athanassiou E. and Papadopoulou M., 2013. The green space factor as a tool for regulating the urban microclimate in vegetation-deprived Greek cities. Proceedings of the 1st Changing Cities: Spatial, morphological, landscape & socio-economic dimensions Conference, Skiathos.