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Urban Intervention Strategy for Networking Zografos Public Spaces

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ABSTRACT

The purpose of the research is to develop urban environment networks in order to formulate strategic urban interventions for the networking of public spaces.

In the case of Zografos Municipality (Attica, Greece), the research aims to establish a coherent network of public spaces, with the prioritization of urban interventions at nodes (public spaces) and their connections, as the existing public spaces do not constitute a network. The methodology starts with the configuration of urban networks by defining nodes and connections and proceeds to export data per network node. Applying Hierarchical Clustering as a methodology for grouping and analyzing network and other features (ownership, accessibility, total area) results in the formulation of strategic urban interventions, with the selection of nodes that meet multiple criteria.

Author Keywords

Network; Urban; Hierarchical Clustering; Multiple Criteria

ACM Classification Keywords

I.6.1 SIMULATION AND MODELING

1 INTRODUCTION

The methodology for prioritizing urban interventions in Zografos nodes (public spaces) and their interconnections was developed within the framework of the research program entitled “Intervention Strategies for Networking and Upgrading of Zografos Public Spaces” [1].

The description of the urban environment as a network configuration presupposes the definition of the network nodes and connections [2], [3]. In order for the network connections to be defined, the proximity relations of the actual geographic space are translated to network connections. With the consideration of the urban environment as a network configuration two groups of nodes' characteristics arise, those that refer to the network structure and those that describe urban characteristics, such as physical structure characteristics, ownership status and plantation cover.

2 EXISTING CONFIGURATION OF URBAN OUTDOOR SPACES OF ZOGRAFOS

In its current state, the urban outdoor spaces configuration of the Municipality of Zografos includes 24 subnets (one subnet with 11 nodes, 4 subnets with 4 nodes, 5 subnets with 3 nodes and 14 subnets with 2 nodes) and 46 isolated nodes. It includes in total 116 nodes (based on the research team's records) and 52 existing links between them. Urban outdoor spaces are interconnected when there is direct proximity to each other in the real geographical space (Figure 1).

The network dynamics (the dynamic network topology) are quantified by applying specific network algorithms (degree, betweenness centrality, eigenvector centrality, closeness centrality and eccentricity), which translate the network dynamics into variable values per node. The values of variables per node resulting from the application of the network algorithms derive solely from the network structure. The implementation of the network algorithms shows a great network component, in number of connected nodes, comprising 11 nodes (i22, i3, i4, i2, g4a, g4b, g4c, g4d, g4e, g4f, g5) and 12 interconnections (Table 1, Figures 2,3). Lacking an internal coherence, the existing configuration of urban outdoor spaces of the Municipality of Zografos does not constitute a network.

3 NETWORK OF URBAN OUTDOOR SPACES OF ZOGRAFOS

In order to select the nodes, and therefore the connections, which are more important for the gradual establishment of a coherent network of urban outdoor spaces, we start with a coherent hypothetical network where all the nodes are interconnected. This constitutes the desired final outcome of the urban interventions strategy. At the new hypothetical network, all nodes are connected using short paths, that is to say up to four building blocks of the existing urban fabric, provided that nodes - free spaces are directly connected by road axes. This sets up a cohesive network of urban outdoor spaces with 116 nodes and 156 connections (Figure 4). At a next step, the network algorithms are implemented. For the purpose of this research we focus on the network feature of degree, betweenness centrality, eigenvector centrality, closeness centrality and eccentricity (Table 2, Figures 5, 6) [4].

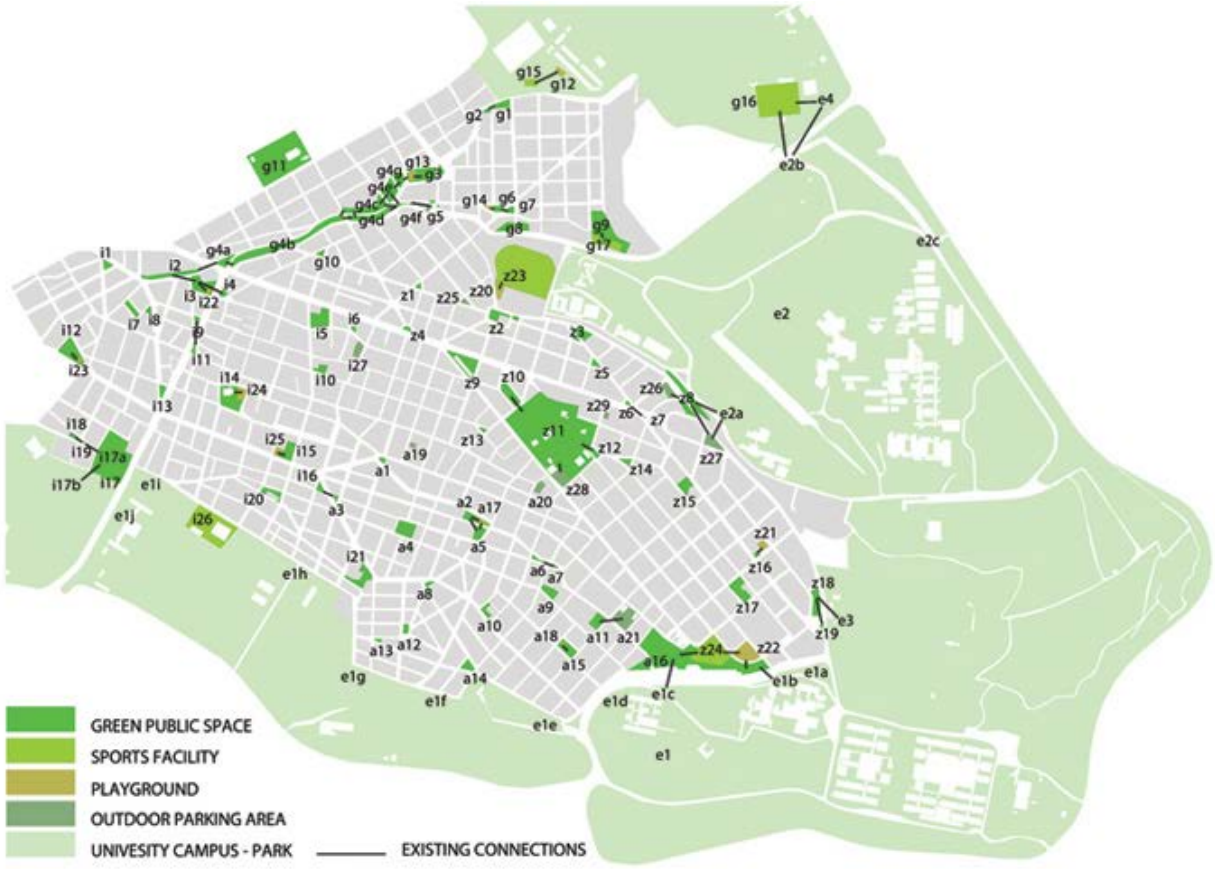
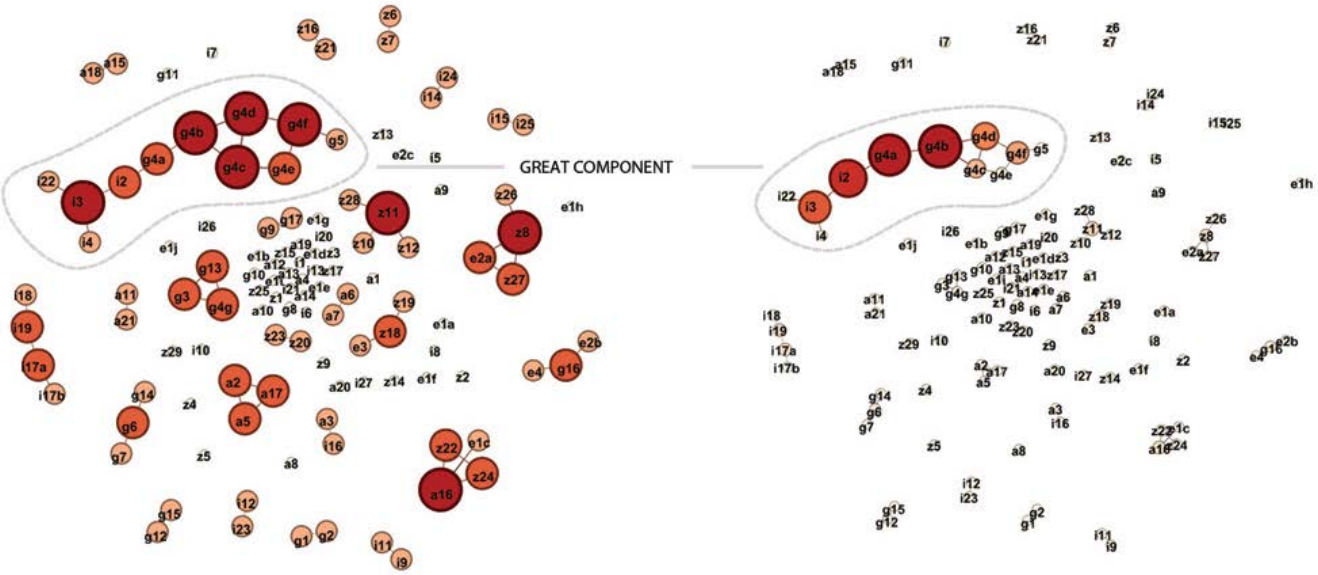


Figure 1. The existing configuration of urban outdoor spaces of the Municipality of Zografos.

Id	Degree	Betweenness Centrality	Eigenvector Centrality	Closeness Centrality	Eccentricity
G1	1	0	0.021835	1	1
G3	1	0	0.223319	1	1

Table 1. Table extract of network characteristics per node.



Figures 2,3 The existing configuration of urban outdoor spaces of the Municipality of Zografos. The nodes` size and color correspond to degree (left) and betweenness centrality measure (right).

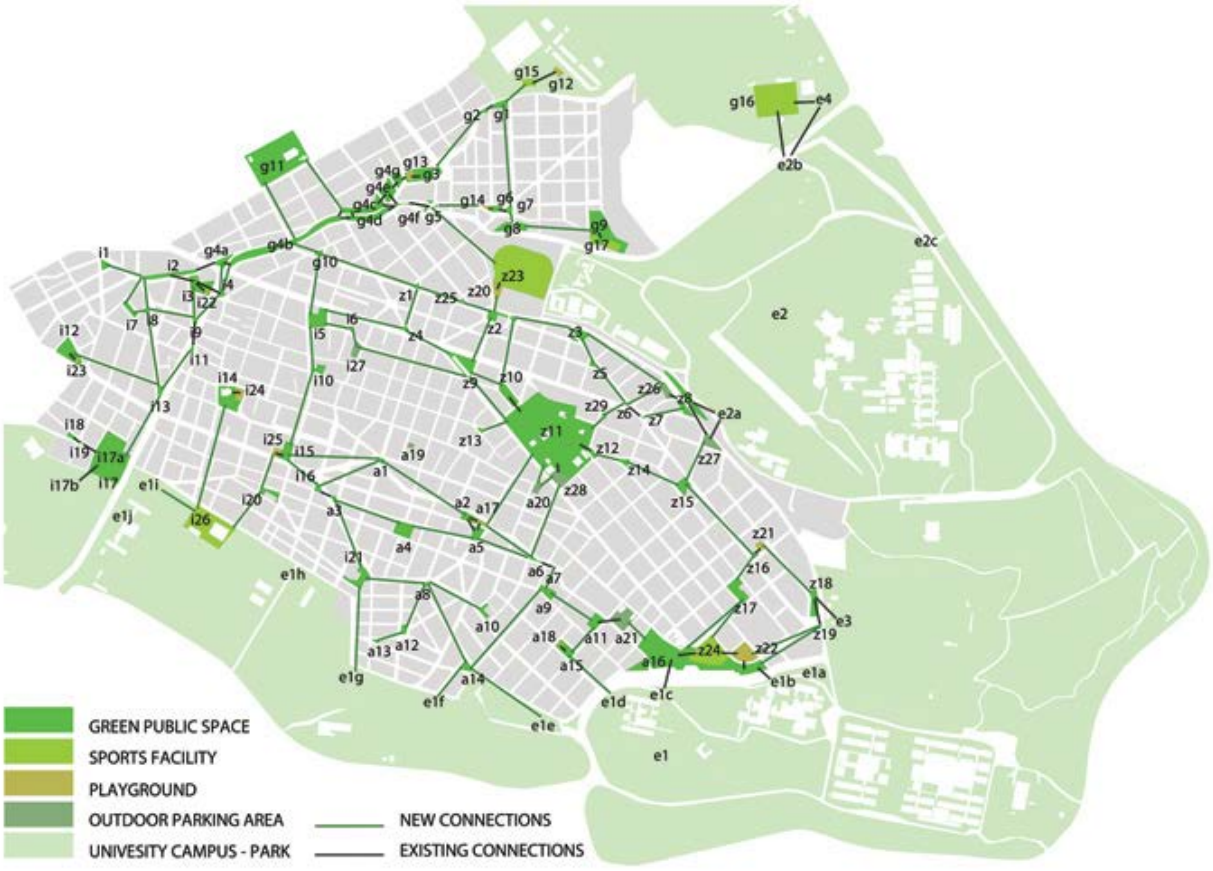
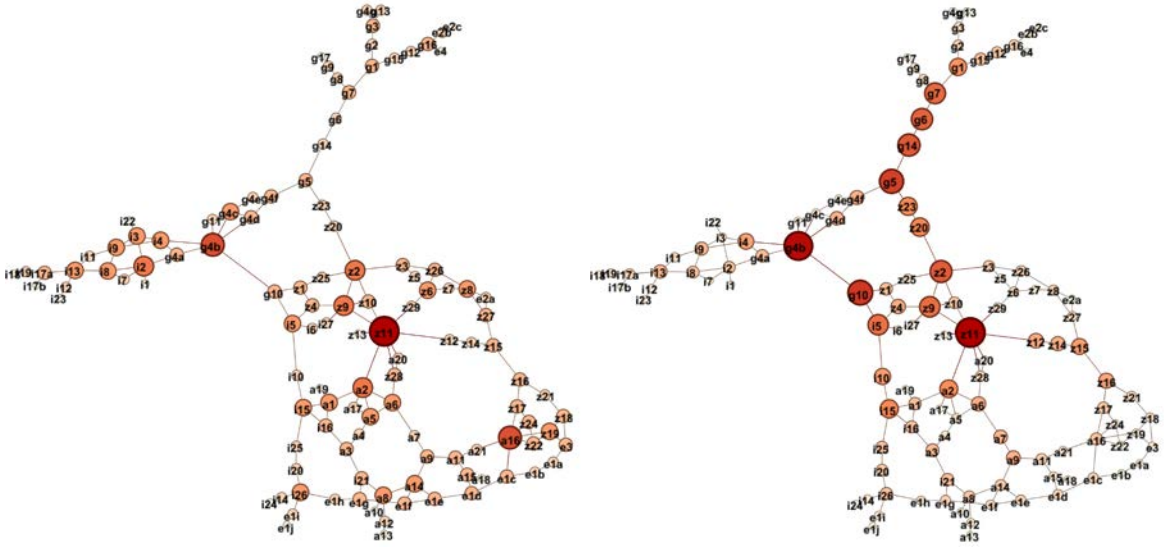


Figure 4. The coherent hypothetical network of urban outdoor spaces of the Municipality of Zografos.

Id	Degree	Betweenness Centrality	Eigenvector Centrality	Closeness Centrality	Eccentricity
G1	3	1074	0.101668	10.31304	17
G3	3	226	0.088618	12.2087	18

Table 2. Table extract of network characteristics per node.



Figures 5,6 The coherent hypothetical network of urban outdoor spaces of the Municipality of Zografos. The nodes` size and color correspond to degree (left) and betweenness centrality measure (right).

4 HIERARCHICAL CLUSTERING

To this point, network algorithms have been implemented and variables referring to the network structured are assigned per node. In addition, characteristics referring to physical structure features (material, cover, surface materials, vegetation), ownership, status, and accessibility are assigned to each node. Each network node therefore has multiple network and other features. In order to be able to analyze and manage data in the direction of building strategic urban interventions, a methodology for finding associations between nodes and their characteristics is applied (Hierarchical Clustering) [5].

This allows for the clustering of nodes and their attributes, with the application of similarity measures (Pearson's correlation coefficient), of distance metrics (average group linkage) and the definition of the minimum similarity index [6].

4.1 Node similarity results based on network characteristics

The application of Hierarchical Clustering on datasets of nodes with their network characteristics results in groups of more similar nodes being detected solely based on the network structure.

The node clusters that emerge with the application of Hierarchical Clustering have a similar role in the Zografos Municipality's free space network in terms of network function, measured as network characteristics (degree, eigenvector centrality, betweenness centrality, closeness centrality, eccentricity). These include nodes that appear to be scattered but have similar relative positions in the network (Figure 7).

Group 06 includes nodes (z9, z11, z2, a2, g10, i5) with high degree, high betweenness centrality and eigenvector centrality and low closeness centrality and eccentricity values (mean and maximum network distances). Group 08 includes nodes (z20, z23, g5, g6, g14, g7) with high betweenness centrality and eigenvector centrality and low closeness centrality and eccentricity values, while group 07 includes nodes (g4d, i4, g4a, g4b, g4f) with average to high values of degree, betweenness centrality and eigenvector centrality and low closeness centrality and eccentricity values. Groups 02 and 03 include nodes with average degree and betweenness centrality values, low closeness centrality values, and average eccentricity values. Groups 01, 04 and 05 include nodes with low degree and low betweenness centrality values, and high values of closeness centrality and eccentricity (long mean and maximum network distances).

4.2 Node similarity results based on urban characteristics

By shifting the similarity index, different clusters of urban outdoor spaces are produced, producing groups of closer or most distant correlations, namely clusters of nodes that have more or less similar urban identity, based on other characteristics. In the urban outdoor spaces network of the Municipality of Zografos the characteristics that don't refer to network structure are quantitative and qualitative. Coverage is a quantitative characteristic, while other physical structure features (materialized, surface materials, vegetation cover), ownership status, status and accessibility are qualitative features. In order to generate clusters of free spaces using Hierarchical Clustering, the following values are applied:

- constructed urban outdoor space: yes (1), no (0)
- cover area: numeric value
- surface materials: hard surfaces (0), hard surfaces and soil (5), soil (10)
- vegetation cover: little or no cover (0), low plantation (5), high plantation (10)
- ownership status: special status (0), public (10)
- current condition: poor (0), average (5), good (10)
- accessibility: no access (0), controlled entrance (5), free access (10)

By setting the minimum similarity index to 0.95, 11 clusters of urban outdoor spaces and 3 isolated spaces are produced (Figure 8). From the generated clusters, groups 03, 07 and 08 include constructed free access public spaces which are in good condition. Of these, groups 03 and 07 include urban spaces with high plantation, while group 08 includes urban spaces with low plantation. Isolated node z11 is also a public space with free access and high plantation that does not belong to the above groups due to its large cover area. Cluster 02 also includes free access and constructed public spaces with high plantation, with the exception of two public spaces (z9 and a10) that do not have sufficient vegetation cover. Group 11 includes privately owned parking areas with controlled entrance, while groups 01, 04, 06, 09 and 10 include public spaces in moderate or poor current condition. Isolated public spaces z16 and i10 are also in moderate and poor current condition.

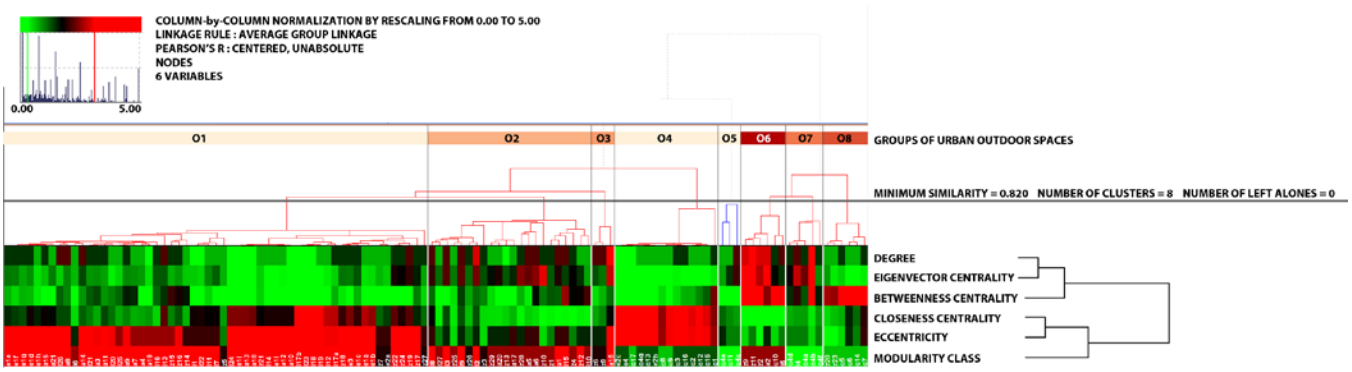


Figure 7. Groups of urban outdoor spaces based on network characteristics.

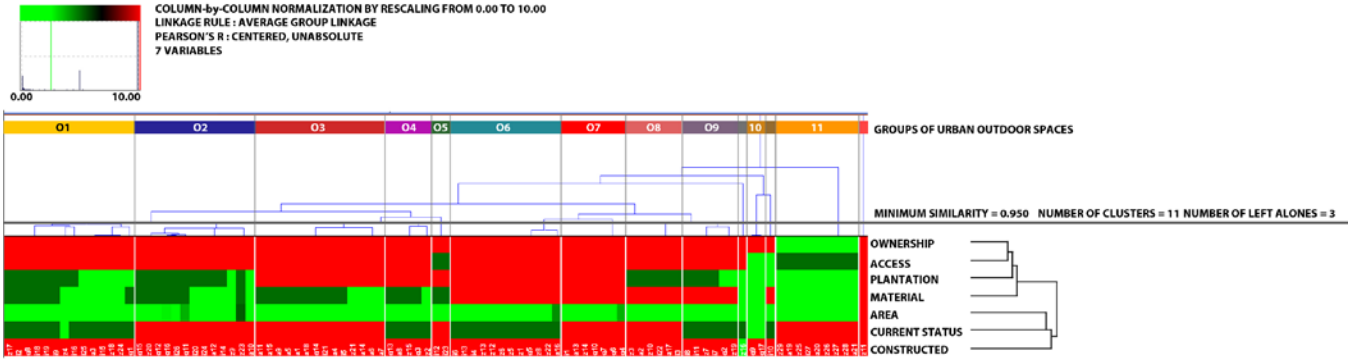


Figure 8. Groups of urban outdoor spaces based on urban characteristics.

5 URBAN INTERVENTION STRATEGY FOR NETWORKING ZOGRAFOS PUBLIC SPACES

5.1 Selection of groups of nodes important for their role in the network

In order to set up a network of public spaces, priority is given to nodes that are included in stronger groups in terms of their ability to link subnets and isolated nodes. Therefore, the nodes that are most important for their overall role in the network are selected at first.

The choice of these specific network features is related to the research question. As the purpose of urban interventions is the ultimate establishment of a cohesive network, nodes that have greater ability to connect subnets and isolated nodes are considered more important (Figure 9).

By grouping the nodes according to the values of variables resulting from the application of network algorithms, the groups that include the most important nodes in the network are selected based on the following criteria:

- high degree value (nodes that are connected to more neighboring nodes)
- high value of betweenness centrality (nodes that are more important in their ability to group nodes together)
- high value of eigenvector centrality (nodes that are important because the adjacent nodes have a high degree value)
- low closeness centrality (nodes having short average network distances from all other nodes in the network)
- low eccentricity value (nodes with a short maximum distance from the farthest node).

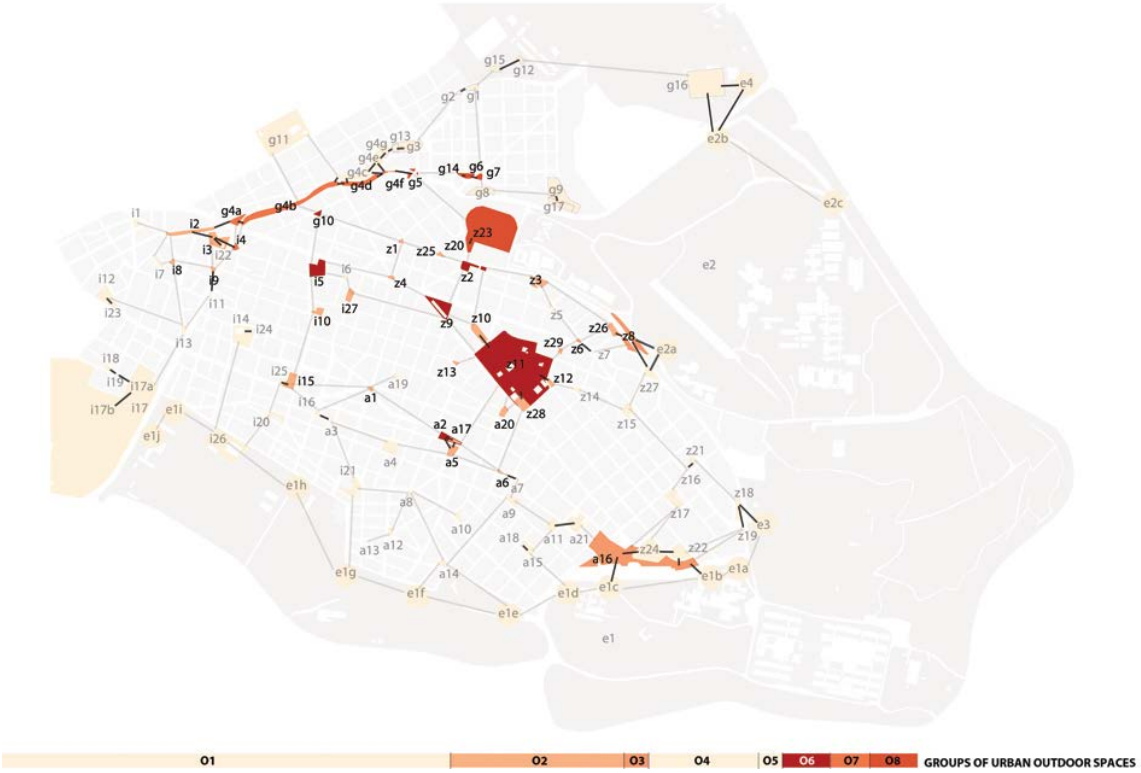


Figure 9. Selection of nodes belonging to groups 02, 03, 06, 07, 08, based on network characteristics.

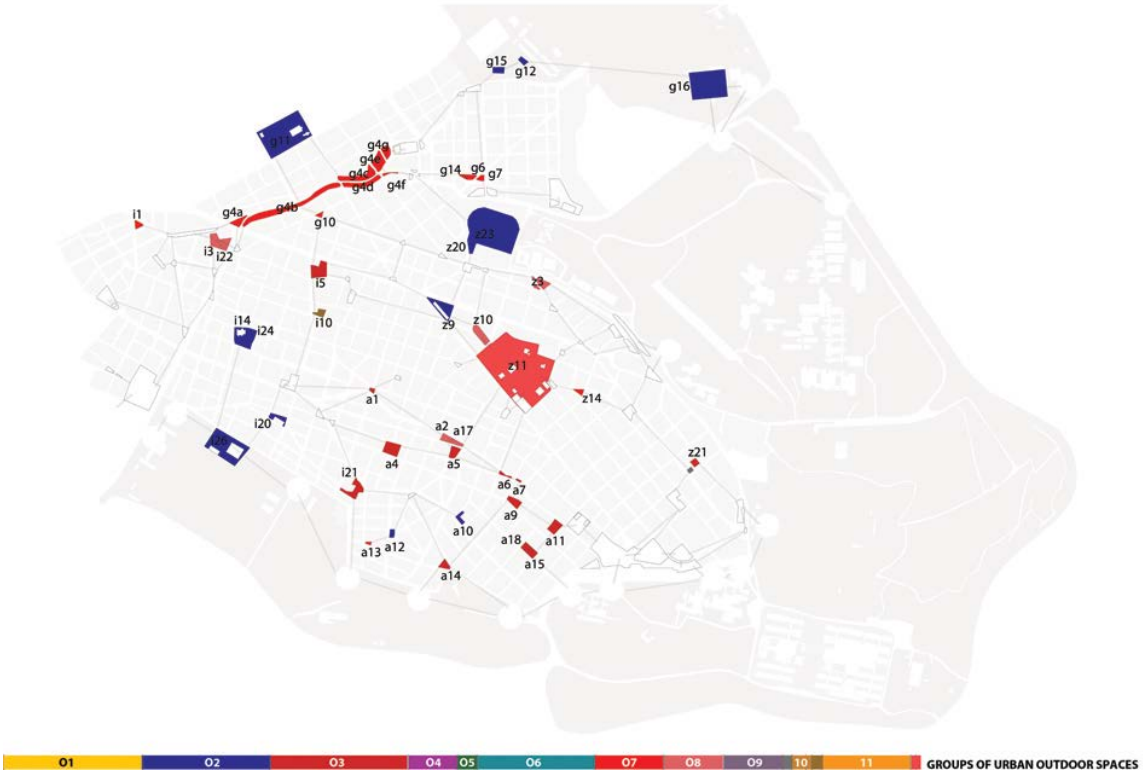


Figure 10. Selection of nodes belonging to groups 02, 03, 07, 08 and left-alone node z11, based on urban characteristics.

Figure 11. Selection of public spaces that meet multiple criteria.

5.2 Selection of groups of nodes that meet other criteria

Hierarchical clustering results based on other attributes produced some groups of nodes being public, constructed outdoor spaces with free access and sufficient vegetation cover. Since the intervention in these nodes is rather optional, giving priority to implementation in these public places, the financial cost will only concern networking with intervention in the connections between them (Figure 10).

Clustering the nodes according to their attributes yields groups of nodes that are more important based on the following criteria:

- ownership status: public
- accessibility: free access
- vegetation cover: low and mainly high plantation
- constructed urban outdoor space: yes
- current condition: good

5.3 Urban Intervention Strategy by selecting for a first stage implementation of nodes that meet multiple criteria

At this point the nodes that meet multiple criteria are selected. The aim is to set up a network by intervening only in the links between them, as these are public, constructed spaces in good current condition, with free access and sufficient vegetation cover. In addition, these are public spaces that are important for their role in the network and therefore the intervention at the connections between them will quickly give a network configuration to the public spaces in the Municipality of Zografos.

6 CONCLUSION

With the combined management of data related to network as well as urban characteristics, it is possible to formulate an strategy that prioritizes the urban interventions. The application of network algorithms allows us to extract information about the importance of some public spaces for their relative position in the network. By applying the Hierarchical Clustering to the network and urban features, we are able to select connections between selected nodes that meet multiple criteria. In a next step, nodes - public spaces that are directly linked to the original nodes are selected for implementation. In this way, with the least

possible use of financial resources, an initial network of public spaces for the Municipality of Zografos is created.

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