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Spatial point pattern analysis of urban retail stores: the case of twelve large- and medium-sized Greek cities

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Abstract

The retailers' profitability and the consumers' satisfaction depend on finding the optimal location for a retail store. When considering the stores' spatial distribution, business potential can be understood and a squandering planning of resources can be avoided. In this paper we identify the spatial patterns of retail stores located in the traditional commercial centers of twelve large -and medium-sized Greek cities, aiming to explain why such patterns exist. The type of retail activities was determined using the image of the ground-floor stores provided by the Google Street View (GSV) service and thus 7322 stores were recorded in a geodatabase as point features. The results reveal that the retail stores' distribution has a clustered and random spatial pattern at least in one city, where the high population density and the increase in rental prices of premises for professional activities constitute the factors that form these spatial patterns respectively.

1. INTRODUCTION

Following a period of economic growth in Greece from 2000 until 2008 (Balios, et al. 2015; Papadimitriou, et al. 2012), the Greek economy experienced a continuing recession (Mavridis, 2018), in the context of the global financial crisis that began in 2008 (Haddad, et al. 2020; Ozturk and Sozdemir, 2015). The demand for goods and services was severely affected (Vlamis, 2014), causing the risk of bankruptcy to a number of enterprises (Korol, 2017), which resulted in massive business closures (Tsampra, 2018). From a geographic perspective, the retail location decisions matter for the store's profitability (Timmermans, 2004), for which Woods and Reynolds (2012) highlight the necessity of the linkage between the store's retail location planning and marketing departments.

The objectives of this paper are initially the evaluation of the retail sector operability of twelve Greek cities and their retail land use categories during a period of prolonged recession, followed by their mapping in order their location and relocation, as well as, the extent of the traditional commercial centers to be geovisualized from 2011 to 2014. Afterwards, spatial point pattern analysis will investigate the retail stores' distribution in order to be interpreted in relation to a number of factors.

2. BACKGROUND

When investigating the retail location theories (Wieland, 2018), the importance of geographical location is pointed out, either for the quality of urban life (Rosu, et. al 2015) or for the retail success (Saxena and Hashemi, 2011), considering the store accessibility (Teller and Reutterer, 2008) and the transportation infrastructure (Nilsson and Smirnov, 2016) as the the factors that affect the retailers' preferences to choose their store locations.

Similar studies have investigated the spatial patterns of retail activities. In particular, Han, et al. (2019) identified the spatial patterns of retail stores in the road network structure of the Chinese city of Zhengzhou using points of interests (POIs) by applying the *Network-Based Kernel Density Estimation* (NKDE) and employing the global, local, and weighted closeness centrality. Cui and Han (2015) investigated the spatial patterns of retail stores in Zhengzhou using POIs by applying the *Standard Deviational Ellipse* (SDE), the *Average Nearest Neighbor* index and the *Kernel Density Estimation* (KDE), while they quantified the centrality of nodes of urban streets using the indices of *betweenness centrality*, *closeness centrality* and *straightness centrality*. Wu, et al. (2018) examined the spatial distribution pattern of enterprises in Beijing and their influencing factors by applying the KDE, the *Kernel-Nearest Neighbor* (KNN) and the *Vector analysis theory on landscape pattern* (VATLP).

3. DATA AND METHODS

3.1. Data

The Greek local governments (municipalities and regions), the trade associations and the chambers were asked to provide data regarding the type of product or service sold by their registered retail stores in order to be classified into a land use category, as well as

the retail stores' addresses in order to be identified through the *Goggle Maps* service and then to be registered in a geodatabase as point features. However, our request was rejected by the aforementioned stakeholders due to the *General Data Protection Regulation (GDPR)*, whose compliance principles protect the breach of personal data (Nabbosa and Iftikhar, 2019). Thus, our method for collecting data on the type of retail activity was based on using the *Google Street View (GSV)* service, a reliable source to identify commercial entities (Zamir, et al. 2011). The *GSV* service consist of panoramic 360 degree images of streetscapes, whose viewing angles are identical to those of the citizen (Li, et al. 2017; Bartzokas-Tsiompras et al. 2020, 2021a, 2021b). The images have a temporal alternation which differs per country. In the case of Greece, the *GSV* images are available for the years 2011 and 2014, except for the municipality of Athens whose images are also available for the year 2009.

3.2. Methods

3.2.1 Selection of cities

Considering the Greek framework regarding the definitions for the city size, the *Hellenic Statistical Authority* provides criteria for classifying a population as rural or urban depending on the population size of its settlement (Kasimis and Papadopoulos, 2013). Specifically, the population is defined as urban if the most populated settlement of the municipal and community units contains more than 2000 inhabitants. On the other hand, if the most populated settlement of the municipal and community units contains less than 2000 inhabitants, then the population is defined as rural. Papamanolis (2015) considered the largest Greek cities as those whose population is over 50,000 inhabitants in his study regarding the main characteristics of the urban climate and the air quality prevailing in them.

When investigating the European framework in terms of urbanity, Dijkstra and Poelman (2014, 2012) devised the *Degree of Urbanization (DEGURBA)*, namely a classification that indicates the character of an area, which is based on a combination of geographical contiguity (in particular, the Local Administrative Units of level 2 (LAU 2)) and population density (specifically, the population grid square cells of 1 km2). The DEGURBA classification, whose usefulness is mentioned in several studies (Gibas and Majorek, 2020; Pratesi, et al. 2020; Klimanek and Filas-Przybył, 2019; Bartzokas-Tsiompras & Photis, 2019), consists of three categories (Dijkstra and Poelman, 2014, 2012):

- the Cities or Densely populated areas, which are specified when at least 50% of the population living in high-density clusters (or urban centres), which means that an area is defined as "city" if it contains at least an urban centre of at least 50000 inhabitants.
- The Towns and suburbs or Intermediate density areas, which are specified when less than 50% of the population living in rural grid cells and less than 50% of the population living in a high-density cluster, which means that an area is defined as "town" if it contains at least an urban cluster with population between 5000 and 50000 inhabitants.
- The Rural Areas or Thinly populated areas, which are specified when more than 50% of the population living in rural grid cells, which means that an area is defined

as "rural" if it contains less than 5000 inhabitants who live in grid cells outside of urban clusters.

Taking into account the aforementioned methodology and the population thresholds, the municipalities of Athens, Thessaloniki, Patras, Heraklion, Larissa, Volos, Ioannina, Kavala and Kalamata will compose the large-sized Greek cities, whereas the municipalities of Serres, Chalcis and Chania will constitute the medium-sized Greek cities.

3.2.2 Delimitation of commercial areas

The city center is a substantial part of any city as it constitutes the urban growth core due to its political, economic and social role (Nooraddin, 2016). According to Mitkoviœ and Diniœ (2004), a city center is characterized by central urban functions, in particular, commercial (retail trade, handicraft-and-service, catering and tourism, financial and business services), communication-information, educational-scientific, cultural-entertainment, sport-recreation, social-health protection and social-political activities. Among these services, Asfour and Ghali (2014) includes both the high land prices, high traffic density and high population density as major characteristics of a city center.

Having defined the concept of city center and taking into account its association with commercial activities (McCann, 2002), the delimitation of urban commercial areas constitutes the next issue to be investigated. According to Bakogiannis, et al. (2016), the development of *Open Malls* refers to the upgrading of an existing traditional urban commercial center, as well as to the regeneration of neglected urban areas.

The planning for *Open Malls* in Greece was activated in the framework of funding proposals, which were formulated in accordance with criteria and submitted by the municipalities and the trade associations (or the chambers). Considering that the practice of *Open Malls* is a worthwhile method for delimiting the commercial core of city centers, the aforementioned stakeholders provided, upon request, the name of streets that designate the *Open Mall* of the twelve Greek municipalities that were selected in this research, regardless the outcome of the proposals' evaluation.

3.2.3 Retail Land Use categories

For the purposes of both the statistical and spatial analysis, as well as the urban land use mapping, the type of product or service of the 7322 registered stores was classified into 13 land use categories using the NACE Rev. 2 classification method, which has been utilized from various studies (Amountzias, 2020, 2019).

The classification method consists of 21 classes which are divided in two-digit, three-digit and four-digit branches and are identified by the letters of the alphabet, A to U. At first, every type of product or service of the 7322 registered stores, which has been recorded in a geodatabase as an attribute of the point feature, was classified into 57, 131 and 128 four-digit branches of NACE Rev. 2. for the years 2009, 2011 and 2014 respectively. Although the four-digit branches of economic activity can be classified into the three-digit, two-digit and single-digit branches of NACE Rev. 2 in order their total sum to be reduced and thus be appropriate for the purposes of this research, their classification will generalize the content of the land use categories in a great extent, resulting in the incorporation into one category a variety of stores that according to the four-digit branches differ from each other. Since there is a big difference in the number

of stores per single-digit branch, as well as, a large divergence in the branches' content throughout the time frame, new urban land use categories have to be created that will reflect the most feasible in content equal distribution of stores. Thus, according to the table 1, 13 new land use categories will be created, by classifying into them the four-digit branches of NACE Rev. 2, aiming every city to be characterized by the same total of land use categories and thereby the comparative analysis to be effective, in case there is at least one city with less than 13 categories.

Table 1. The new retail land use categories

Retail land use categories	Retail Stores in 2009	Retail Stores in 2011	Retail Stores in 2014
K01 Clothing, Footwear and Sports Equipment	234	1629	1368
K02 Electrical and domestic appliances	120	797	718
K03 Café services and related activities	130	637	675
K04 Food	54	476	516
K05 Pharmacies, Optical products , Medical Supplies and Cosmetics	74	385	398
K06 Provision of personal and specialized services	36	341	361
K07 Welfare Services	62	324	295
K08 Jewelry	52	301	265
K09 Training and Entertainment Items	128	295	268
K10 Offices, Medical offices , Laboratories	20	236	247
K11 General trade	20	231	219
K12 Photography Activities and Printing Offices	86	222	197
K13 Closed stores-Inactive commercial activities	150	1448	1795

4. RESULTS

4.1. Statistical Analysis

The results of stores' registration for each city are presented in the table 2, where 7322 commercially active and inactive retail stores have been registered into the land use geodatabase, of which the municipality of Patras contain the most of them, followed by the municipalities of Athens, Larissa and Thessaloniki.

The inquiries that were investigated by the statistical analysis are related to:

- the percentage of the commercially active and inactive retail stores, as well as their percentage change·
- the percentage of the commercially active retail stores that maintained their commercial activity and the commercially inactive retail stores that remained inactive·
- the percentage of the retail stores that ceased their commercial activity and those that started operating a commercial activity·
- the retail land uses that are characterized by the highest percentage of their stores' retention during the time period 2011-2014·
- the retail land uses of which most of the commercially active retail stores ceased their operation during the time period 2011-2014·

- the retail land uses for which most of the commercially inactive retail stores tend to start operating a commercial activity during the time period 2011-2014.

In response to the above inquiries, according to the table 3, 4, 5 and 6, the cities whose economies were most affected by the economic crisis are 7 out of 12 of the total, in particular the city of Volos, Ioannina, Patras, Athens, Kavala, Kalamata and Chalcis, which are characterized by:
- a high reduction of the commercially active retail stores and a high increase of the commercially inactive retail stores·
- a low percentage of the commercially active retail stores that maintained their commercial activity and a high percentage of the commercially inactive retail stores that remained inactive·
- a low percentage of retail stores that started operating a commercial activity and a high percentage of retail stores that ceased their commercial activity.

Table 2. The recorded commercially active and inactive retail stores for each selected city

City/Town	Number of recorded stores
Athens	1302 in total, of which: • 1166 stores for the years 2009, 2011 and 2014 • 136 stores in addition for the years 2011, 2014
Thessaloniki	638
Patras	2111
Heraklion	203
Larissa	722
Volos	423
Ioannina	319
Kavala	208
Kalamata	261
Serres	585
Chalcis	282
Chania	268
Total	**7322**

On the contrary, the cities whose economies were less affected by the economic crisis are 5 out of 12 of the total, in particular the city of Chania, Thessaloniki, Serres, Heraklion and Larissa.

Table 3. The percentage of the commercially active and inactive retail stores, as well as their percentage change

City/Town	Commercially active stores	Commercially inactive stores	Change of commercially active stores (%)	Change of commercially inactive stores (%)
Thessaloniki	2011: 84,95% 2014: 84,64%	2011: 15,05% 2014: 15,36%	A decrease of 0,31%	An increase of 0,31%
Larissa	2011: 84,63% 2014: 82,96%	2011: 15,37% 2014: 17,04%	A decrease of 1,67%	An increase of 1,67%
Chalcis	2011: 75,53%	2011: 24,47%	A decrease of 1,77%	An increase of 1,77

	2014: 73,76%	2014: 26,24%		
Heraklion	2011: 84,24% 2014: 81,77%	2011: 15,76% 2014: 18,23%	A decrease of 2,47%	An increase of 2,47%
Serres	2011: 87,18% 2014: 84,62%	2011: 12,82% 2014: 15,38%	A decrease of 2,56%	An increase of 2,56%
Chania	2011: 91,04% 2014: 88,43%	2011: 8,96% 2014: 11,57%	A decrease of 2,61%	An increase of 2,61%
Kavala	2011: 80,29% 2014: 76,44%	2011: 19,71% 2014: 23,56%	A decrease of 3,85%	An increase of 3,85%
Patras	2011: 76,74% 2014: 71,53%	2011: 23,26% 2014: 28,47%	A decrease of 5,21%	An increase of 5,21%
Kalamata	2011: 82,76% 2014: 76,63%	2011: 17,24% 2014: 23,37%	A decrease of 6,13%	An increase of 6,13%
Ioannina	2011: 75,24% 2014: 68,97%	2011: 24,76% 2014: 31,03%	A decrease of 6,27%	An increase of 6,27%
Volos	2011: 73,05% 2014: 64,54%	2011: 26,95% 2014: 35,46%	A decrease of 8,51%	An increase of 8,51%
Athens	2009: 87,14% 2011: 79,19% 2014: 70,66%	2009: 12,86% 2011: 20,81% 2014: 29,34%	2009-2011: decrease by 7,95% 2011-2014: decrease by 8,53%	2009-2011: increase by 7,95% 2011-2014: increase by 8,53%

Table 4. The percentage of the commercially active retail stores that maintained their commercial activity and the commercially inactive retail stores that remained inactive

City/Town	Percentage of commercially active retail stores that maintained their commercial activity	Percentage of commercially inactive retail stores that remained inactive
Chania	83,21%	3,73%
Serres	79,15%	7,35%
Thessaloniki	76,18%	6,58%
Larissa	75,62%	8,03%
Heraklion	73,89%	7,88%
Kalamata	72,03%	12,64%
Kavala	69,23%	15,5%
Athens	2009,2011: 77,02% 2011,2014: 65,21%	2009,2011: 9,61% 2011,2014: 15,36%
Patras	64,57%	16,30%
Chalcis	63,12%	13,83%
Ioannina	63,01%	18,81%
Volos	57,92%	20,33%

Table 5. The percentage of the retail stores that ceased their commercial activity and those that started operating a commercial activity

City/Town	Percentage of retail stores that ceased their commercial activity	Percentage of retail stores that started operating a commercial activity
Chania	7,84%	5,22%
Serres	8,03%	5,47%
Thessaloniki	8,78%	8,46%
Larissa	9%	7,34%
Heraklion	10,34%	7,48%
Kalamata	10,73%	4,60%
Kavala	11,06%	7,21%
Patras	12,17%	6,96%
Ioannina	12,23%	5,96%

Chalcis	12,41%	10,64%
Athens	2009-2011: 10,12% 2011-2014: 13,98%	2009-2011: 3,26% 2011-2014: 5,45%
Volos	15,13%	6,62%

Regarding the retail land uses that are characterized by the highest percentage of their stores' retention during the time period 2011-2014, according to the table 6, the category of Clothing, Footwear and Sports Equipment (K01) had the highest percentage of stores' retention in 7 cities, while the Closed stores-Inactive commercial activities (K13) had the highest percentage of stores' retention in 5 cities. The retail land uses with the second highest percentage of their stores' retention consist of the categories of Clothing, Footwear and Sports Equipment (K01) and Closed stores-Inactive commercial activities (K13), where each of them is located in 4 cities. In conclusion, the retail land use with the third highest percentage of stores' retention is the Electrical and domestic appliances (K02) which is located in 5 cities, while this category has the second highest percentage in 2 cities.

Table 6. The land uses that are characterized by the highest percentage of their stores' retention during the time period 2011-2014 (the color of gold, silver and copper corresponds to the highest, to the second highest and to the third highest percentage respecively)

City/Town	K01	K02	K03	K04	K05	K06	K07	K08	K09	K10	K11	K12	K13
Athens	13,59	6,14	6,61	3,46	4,30	1,61	3,69	3,30	7,76	1,15	0,77	5,61	15,36
Thessaloniki	23,04	6,74	11,60	2,82	2,98	3,61	2,19	5,96	2,04	1,72	2,04	0,94	6,58
Patras	14,12	7,53	6,73	4,59	4,59	4,26	4,64	2,13	1,75	2,61	2,51	1,56	16,30
Heraklion	22,17	3,45	4,43	1,48	5,91	0,99	4,93	2,46	4,93	2,96	0,49	2,46	7,88
Larissa	22,16	5,68	5,96	5,54	6,79	3,60	3,19	3,05	2,22	1,52	1,52	1,80	8,03
Volos	8,51	8,27	3,55	7,57	2,60	5,67	3,78	1,65	0,95	6,15	2,36	2,36	20,33
Ioannina	16,93	12,54	6,90	6,27	1,88	3,13	1,88	2,82	0,31	1,25	3,13	No stores for 2011	18,81
Kavala	6,25	10,58	11,06	11,54	3,37	2,88	2,40	4,81	2,40	0,96	3,37	1,44	12,50
Kalamata	22,59	11,49	3,83	3,83	4,98	6,51	2,30	1,92	1,92	3,45	0,77	1,92	12,64
Serres	18,46	9,91	5,81	8,38	4,10	4,62	2,74	3,93	1,20	5,98	2,56	1,71	7,35
Chalcis	19,15	6,74	1,77	8,16	4,26	4,26	3,19	2,84	1,42	1,06	1,77	1,42	13,83
Chania	17,91	10,82	7,46	6,34	4,10	5,22	3,73	4,85	3,36	2,61	4,48	1,87	3,73

According to the table 7, the retail category of Clothing, Footwear and Sports Equipment (K01) constitutes the retail category of which most commercially active stores ceased their operation in 2014, excluding the city of Kavala, whose respective retail land uses consist of the categories of Electrical and domestic appliances (K02) and Food (K04), as well as, the city of Chania whose respective retail land uses consist of the categories of Pharmacies, Optical products, Medical Supplies and Cosmetics (K05) and Welfare Services (K07).

Table 7. Percentage of stores per land use whose operation ceased in 2014 (the color of gold and silver corresponds to the highest and to the second highest percentage respectively)

City/Town	K01	K02	K03	K04	K05	K06	K07	K08	K09	K10	K11	K12
Athens	2,53	1,38	2,30	0,61	0,46	0,38	0,92	1,00	2,30	0,54	0,69	0,84
Thessaloniki	2,98	0,94	2,19	0,16	0,31	0,16	0,47	0,47	0,16	0,63	0,31	0
Patras	3,03	2,04	1,94	0,47	0,47	0,81	0,66	0,43	0,66	0,33	0,81	0,52
Heraklion	3,94	0,99	0,99	0,49	0,49	0	0,99	0,49	0,49	0,49	0	0,99

	K01	K02	K03	K04	K05	K06	K07	K08	K09	K10	K11	K12
Larissa	3,32	2,22	0,14	0,69	0,14	0,55	0,69	0	0,14	0	0,83	0,28
Volos	3,78	3,55	1,42	0,95	0,24	1,65	0,47	0,47	0,47	0,95	0,71	0,47
Ioannina	4,70	1,57	2,19	0,94	0,31	0,94	0	0,63	0,31	0,31	0,31	No stores for 2011
Kavala	0,96	1,92	1,44	1,92	0	1,44	0,48	0,48	0,48	0,48	1,44	0
Kalamata	4,21	2,30	0,38	0,77	0,38	0	0	0,77	0	0,38	0,77	0,77
Serres	2,39	1,20	1,03	0,68	0	0,68	0,17	0,17	0,85	0	0,68	0,17
Chalcis	5,32	1,42	0	1,77	0,71	0,71	0	0,71	0,71	0,35	0,71	0
Chania	1,49	0,75	0,75	0,37	1,49	0	1,49	0,37	0,37	0,37	0	0,37

Regarding the retail land uses for which most of the commercially inactive retail stores tend to start operating a commercial activity during the time period 2011-2014, according to the table 8, it is observed that in the majority of cities the startups' operating activities mainly focused on Clothing, Footwear and Sports Equipment (K01) and on Café services and related activities (K03), which constitute the retail categories with the highest and the second highest percentages, followed by the category of Electrical and domestic appliances (K02), while the new operating activities of the cities of Volos and Kavala focus on Food (K04) and General trade (K11) respectively.

Table 8. Percentage of commercially inactive stores per land use which started to operate in 2014 (the color of gold and silver corresponds to the highest and to the second highest percentage respectively)

City/Town	K01	K02	K03	K04	K05	K06	K07	K08	K09	K10	K11	K12
Athens	0,38	0,92	1,23	0,61	0,69	0	0,54	0	0,54	0,15	0,31	0,08
Thessaloniki	1,72	0,78	2,82	0,78	0,47	0,47	0,16	0,16	0,31	0,47	0,31	0
Patras	0,95	0,81	1,42	0,66	0,52	0,66	0,24	0,14	0,19	0,66	0,52	0,19
Heraklion	3,94	0,49	1,48	0,49	0,49	0,49	0,49	0	0	0	0	0
Larissa	1,52	0,97	0,69	0,97	0,42	0,83	0,42	0,42	0,14	0,14	0,28	0,55
Volos	1,18	0,95	0,47	2,13	0,24	0,24	0	0	0	0,47	0,71	0,24
Ioannina	0,63	1,25	0,94	0,63	0	0,94	0	0	0,31	0	0,94	0,31
Kavala	0	1,92	1,44	0,48	0	0,48	0	0,48	0	0,48	1,92	0
Kalamata	1,92	0	0,77	0	0	1,15	0	0,77	0	0	0	0
Serres	1,37	0,68	1,03	0,34	0,17	0,51	0,34	0	0,34	0,34	0,34	0
Chalcis	4,26	1,06	0,35	1,06	0,35	1,42	0,35	0	1,06	0	0,71	0
Chania	1,49	0	1,12	0,75	0,37	0,37	0	0,75	0	0,37	0	0

4.2. Retail Land Use Mapping

Urban land use mapping matters for urban planning (Ty, et al. 2016), especially due to its usefulness for disparate occasions, among which are the commercial areas (Huang, et al. 2018). Figure 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13 illustrate the location of retail stores classified by 13 urban land use categories and therefore the extent of *Open Mall* for each city and per year of reference according to the temporal dimension of the *GSV* images. The maps were created using the *ArcMap* of the *ESRI ArcGIS Desktop 10.8.1,* based on the *Hellenic Geodetic Reference System 1987 (HGRS87)* and the *Transverse Mercator* projection.
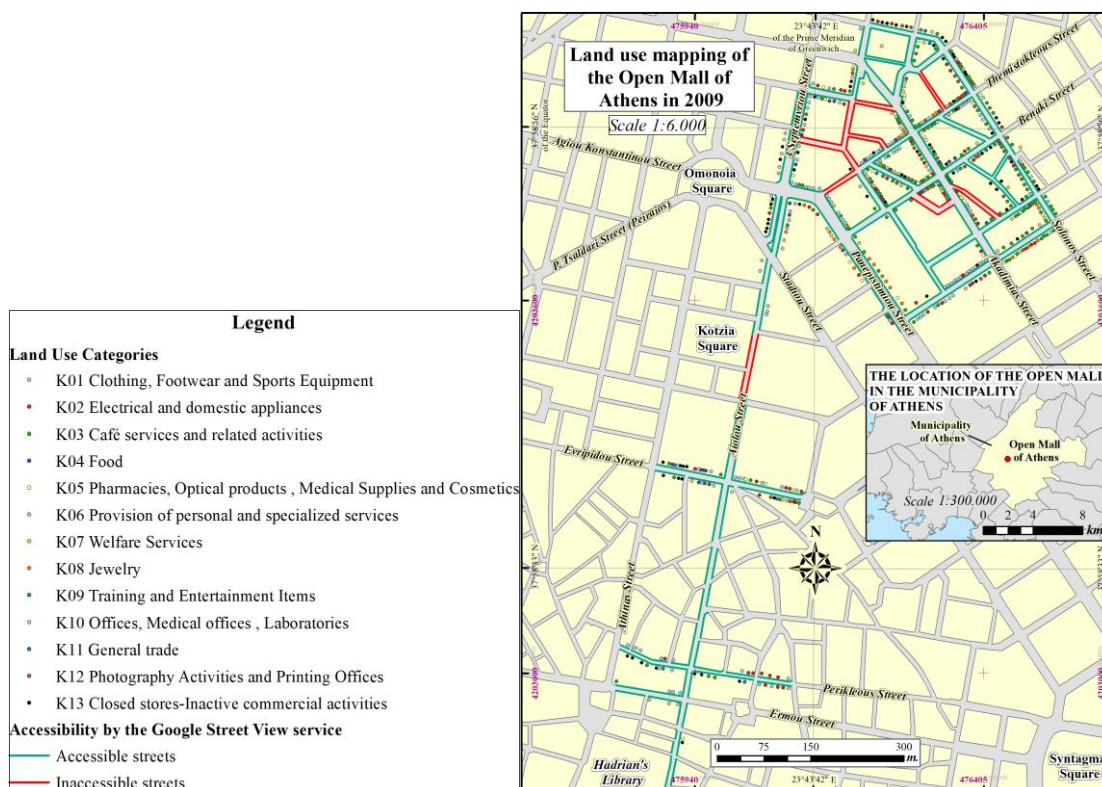
Figure 1. The map legend (right) and the *Open Mall* of Athens and its retail stores in 2009 (left)
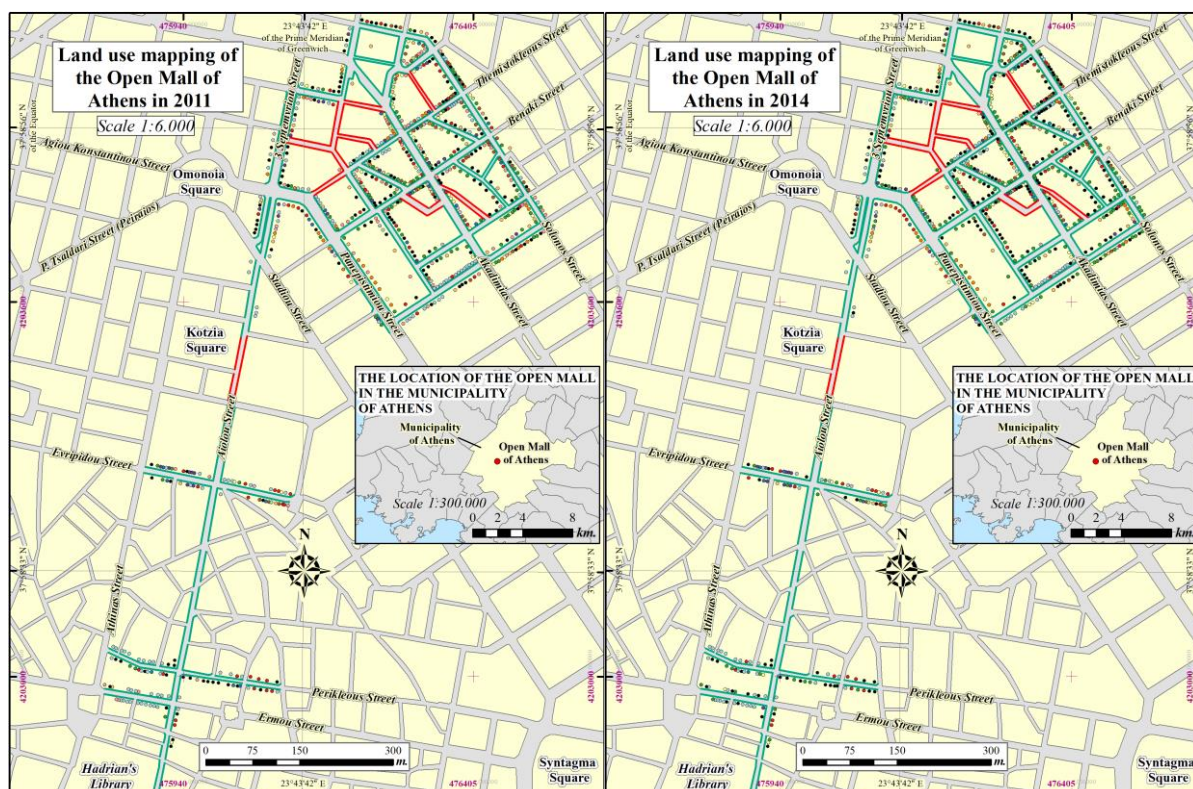

Figure 2. The *Open Mall* of Athens and its retail stores in 2011 (right) and in 2014 (left)
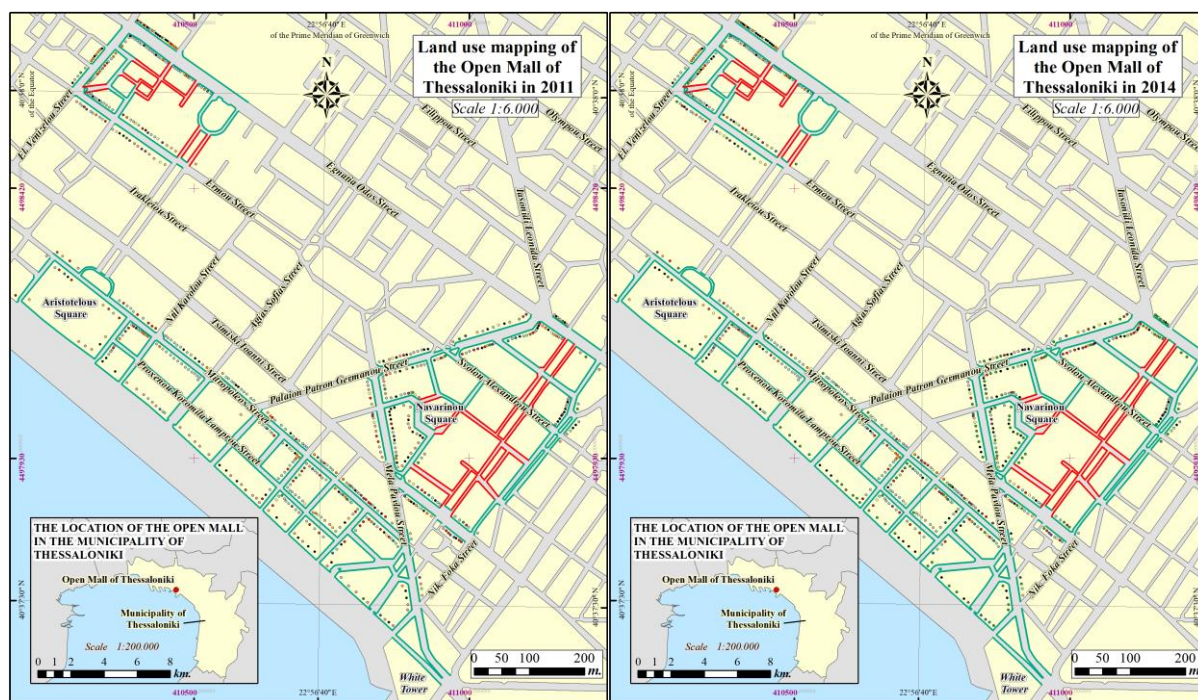
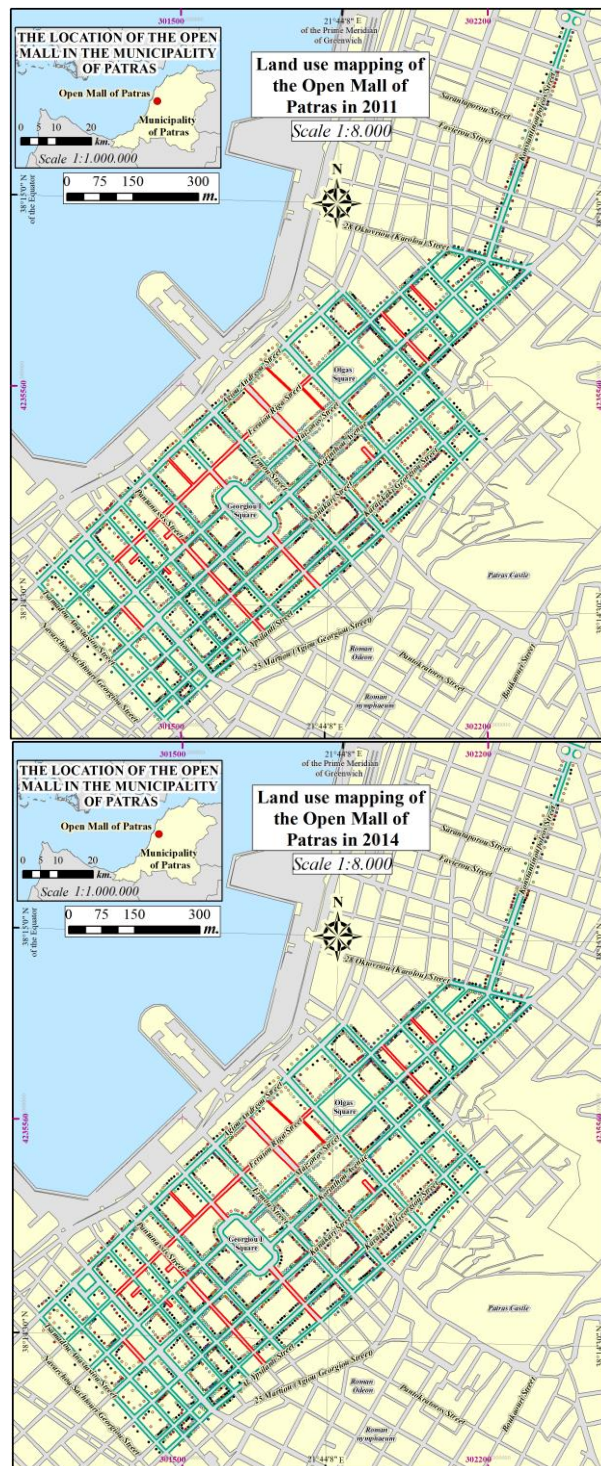**Figure 3.** The *Open Mall* of Thessaloniki and its retail stores in 2011 (right) and in 2014 (left)

Figure 4. The *Open Mall* of Patras and its retail stores in 2011 (right) and in 2014 (left)
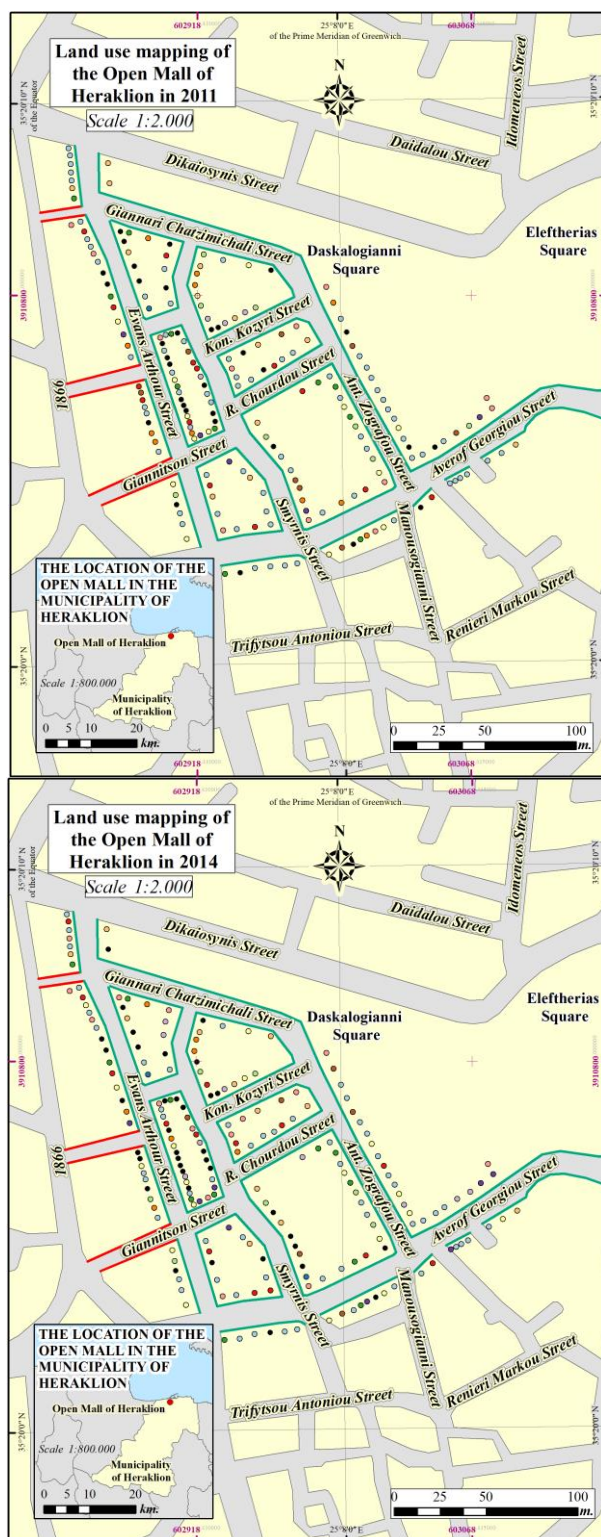
Figure 5. The *Open Mall* of Heraklion and its retail stores in 2011 (right) and in 2014 (left)
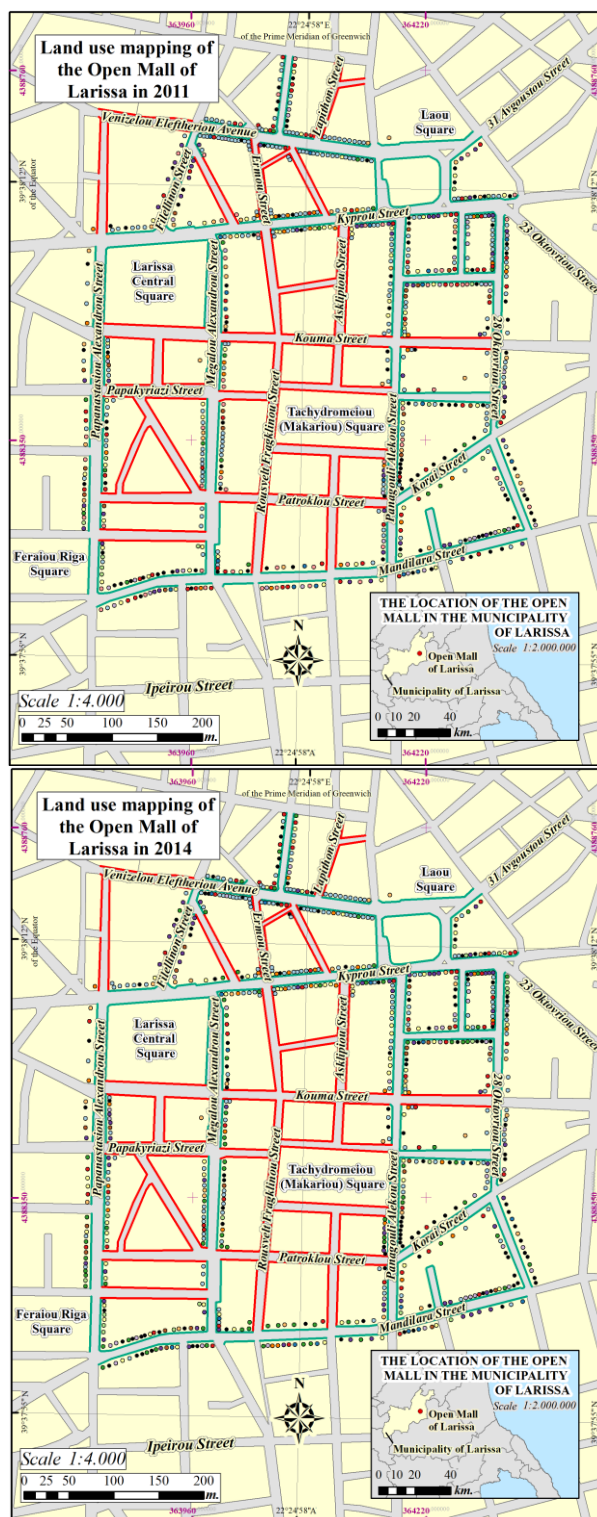
Figure 6. The *Open Mall* of Larissa and its retail stores in 2011 (right) and in 2014 (left)
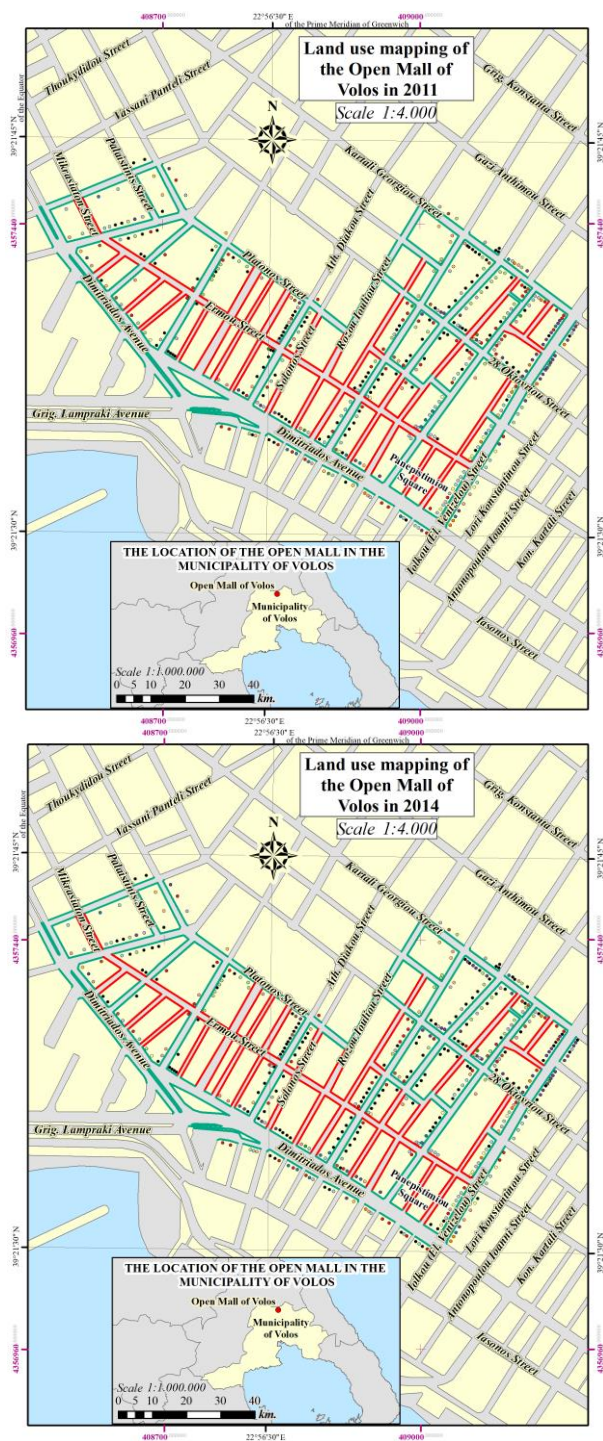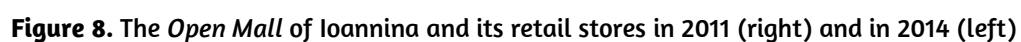
Figure 7. The *Open Mall* of Volos and its retail stores in 2011 (right) and in 2014 (left)

Figure 8. The *Open Mall* of Ioannina and its retail stores in 2011 (right) and in 2014 (left)
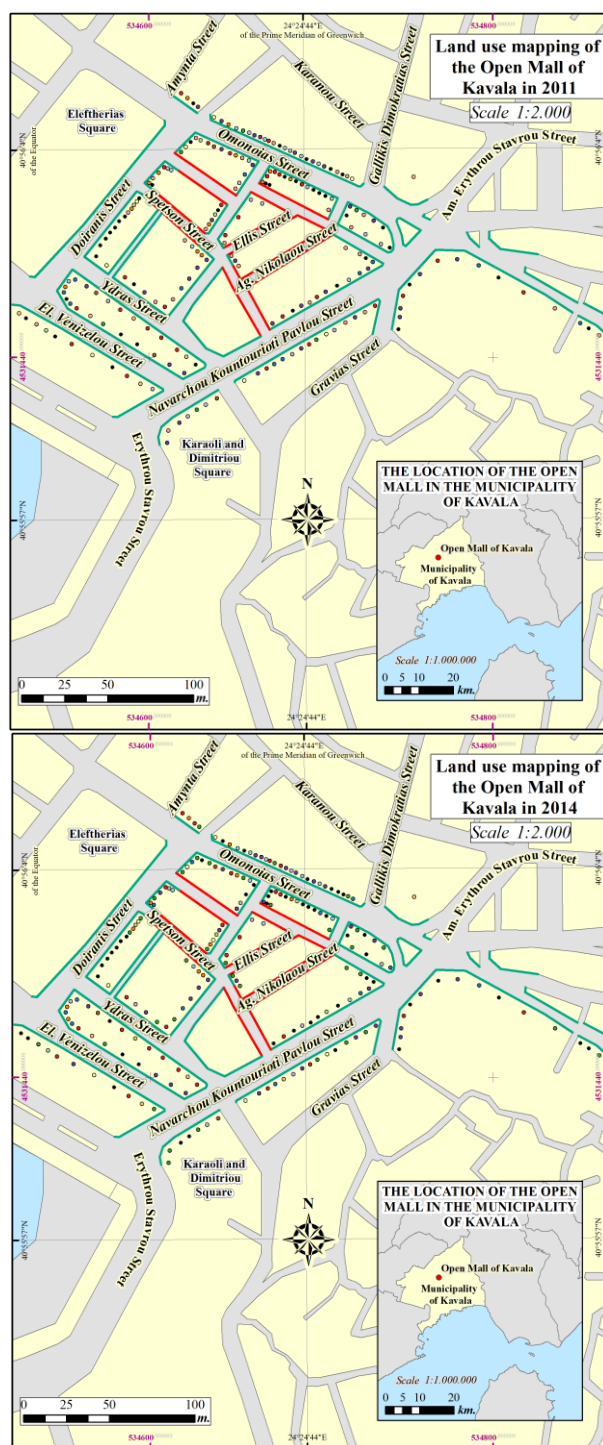
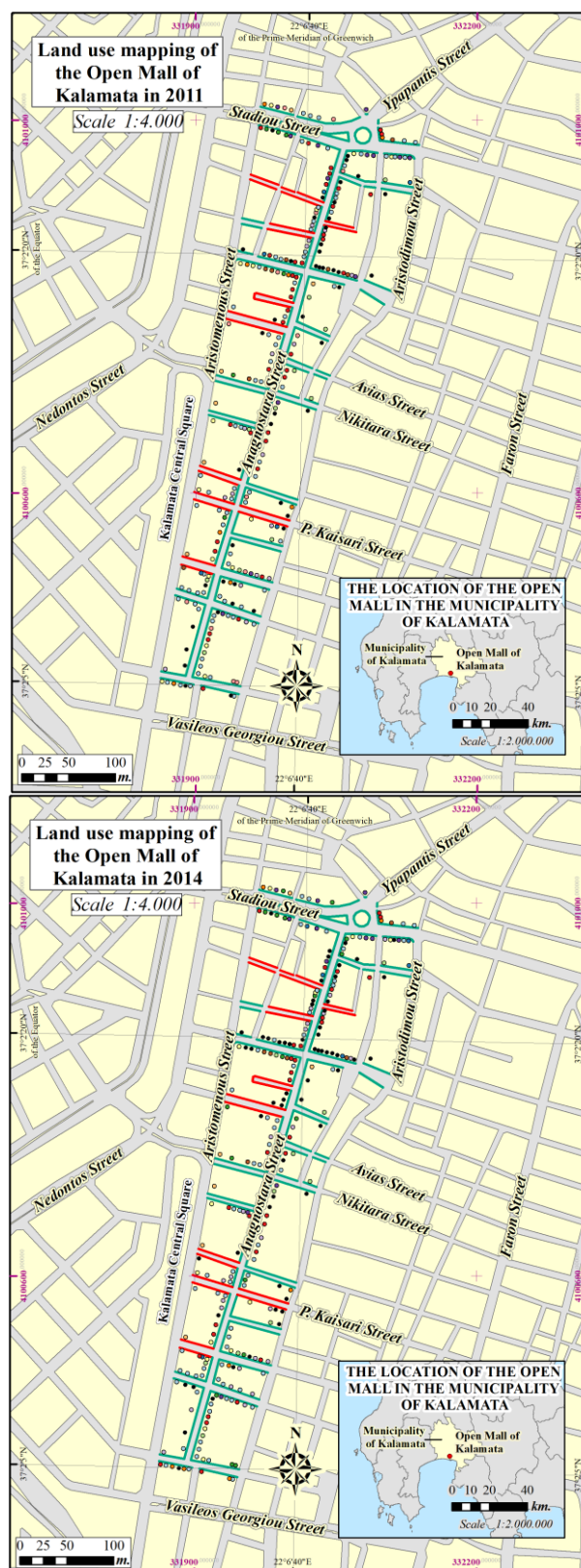**Figure 9.** The *Open Mall* of Kavala and its retail stores in 2011 (right) and in 2014 (left)

Figure 10. The *Open Mall* of Kalamata and its retail stores in 2011 (right) and in 2014 (left)
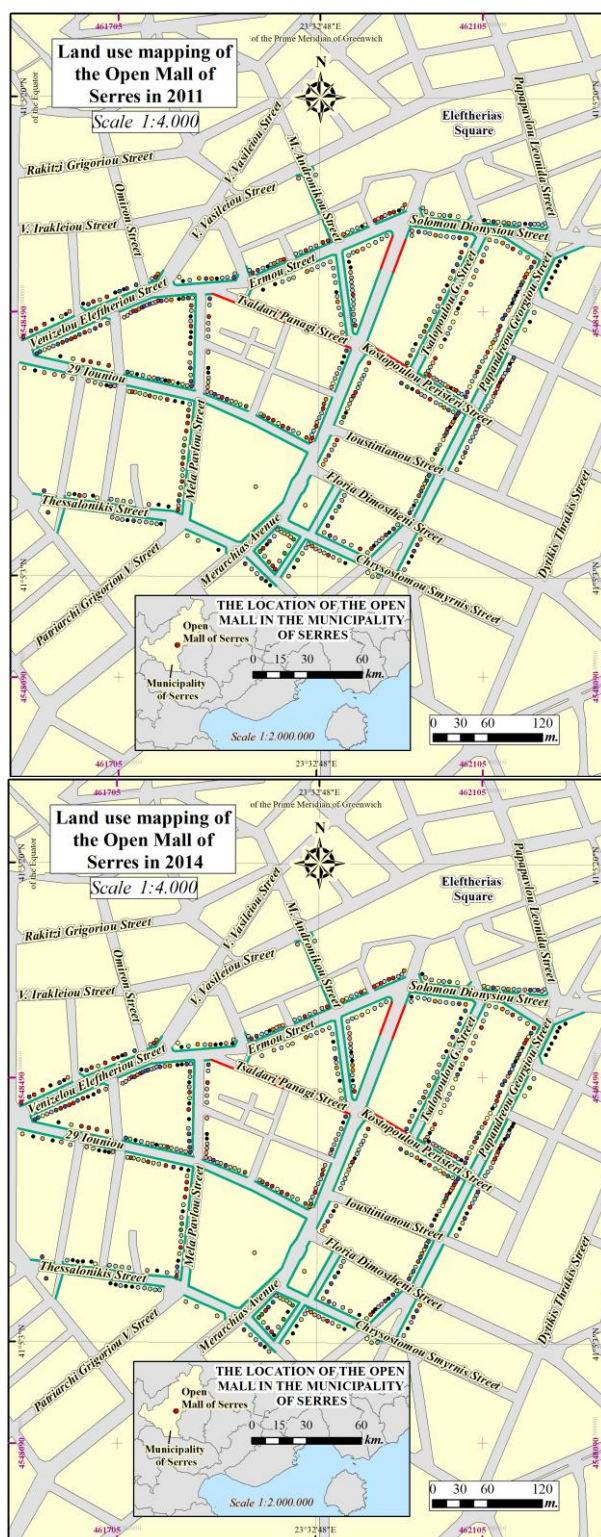
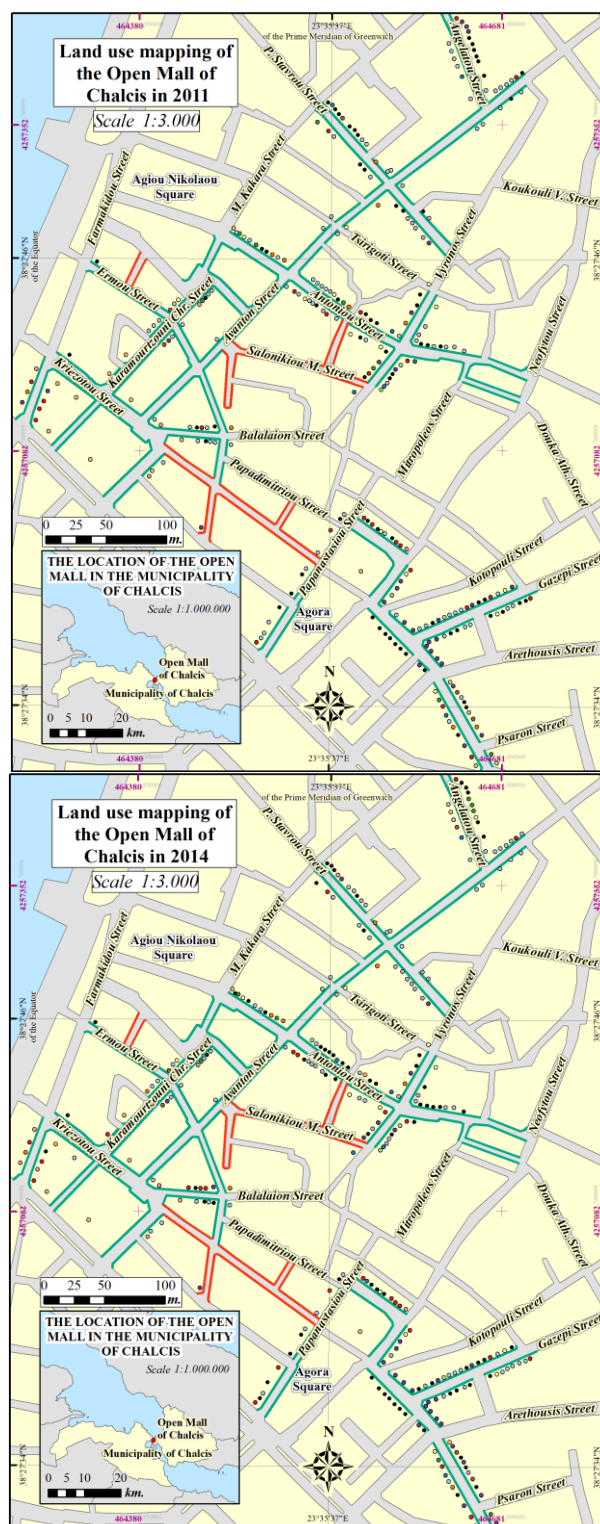**Figure 11.** The *Open Mall* of Serres and its retail stores in 2011 (right) and in 2014 (left)

Figure 12. The *Open Mall* of Chalcis and its retail stores in 2011 (right) and in 2014 (left)
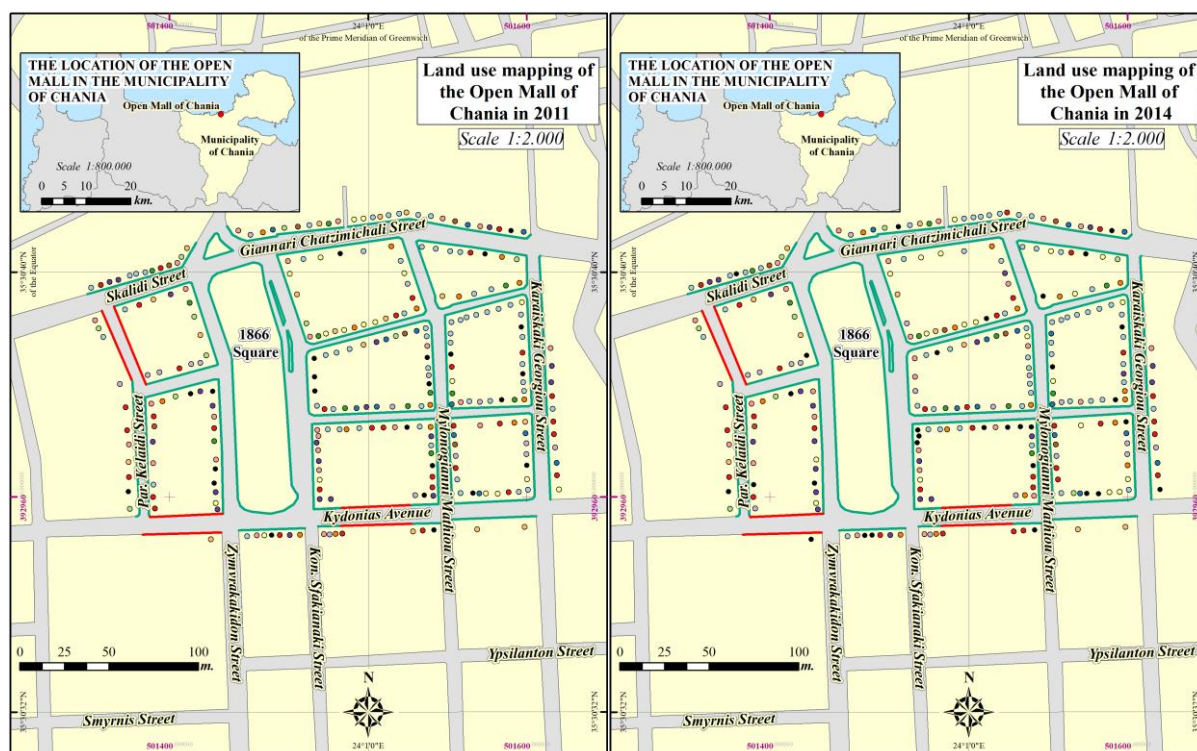
Figure 13. The *Open Mall* of Chania and its retail stores in 2011 (right) and in 2014 (left)

4.3. Spatial Analysis

The results of the *Average Nearest Neighbor (ANN)* tool are presented in the table 10 and 11, while the table 12 characterize the spatial patterns as clustered, random or dispersed. The *ANN* geoprocessing tool was utilized to the retail stores of the reference years of 2011 and 2014, excluding the retail stores of 2009 as it is a reference year for data collection only for the city of Athens. In order the *ANN* tool to be used, a minimum bounding box that encloses all the retail stores was specified for each *Open Mall*.

Table 10. The results of the Nearest Neighbor Ratio per land use category for each city in 2011

City/Town	K01	K02	K03	K04	K05	K06	K07	K08	K09	K10	K11	K12	K13
Athens	0,07	0,12	0,09	0,22	0,15	0,21	0,31	0,05	0,14	0,12	0,16	0,06	0,14
Thessaloniki	0,57	0,70	0,85	1,15	0,98	0,46	0,95	0,55	1,16	1,12	1,09	1,69	0,69
Patras	0,73	0,89	0,90	0,83	1,02	0,89	1,08	0,79	1,04	0,86	1,05	0,92	0,85
Heraklion	0,81	0,97	0,97	1,23	1,00	0,40	1,13	0,82	1,15	1,04	Unable to be performed, as one point exists and at least two are necessary	0,97	0,95
Larissa	0,60	0,76	0,75	0,63	0,96	0,74	0,98	0,90	1,12	0,79	0,96	0,75	0,73
Volos	0,70	0,82	1,00	0,80	0,92	1,09	1,13	0,69	1,08	0,69	1,29	1,00	0,73
Ioannina	0,60	1,12	1,07	1,33	1,62	1,81	2,79	1,30	1,99	0,83	0,70	No stores	0,97

												for 2011	
Kavala	1,22	1,10	1,12	0,98	1,48	1,12	1,61	0,64	1,71	1,39	1,07	1,36	1,11
Kalamata	0,80	0,71	1,23	1,09	1,12	0,76	1,52	1,57	1,16	1,14	1,39	1,32	0,94
Serres	0,74	0,77	0,93	0,85	1,10	0,70	1,10	0,88	0,97	0,73	0,64	1,09	0,81
Chalcis	0,70	1,32	1,59	0,86	0,99	0,94	1,22	1,15	1,09	0,67	1,54	0,97	0,71
Chania	0,79	1,05	1,22	0,88	0,86	0,84	1,27	1,15	1,19	1,38	0,89	1,71	0,97

Table 11. The results of the Nearest Neighbor Ratio per land use category for each city in 2014

City/Town	K01	K02	K03	K04	K05	K06	K07	K08	K09	K10	K11	K12	K13
Athens	0,07	0,09	0,20	0,17	0,13	0,06	0,13	0,01	0,10	0,11	0,24	0,12	0,15
Thessaloniki	0,62	0,74	0,84	0,98	0,93	0,55	1,06	0,53	1,29	0,83	1,20	1,69	0,69
Patras	0,76	0,86	0,95	0,87	1,03	0,87	1,06	0,70	1,11	0,91	1,00	1,09	0,84
Heraklion	0,81	1,11	1,24	0,76	1,13	0,64	1,21	0,68	0,98	0,85	2,00	0,90	0,75
Larissa	0,66	0,87	0,69	0,76	0,81	0,66	1,23	0,87	1,28	0,68	0,89	0,65	0,69
Volos	0,66	0,92	1,18	0,70	0,90	1,15	1,17	0,67	1,17	0,71	1,12	0,97	0,69
Ioannina	0,68	1,11	1,40	0,85	1,83	1,63	2,79	1,19	2,16	2,35	0,99	2,05	0,67
Kavala	1,27	1,11	1,00	0,97	1,31	1,12	1,51	0,58	1,51	1,58	1,15	1,87	0,74
Kalamata	0,82	0,73	1,01	1,03	1,25	0,82	1,52	1,37	0,82	1,25	1,65	1,00	0,87
Serres	0,78	0,74	0,86	0,79	1,18	0,69	1,19	0,83	0,69	0,72	0,76	0,85	0,71
Chalcis	0,79	1,02	1,59	0,95	1,33	0,84	1,99	1,85	0,67	1,20	1,61	1,27	0,76
Chania	0,84	0,99	1,28	0,89	0,88	1,02	1,01	1,33	1,14	0,90	0,90	1,48	1,12

Table 12. The spatial distribution patterns and their intensity percentages

Legend analysis of the *Average Nearest Neighbor*						
1%	5%	10%		10%	5%	1%
Clustered			Random	Dispersed		

Regarding the retail land use categories whose spatial pattern remained clustered from 2011 to 2014, the distribution of retail stores classified as:

- K01 Clothing, Footwear and Sports Equipment has been observed in 11 of the 12 cities, excluding the city of Kavala.
- K02 Electrical and domestic appliances has been observed in 6 of the 12 cities, in particular Athens, Thessaloniki, Patras, Heraklion, Kalamata and Serres
- K03 Café services and related activities has been observed in 3 of the 12 cities, in particular Athens, Thessaloniki and Larissa
- K04 Food has been observed in 5 of the 12 cities, in particular Athens, Patras, Larissa, Volos and Serres
- K05 Pharmacies, Optical products, Medical Supplies and Cosmetics has been observed in one city, in particular Athens
- K06 Provision of personal and specialized services has been observed in 4 of the 12 cities, in particular Athens, Thessaloniki, Larissa and Serres
- K07 Welfare Services has been observed in one city, in particular Athens
- K08 Jewelry has been observed in 3 of the 12 cities, in particular Athens, Thessaloniki and Patras
- K09 Training and Entertainment Items has been observed in one city, in particular Athens

- K10 Offices, Medical offices, Laboratories has been observed in 3 of the 12 cities, in particular Athens, Volos and Serres
- K11 General trade has been observed in one city, in particular Athens
- K12 Photography Activities and Printing Offices has been observed in 2 of the 12 cities, in particular Athens and Larissa
- K13 Closed stores-Inactive commercial activities has been observed in 7 of the 12 cities, in particular Athens, Thessaloniki, Patras, Larissa, Volos, Serres and Chalcis.

Regarding the retail land use categories whose spatial pattern remained random from 2011 to 2014, the distribution of retail stores classified as:

- K02 Electrical and domestic appliances has been observed in 3 of the 12 cities, in particular Ioannnina, Kavala and Chania
- K03 Café services and related activities has been observed in 3 of the 12 cities, in particular Volos, Kavala and Kalamata
- K04 Food has been observed in 6 of the 12 cities, in particular Thessaloniki, Heraklion, Kavala, Kalamata, Chalcis and Serres
- K05 Pharmacies, Optical products, Medical Supplies and Cosmetics has been observed in 5 of the 12 cities, in particular Thessaloniki, Patras, Heraklion, Volos and Chania
- K06 Provision of personal and specialized services has been observed in 4 of the 12 cities, in particular Volos, Kavala, Chalcis and Chania
- K07 Welfare Services has been observed in 5 of the 12 cities, in particular Thessaloniki, Patras, Heraklion, Volos and Serres
- K08 Jewelry has been observed in 3 of the 12 cities, in particular Heraklion, Larissa and Serres
- K09 Training and Entertainment Items has been observed in in 5 of the 12 cities, in particular Thessaloniki, Heraklion, Volos, Kalamata and Chania
- K10 Offices, Medical offices, Laboratories has been observed in 4 of the 12 cities, in particular Thessaloniki, Heraklion, Kalamata and Chalcis
- K11 General trade has been observed in in 4 of the 12 cities, in particular Patras, Larissa, Kavala and Chania
- K12 Photography Activities and Printing Offices has been observed in 5 of the 12 cities, in particular Patras, Heraklion, Volos, Serres and Chalcis
- K13 Closed stores-Inactive commercial activities has been observed in in one city, in particular Chania

Regarding the retail land use categories whose spatial pattern dispersed from 2011 to 2014, the distribution of retail stores classified as:

- K01 Clothing, Footwear and Sports Equipment has been observed in one city, in particular Kavala
- K03 Café services and related activities has been observed in 2 of the 12 cities, in particular Chalcis and Chania
- K05 Pharmacies, Optical products, Medical Supplies and Cosmetics has been observed in one city, in particular Ioannina
- K06 Provision of personal and specialized services has been observed in one city, in particular Ioannina
- K07 Welfare Services has been observed in 2 of the 12 cities, in particular Ioannina and Kavala
- K08 Jewelry has been observed in in one city, in particular Kalamata

- K09 Training and Entertainment Items has been observed in 2 of the 12 cities, in particular Ioannina and Kavala
- K11 General trade has been observed in one city, in particular Chalcis
- K12 Photography Activities and Printing Offices has been observed in 2 of the 12 cities, in particular Thessaloniki and Chania

5. DISCUSSION

According to Photis (2009), a random spatial pattern is generated as a result of the random distribution of points, where the location of a spatial point is independent of the location of any other spatial point. A dispersed spatial pattern reflects the concept of competition and thus is generated as a result of the regular distribution of points, where the activities are located in such manner that they abstain as far apart as possible from each other. A clustered spatial pattern indicates the concept of attractiveness and thereby is generated as a result of the clustered distribution of points, where the activities tend to be in a proximity with each other.

Concerning the spatial patterns' interpretation per retail land use category, the factor that forms the clustered spatial pattern of the commercial land uses, especially for the categories of Clothing, Footwear and Sports Equipment (K01), Electrical and domestic appliances (K02) and Café services and related activities (K03), is the high population density that characterizes the selected cities, which is enhanced both by the cities' location in the greater area resulting in the labour input and the student community as there are many institutions of higher (tertiary) education. A parameter that contributes to the clustering of the above retail land uses is tourism, where taking into consideration the cities' specific characteristics and the alternative forms of tourism in Greece, tourists enhance the trade operators to locate their stores in proximity to each other. Furthermore, the clustered spatial pattern observed in the cities of Volos and Kavala is reinforced by the immediate proximity of the *Open Mall* to the cities' port, while the clustered spatial pattern of Food (K04) observed in Larissa, Volos and Serres is enhanced as well by the proximity of the city centres to the plains located in the greater area of the municipalities. Regarding the interpretation of the random spatial pattern, which was observed in a variety of retail land use categories in many cities both in 2011 and in 2014, the effort of maintaining the stores' operation is the main factor that forms this spatial pattern. More specifically, the increase in rental prices of premises for professional activities forced the entrepreneurs in choosing the suitable location based on an economic benefit (such as a low rent) and not considering the proximity to other retail stores with similar products or services which would eventually yield a gain to them due to the consumers visit. In conclusion, the dispersed spatial pattern, which was observed in a variety of retail land uses especially in the city of Ioannina, is formed due to the entrepreneurs' intent to select locations that enables them to cover a specific part of the marketing area, aiming to be competitive compared to other retail stores in terms of consumers attraction.

6. CONCLUSIONS

The GSV service is a credible free source for gathering spatial and temporal data and its usefulness is significant for the detection of the type of product or service the retail store promotes to customers, especially when taking into account the restrictions set by the GDPR on data provision. However, the GSV images' temporal dimension is limited as it is intermittently updated (Vandeviver, 2014). Nevertheless, it is worth noting that the GSV images have been exploited for various scientific fields beyond the topic of retail, such as for the detection and monitoring of the spread of invasive alien plants (Kotowska, et al. 2021), or for the production of 3D city models along with very high resolution satellite images (Kraff, et al. 2020), as well as from studies that utilized machine (Yang, et al. 2020; Dakin, et al. 2020) and deep learning methods (Ki and Lee, 2021; Nagata, et al. 2020), thus reflecting the utility of this data source.

It is worth noting that the selected municipalities have a large area due to the administrative reform of *Kallikratis* plan (Papafragkaki and Photis, 2014) according to which the Greek municipalities were reduced to 325 larger municipalities (Kalimeri, 2018). Thereby, the size of an *Open Mall* does not reflect the actual size of the municipality's commercial area, but reflects the traditional commercial streets, as delimited by the municipalities and the trade associations or chambers, aiming to be upgraded through the development of local retail in order to regain vitality and viability (De-Juan-Vigaray and Seguí, 2019).

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