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UTILIZING GEOGRAPHICAL INFORMATION SYSTEM FOR MAPPING SCHOOLS DISTRIBUTION. CASE STUDY: THE 4TH LOWER SECONDARY SCHOOL IN FLORINA CITY, GREECE

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Abstract. The Geographic Information System (GIS) is still a special tool for mapping schools, comprehending urban planning, and allocating educational resources. In order to demonstrate the value of utilizing GIS techniques to support educational planning authorities, the study conducted a GIS analysis for the distribution of lower secondary schools in Florina, Greece, to comprehend, reorganize, and resolve the issues with the schools' distribution, availability, and placement in Florina City. Education and population data gathered from authorities were incorporated into a Geodatabase for the study area. The research region's school accessibility, student density, and location distribution are all understood through the use of spatial analyses. The analysis's findings help the Greek authorities make better planning decisions, address current and upcoming issues with providing public schools to citizens, and – above all – improve educational services by identifying services, students, density, directional growth of the schools, and served and unserved populace. The findings revealed two regions with school deserts that need new schools: initially the 4th Lower-Secondary School (Gymnasium) of Florina and possibly in the future the 5th Lower-Secondary School (Gymnasium) of Florina.

Keywords: geographic information system (GIS); QGIS; school mapping; planning; educational facilities; school desert

1. Introduction

Both urban and rural areas are witnessing considerable growth in all aspects, including the education sector. The authorities, in order to meet demand and ensure equity, must properly plan and distribute educational facilities. Planning educational facilities is a unique method to arrange schools and facilities for optimal use at all levels to promote development and prosperity in the social, cultural, political, and economic spheres. It includes a broad range of planning and management related to the resources' allocation, location, and distribution of educational services (Lagrab & Aknin 2015). Planning for schools include mapping and arranging the locations of schools

to ensure equitable and competent distribution, particularly during periods of significant educational system expansion or reform (Ngigi et al. 2012). In order to assist decision-makers and planners, school mapping entails building relational geospatial databases for demographic, educational, social, and economic data for educational authorities. (Khobragade & Kale 2016). Furthermore, it is a crucial instrument for comprehending the disparities resulting from the investment made by the public authority.

As a result, the distribution pattern of educational institutions is determined by the investment made by governmental authorities. Additionally, school mapping is a strategic planning technique that attempts to solve the lack of deliberate effort to situate educational facilities in a location that will maximize their use by a specific demographic (Ekpoh 2018). Therefore, it is a dynamic vision of how education services will look in the present and, in the future, to help with policy implementation and to help authorities make better decisions about where to locate schools and how to distribute them across different regions to ensure maximum utilization. According to (Akpakwu 2012), to promote accessibility and equity in the distribution and prevent over-localization or over-concentration of schools in some locations while other areas lack them, school mapping is crucial (Murad et al. 2020). Authors of (Lubienski & Lee 2017) spearheaded the call to use geospatial methods in school choice research to expand beyond the analysis of neighborhood and local effects and scale up to using GIS to capture broader trends and consequences. The creation of favorable conditions for attaining universal education is another reason why school mapping is important. Likewise, it is a means for research, gaging accessibility and aiding good decision-making for better policies of planning (Belarem et al. 2018).

In order to make decisions on the best place for a new educational facility, this study models the system of educational facilities found in a large city or municipality. The planning of a new school is a multifaceted process, as will be demonstrated, and as a result, a particularly difficult decision will need to be made. This decision will be based on a thorough analysis of numerous factors, including the area's deficiencies and the amount of land available for the construction of schools within the urban area under study.

Due to the intricacy of this choice, GIS modeling of the educational system and its administration is unavoidable. In particular, the analysis data that must be incorporated into the GIS is provided, along with the interpretation, analysis, and conclusion-drawing process pertaining to the issues of the current situation and the methodology for identifying those crucial spatial entities where the construction of a new, educational installation is more urgent. The educational system in Florina, Greece, will serve as a case study for the methodology's implementation.

2. School Mapping Methodology

2.1. School Mapping

School mapping methodology has many procedures according Ekpoh (2018), as firstly, standards are defined. The establishment of standards, standards, and catchment areas serves as a key foundation for school mapping. The rules also define the catchment region that a possible school would serve and the distance a child must walk. Secondly, the educational development diagnosis. Diagnosis' objectives are to determine the allocation of educational resources in certain locations as well as the system's strengths and shortcomings. Statistics are gathered on the entire population by age and sex group in order to diagnose the educational status. Exact data on significant metrics is needed. Thirdly, a forecast of future enrolment in schools. A further phase in school mapping is evaluating potential student enrolment. This prediction is always based on the entire anticipated population of school age and the catchment area. Finally, taking a decision to locate a school is based on the standards specified by the authority. The standards here depend on the threshold population and the catchment area. School mapping does not decide on the site to construct schools, it only indicates the most appropriate areas where schools are to be located. Furthermore, in the process of mapping schools, evaluating the necessary facilities is also crucial. In this sense, the facilities of a planned new school or those of an existing school are evaluated. A comprehensive evaluation encompasses both instructional resources and physical infrastructure.

Education and the placement of schools in urbanized areas are crucial components to serve community needs. Planning will be a mystery unless there is a tool to assist decision makers in planning schools in accordance with the defined criteria (Al-Rasheed & El-Gamily 2013). In addition, (Caillods 1993) views school mapping as a collection of methods and strategies for predicting future needs in local education and organizing the steps necessary to address them.

According to Ana et al. school mapping research focuses on three topics, consisting of evaluating school policies, mapping as an infrastructure database, and school information tools. The mapping method used for evaluating school policies is a qualitative method, while as a database using Geographic Information System (Ana et al. 2021).

2.2. Micro-planning

According to scholars, school mapping is the process of planning and implementing education at both the macro and local levels. Micro-level planning is done at the district or local government level, and macro-level planning is done at the state level for the distribution of educational resources. Another

issue it tackles is deciding what kind of teachers should be employed and placed in classrooms to teach or oversee specific subjects, especially in the sciences[1].

Micro level planning is defined as planning at the smallest possible spatial level. Micro level planning refers to planning done at a city or even the habitation level in small regions. The goals of micro level planning are to mobilize the community to create city level plans, to support teachers and schools so that they can function more effectively, and to ensure that all local children who are eligible for schooling attend. The primary goal of the micro planning project is to make better and more efficient use of the resources that have already been assigned to a certain locality, area, or school, rather than to provide more resources.

Micro planning shouldn't be thought of as a one-time activity. It is a continual process that manifests itself during the execution and operationalization of plans created at either the local or higher levels. Micro planning is mainly concerned with the tactical aspects of reaching a certain plan aim. Residents might participate in micro planning projects and are actually the target population and focus of micro planning.

Two basic steps in establishing or operationalizing a micro planning project are, firstly understanding the city; this may be the initial step in identifying the issues the city is facing so that the fundamental intervention techniques can be understood and secondly making a city map; a community may have a wide range of amenities, with educational facilities being just one of them. It could be preferable to plot these facilities on a map so that residents of the area can see how their city is divided up in terms of facilities.

3. GIS and School mapping

3.1. The use of GIS for Educational Facilities Planning

Many spatial techniques are used in GIS studies on school choice and segregation. These techniques include modified areal measures like composite population counts (Hogrebe & Tate 2019), average nearest neighbor analysis (ANNA) and density modeling (Gilblom & Sang 2019), and dynamic mapping analysis (Siegel-Hawley 2013). Some others utilize GIS to monitor changes over time (Archbald et al. 2018) or as a direct or supplementary support for multilevel statistical models. For example, tested whether or not racial segregation in metropolitan districts was exacerbated by private schools using a GIS.

In order to identify access areas and ensuing "school deserts", in (Monique & Massaro 2020) routing technology and school catchment zones werw used. The results of their study gave rise to a visual depiction of Pennsylvania's

catchment zones, which are areas where students lack access to high-quality education. A powerful methodological tool for these studies and for influencing policy is the spatial strategy of identifying access deserts.

Urban planning and Geographic Information Systems (GIS) have a complicated interaction: a) the analysis phase, which records and interprets the current urban space and b) the proposal phase, which plans and designs the future features of the urban space. These are the two key stages of the urban intervention process. Planners utilize geographic information systems (GIS) to map and analyze urban areas during the analysis phase. GIS continue to serve as a tool (for example, in the creation of maps) throughout the proposal stage, but they also improve it as a decision support tool. In this case, the organization of thematic layers, the organization of attribute data associated with each thematic level, and their cartographic presentation are not only problems relating to the GIS technique but also outcomes of a particular urban planning logic. Furthermore, political choices can be influenced or even guided by the way thematic layers are designed and presented on a map. The planning of educational facilities with the use of GIS, is the main topic of this essay, which utilizes the educational facilities in the Municipal Unit of Florina in Greece, as a case study. Particularly, the process used to determine the best site for a proposed school is of primary interest, but there is also interest in modeling the system of educational establishments. It is crucial to remember that this application has considered the unique characteristics of the Greek urban planning and education systems, which may vary somewhat from those of other nations.

3.2. The Planning of Educational Facilities in Greece

The three levels of the Greek educational system are primary, secondary, and higher education. Children aged 6 to 12 are admitted to elementary schools, which make up the first tier. Lower-secondary and upper-secondary schools, on the other hand, take students aged 12 to 15 and teenagers aged 15 to 18, respectively. While attendance at upper-secondary institutions is optional, for primary and lower-secondary education it is mandatory. The operation of public schools in elementary and secondary education is the responsibility of each municipality in which these schools are located. This study is focused on the planning of new public educational facilities of lower-secondary education.

Regarding the urban planning system, Structure Plans are established in Greece in order to design public amenities. The development of elementary and secondary school facilities is one of the responsibilities of the structure plans, which are created specifically for each town. As a result of this planning, some properties are designated as locations where the construction of

educational facilities is permitted. In order to acquire these properties and make them accessible for future school building, each municipality must expropriate them while paying the landowners a fair price.

If the landowners are not given the suggested compensation, they may file a lawsuit to have the expropriation removed, the land reclassified as non-educational area, and the land return to its former land use status – which typically permits the construction of residential and commercial uses. Municipalities in Greece are unable to expropriate all of the land assigned for the development of educational facilities because they cannot afford the necessary compensation, which is a result of the high cost of urban property and the financial challenges they frequently encounter. The aforementioned incapacity leads to the municipalities' gradual expropriation of these properties, with priority given to those situated in regions where the greatest deficiencies for a sufficient supply of educational services manifest. In particular, towns only plan their next course of action when they can afford it and when the severity of the challenges facing the educational system demands it.

Early identification of the most pressing issues with the arrangement of educational facilities is essential to the success of such an approach to programming as a continuous or, more accurately, as a fragmented procedure. Thus, it is clear that the GIS modeling of the educational facilities system aids the municipality in keeping an eye on the condition of the educational system nowadays and is essential to the action-taking process in the contemporary Greek urban practice.

3.3. The Issue of Offering Sufficient Educational Services

The Greek Constitution states that all people are entitled to free public education, which must be provided for a minimum of nine years. Additionally, the Code of Municipalities and Communities, which outlines the duties of local government, states that municipalities are now responsible for the construction, operation, and maintenance of schools that have been expropriated from the central state. The aforementioned makes it evident that a municipality's educational facilities must be able to accommodate all of its residents' educational demands. According to this, all municipality pupils who desire to attend schools must be registered and receive educational services.

One of the two possibilities below is unavoidably result of inadequate educational facilities, to meet the demands of the populace, either in terms of quantity or size. The first possibility is the decline in the quality of education provided by enrolling more students than any school can accommodate by growing capacity. Such degradation may be computed by calculating the occupancy ratio, which is the ratio of the school's-built area to the number of pupils enrolled, and comparing it to the relevant planning standard.

Almost all industrialized nations have such standards, which are given in FEK 285/D'/5.3.2004 for Greece. For example, if a lower-secondary school has a 1.000sq.m.-built area and serves 250 students, this means that the occupancy ratio is 4sq.m. per student. This ratio is then compared to the corresponding standard, which for Greece is set to 6sq.m. of built area per student (Pissourios 2011). As it is understood, a comparison between the current occupancy ratio and the planning standard indicates that this lower-secondary school has more students than it should and does not offer sufficient educational services (or, alternatively, that this specific number of students is housed in a building smaller than as it should be). The second alternative is to run the school in two shifts, with half of the students attending in the morning and the other half in the afternoon. Of fact, since schools should only be open in the morning, operating them in two shifts is an indirect degrading of educational services.

4. Study case Area

The Region of Western Macedonia consists of 4 Prefectures: Kozani, Florina, Kastoria, and Grevena. The Prefecture of Florina (fig. 1) is one of the 51 Prefectures of Greece, which is one of the 74 Regional Units of the country.

It has a population of 50,921 inhabitants, according to the 2021 Census, making it the second largest Regional Unit in terms of population in the Region of Western Macedonia after Kozani. Its area amounts to 1,924 square kilometers.

It is located in the north-northwest part of Greece and borders North Macedonia (Pelagonia Region) and Albania (Koritsas Prefecture) to the north and west respectively, while to the south it borders the Regional Units of Kozani and Kastoria and to the east with the Regional Unit of Pella.

4.1. Data collection methods

At the educational facilities planning, each project should begin with an information base of schools, understudies, and educators. GIS layers showing school areas and other critical geographic elements, as for example, infrastructure and buildings, roads and streets, surrounding areas, risk maps, transportation routes, health-related areas, recreational areas and activities, environmental data, social structures and services and other geographic highlights, they provide mapping planners with an incredible data base. For instructional mapping authority professionals, school planning is a masterful ability and also, the study of creating geospatial data sets with social data sets comprising educational, segmented, social, and financial data.

The process followed and the data used to study the school's units include:

- Field surveys using GPS to determine the location of school units.

• Use and processing of satellite images, analogue and digital aerial photographs. Sources of these were Google Earth (GE), the Geographical Service of Greek Army (GYS) and the Greek Land Registry (EK).

• Study and use of GIS and web-GIS data by open data of Greece government.

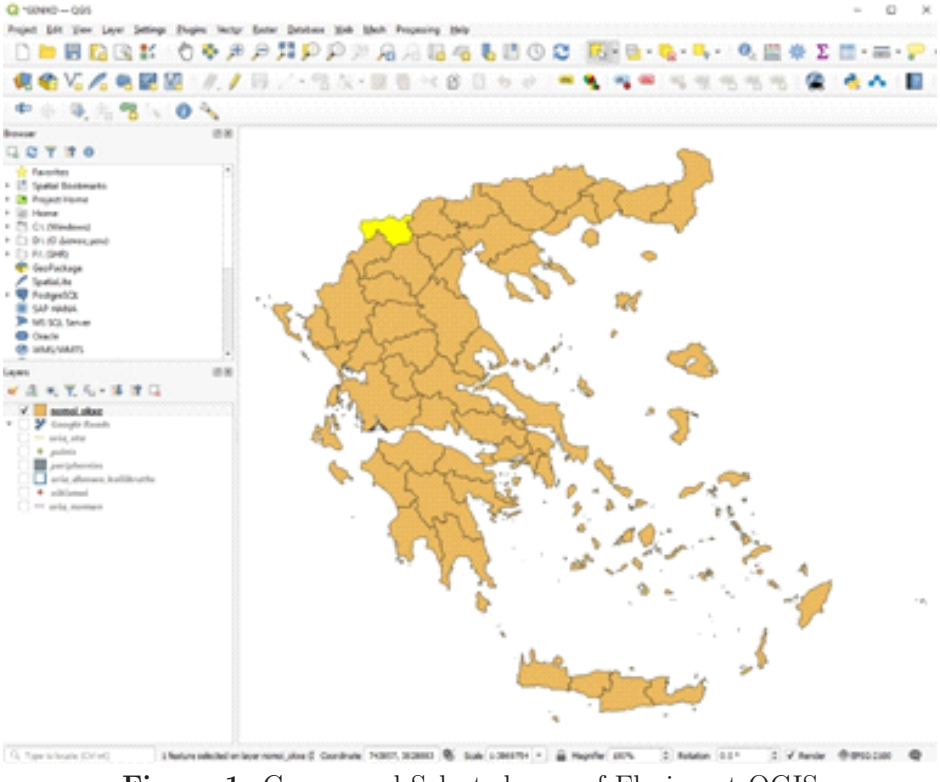

Figure 1. Greece and Selected area of Florina at QGIS

4.2. Demographic analysis of study content

In Greece, a census is conducted every ten years, with the last census being in 2021. The responsible agency for conducting it is the Hellenic Statistical Authority, and the result are published online at the address statistics.gr[2]. In the Region of Western Macedonia, there is a decrease in the general population to the order of 11.43%. In the population groups 0 – 19, which are also the ages where children attend primary and secondary education, a greater decrease is observed compared to the general population, namely 17.15% in the 10 – 19 age group and the highly impressive and at the same time alarming

37.31% in the age group 0 – 9 years. Regarding the extremely large decrease in births in the years between 2011 and 2021 of the censuses, we can mention as a cause the economic crisis of Greece with the corresponding memoranda and the migration abroad of young people for a better life.

Table 1. Population changes from 1991 to 2021

	1991	2001	2011	2021	Percentage change last 30 years	Percentage change last decade
Regional Unity of Florina	52,367	54,109	51,414	44,880	-16.68	-14.56
Municipality of Florina	32,172	33,588	32,881	29,500	-9.06	-11.46
Municipal Unit of Florina	15,354	17,500	19,985	19,198	20.02	-4.10
Municipal Unit of Kato Kleines	4,107	3,787	2,735	2,132	-92.64	-28.28
Municipal Unit of Meliti	7,020	6,909	5,927	4,692	-49.62	-26.32
Municipal Unit of Perasma	5,691	5,392	4,234	3,478	-63.63	-21.74

At the level of the Regional Unit of Florina (former Prefecture of Florina), the general population has decreased by 14.56% (Table 1), a larger percentage compared to the Region of Western Macedonia, but at the level of the Municipality of Florina and the Region of Western Macedonia, the changes are almost the same (-11.46 the population change of the Municipality of Florina and -11.43 the population change of the Region of Western Macedonia). At the Municipal Unit level, the case area of the present article, we

notice that the Municipal Unit of Florina is the only one that increased its population in the last 30 years by 20.02% (table 1). As mentioned above, the economic crisis of the last decade also affected the Municipal Unit of Florina with a small decrease in its population, of the order of 4.10%, in contrast to the large decreases in the three other Municipal Units, Kato Kleines, Meliti, and Perasma. Of course, if we observe the changes of the last 30 years in the respective areas, i.e., in the municipal units of Kato Kleines, Meliti, and Perasma, we will observe the extremely large and, at the same time, disappointing percentage decreases of 92.64%, 49.62%, and 63.63%. Percentages that prove the increase of population and the development of urbanism in the last years in the study area of the Municipal Unit of Florina.

Now, the increase in the population of Florina created problems in education as well. The city's schools could not enroll all the students, and temporary solutions were proposed, such as running morning and afternoon schools, creating temporary classrooms in containers, and renting classrooms for teaching. In the 90s, in secondary education, the problem was temporarily solved with the creation of the 2nd Lower Secondary School of Florina as well as the 2nd Upper Secondary School of Florina.

We must mention that in the Municipality of Florina there is only one city, Florina, and all the other settlements are villages. Here the view of urbanization of the study area is further strengthened, where the city of Florina has increased its population by 25.24% in the last 3 decades. It is worth mentioning that the city of Florina is the only area where its population increased in contrast to the remaining 46 settlements of the study area where the population decreased.

In fig. 2 we notice that the city of Florina has only 3 high schools in which 719 students studied in the 2021-2022 school year. It is worth mentioning that there are not enough classrooms in the city's high schools, and even today, there are classrooms that have been divided in order to accommodate the large number of students (1st Florina middle school and 3rd Florina middle school). In addition, the percentage of middle school students in the city of Florina is 3.75% as opposed to 2.46% of the rest of the regions, a percentage that indicates the existence of a large number of secondary school students as a percentage of the population in the city of Florina.

All of the above suggest that it is imperative for the creation-establishment of a new high school, the 4th Florina Lower-Secondary School (4th Gymnasium), which will solve all the problems of the previous decades as well as the following years. It will decongest the city' s already overcrowded secondary schools and give a new dynamic to the city, which will be able to accommodate additional students.

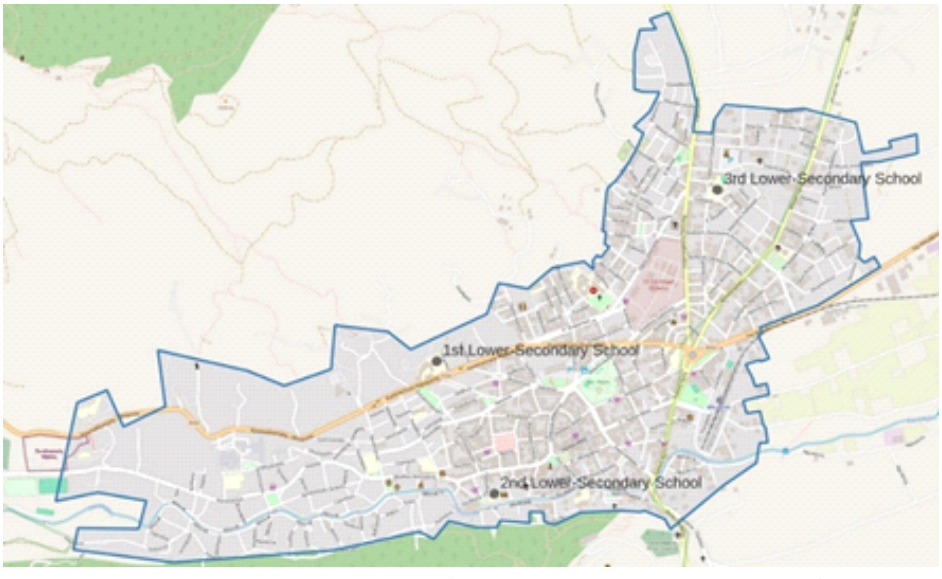

Figure 2. The residential outline of the city with the locations of the three schools of Florina as designed in QGIS

4.3. Methodology for Determining New Educational Facilities

A strategic study of the educational facilities system must take into account only a few of the many factors that influence the educational services that a school provides. A few examples of factors that surely impact the quality of educational services are the age of buildings, the layout of individual rooms, the size of classrooms, the equipment used in the latter, its condition, and its use in the teaching process. These parameters will not be included because they are too comprehensive for the current study's level of analysis. However, just two characteristics appear to be important for the strategic analysis of the educational facilities system, such as these attempted in this study.

Both of these factors – the first being the occupancy ratio and the second being the school's shift operations – have already been discussed in relation to the caliber of educational services. Assuming that:

a) the number of students served by the school is such that the occupancy ratio is equal to the suggested criteria;

b) each school runs on a single, morning shift, it is feasible to determine the regions that provide acceptable educational services based on these two factors. The area in which inhabitants receive sufficient educational services is known as the school's service area, and it may be ascertained using the

approach below and the aforementioned assumptions. Thus, the municipality must step in and plan new school facilities in regions of the municipality that are not served by the service area of the current schools.

4.4. Site Selection

The process of choosing a suitable location for a desired use involves analyzing a region's capabilities in terms of sufficient and acceptable land as well as its relevance to both urban and rural land uses. This process is known as site selection. The definition of site selection given above states that modifications have been used for a very long time, going all the way back to the time when people tried to understand their surroundings in order to locate a better place to live. It is evident that site selection progressively increased in complexity over time as human demands became more varied and sophisticated, necessitating the use of increasingly sophisticated instruments and procedures in addition to more exact planning. Today, choosing a site usually involves careful and ongoing planning, and geographic information systems can greatly aid in speeding up the process. That being said, it should be noted that in many situations, it is either impossible or extremely difficult to choose a site correctly without the use of geographic information systems. Notably, while the site selection criteria vary based on the kind of application, they are all uniform in their quest to identify the ideal place for the intended purpose.

It is obvious that precise and comprehensive location information is required in order to apply measurements and criteria for site selection, especially when choosing a school site. Obtaining this information necessitates doing a great deal of study. It is also evident that the ideal location for a certain project would only be chosen following data analysis and evaluation. (Parast et al. 2016).

It is necessary to analyze the educational facilities in a way that will help identify the part of the municipality that offers the least adequate educational services. It is evident that the municipality can step in by developing a new educational facility in this underprivileged area if it is identified.

The computation of each educational facility's occupancy ratio could serve as the basis for this analysis. With the help of the kernel density estimate function, which is a feature of most GIS programs, these occupancy ratio values might serve as the foundation for the creation of a continuous surface. In contrast to low values, which would suggest places not sufficiently served by existing educational institutions, high values on this surface would indicate locations that receive good educational services. In (Thurstain-Goodwin & Unwin 2000) it was provided one such spatial analytic technique for the delimitation of urban centers. A strategy based on school occupancy ratios, however, is inappropriate for the Greek reality since it obscures from study the

fact that many schools have high occupancy percentages because they work two shifts. Additionally, the schools that have split the classrooms to create extra «virtual» rooms are cases with increased occupancy rates. Because of this, they are designated as areas with inadequate education services.

Finally, the education facilities must be placed in locations far from the land uses that have an influence on the quality of education, and the health and safety of children achieve an equitable, fair distribution of educational services. (Lagrab & Aknin 2015)

4.5. Mapping a new Lower Secondary School at Florina

The spatial analysis based on GIS improving the distribution of educational services. The GIS has the ability to analysis the current locations of educational services to be addressed and improved, and developing proposals for distributing a new school to help the decision-maker to make deliberate scientific decisions.

To model the school site selection, the following information needed (Parast et al. 2016):

- Information on the existing schools and surrounding areas, and their radii.
- Information on urban pathways network and their type of access and positions.
- Information on land use and important uses in school site selection.

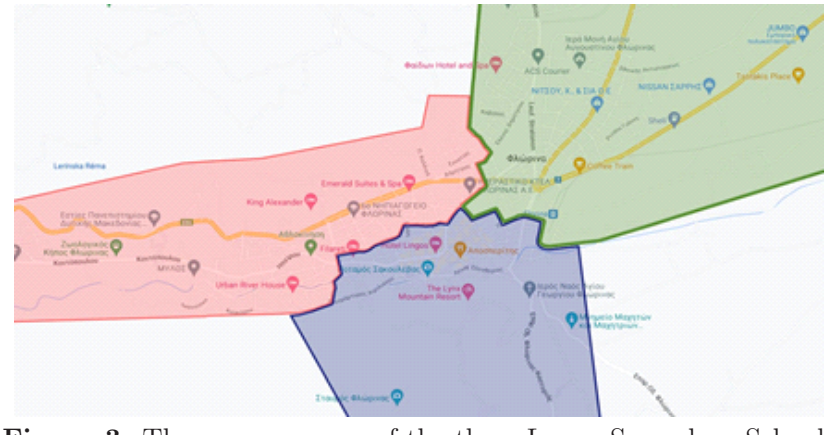

Figure 3. The coverage area of the three Lower-Secondary Schools according to the student allocation decision of the secondary education directorate of Florina

This study is based on equity in the distribution of educational services with a view to achieving the best service to all residents, and takes into

account all the quantitative and spatial criteria in the capacity of a school within their area and the acceptable estimated distance.

In the city of Florina, there are 3 middle schools. According to data from the Secondary Education of Florina, in the year of the 2021 census, the students of the three middle secondary schools were 259, 271, and 189. In fig. 3 the coverage area of the three schools is presented in relation to the addresses of the residences, according to the student allocation decision of the secondary education department of Florina. A coverage that changes according to the urban development of the city.

The coverage area of the 1st middle school is shown in pink, the 2nd middle school in green, and the area of the 3rd middle school in blue. In this particular study, QGIS was used, which is a geographic information system (GIS) software that is free and open-source. On the map of Florina, the residential outline of the city was created and the road network was designed. We created the plots of the middle schools and recorded the number of students per middle school in the attribute table. Then, the area of the city's residential zone was calculated, which is 2.729 km^2. Based on the student population of the three schools, the area was distributed among them proportionally.

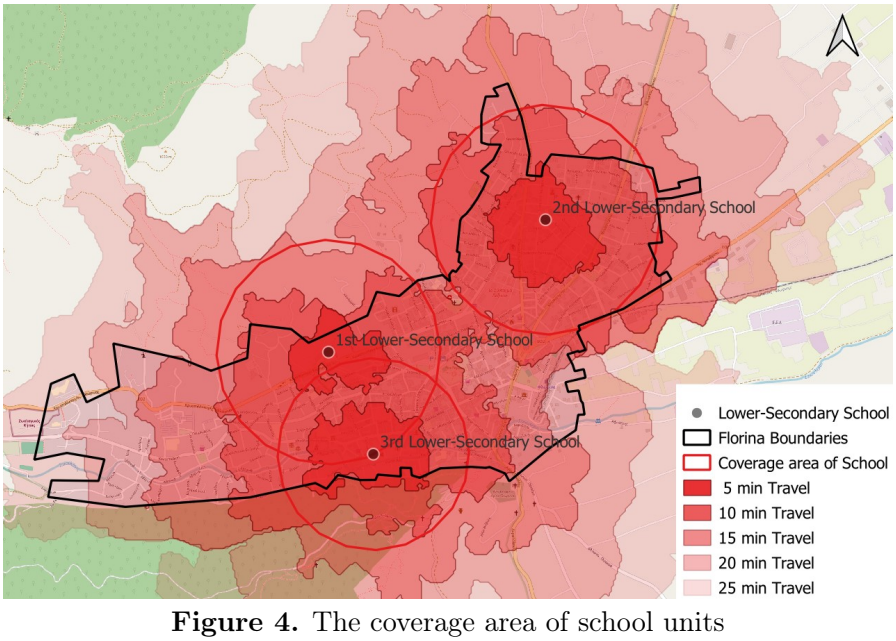

Figure 4. The coverage area of school units

Then, using a buffer, we created circles centered on the location of the schools and with a radius equal to the service area of each school. In fig. 4,

the result of the above process is presented. As we observe, the three circles cover a large part of the city.

We can observe that there is a significant overlap of the circles between the two schools, the 1st and 3rd Gymnasiums of Florina. Specifically, the area of overlap is also the center of the city. Additionally, the 2nd Gymnasium of Florina and the 1st Gymnasium, their circles "touch" nearly at their perimeters. Furthermore, there is also coverage in areas outside the residential zone, where there are no houses but mountains, and this is due to two reasons: firstly, the fact that the 3rd middle school is the oldest school and is located in the historic center of the city, which is at the foothills of Saint Panteleimon Hill and next to the Sakouleva River; and secondly, the fact that the 1st middle school is built in the northern part of the city at the edge of the urban fabric. The only school that has the best possible coverage is the 2nd middle school, which is located at the center of the expansion of the urban complex of Florina towards the northeast.

From this specific map, we can draw additional conclusions, such as that there are two areas that are not covered by middle school units. They are the so-called school deserts. The first is located in the southeast of the city and near the train station, and the second area is in the west of the city at Heroes' Square.

Of these two areas, the first one, which is located near the train station, has significant residential development with multi-story buildings (six floors), while in the second area, the residential development is small, and the buildings do not have more than two or three floors. Therefore, the creation of a new school, the fourth lower secondary school of Florina, is deemed imperative in the educational desert located southeast of the city, specifically in the area of the train station.

Of course, there is a makeshift solution to avoid the construction of new school units, which is the operation of school units in two shifts, morning and afternoon. Opting for a two-shift schedule would mean that half of the student body would attend classes in the morning and the other half in the afternoon. As schools should only be open in the morning, it goes without saying that having two shifts in operation degrades educational services in an indirect way.

For the creation of a new school, the expropriation of undeveloped plots, whether private or public, must take place. Every municipality must take these properties by force, paying the landowners a cash compensation, in order to reclaim the area and use it for the building of schools in the future. As said in (Laitz et al. 2017), schools, especially high-quality ones, contribute strongly to property values and community cohesion.

Due to the high cost of urban land and the frequent financial hardships Greece's municipalities experience, the latter are unable to expropriate all of the land designated for the construction of educational facilities under the Structure Plan since they are unable to make the necessary compensation payments. Due to the aforementioned incapacity, the municipalities are allocating the land that was undeveloped, changing the land use, and prioritizing those located in areas with the greatest shortages for adequate provision of educational services.

One solution to avoid the expropriation of private plots is to investigate the existence of undeveloped plots owned by the state or municipalities, which can be used as sites for the establishment of schools. In this specific area, there is no need for the expropriation of private land as the municipality has two large neighboring plots that can be used for school development, 7318 m^2 and 4,320 m^2 respectively. Both of them meet the article 4.7 (No. 37237/ST1, FEK 635/B/27-4-2007), according to which the minimum area of the required spaces for the construction of school buildings per level of education, with maximum number of students 210, is up to 3,400 m^2 for a 6-place Lower-secondary or Upper-secondary school. In the present study, the first of the two plots will be selected.

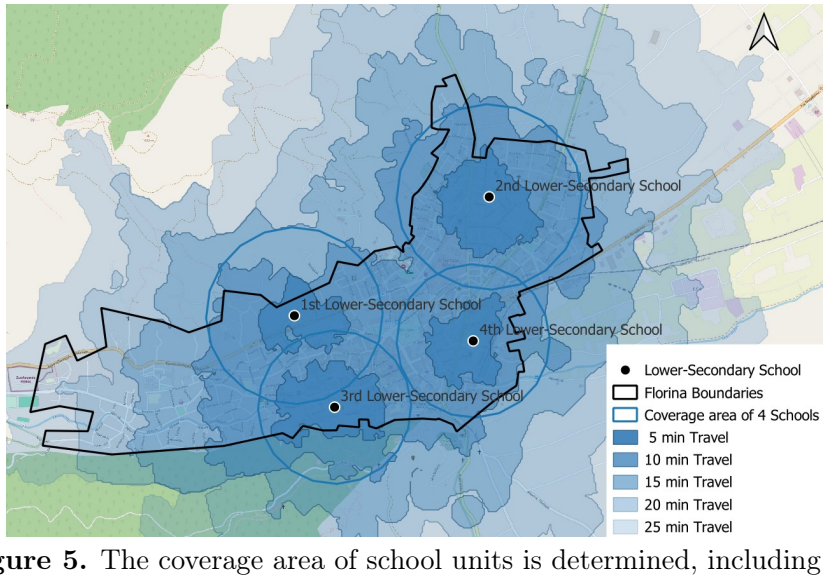

Figure 5. The coverage area of school units is determined, including the 4th Lower-Secondary School using the buffer of QGIS, based on the location of the schools and the area of the circle corresponding to the student capacity of the school

According to Ministerial Decision 10788/2004 (Article 5.B.3), the minimum viable unit of a middle school consists of a student body of 105 children (three classes of 35 students each), which, according to demographic statistics, corresponds to a population of 2,100 residents. The required area per user, generally ranges from 7 to 11 square meters per user, which is satisfied with the specific plot.

At this point, the coverage area of the three schools will change as a new school will be created, and some students will be transferred from the existing schools to it. The number of 719 students must be redistributed among the four schools, with a proposed indicative distribution of 200 students to the 1st middle school, 219 students to the 2nd middle school, 150 students to the 3rd middle school, and 150 students to the new 4th middle school (table 2). Therefore, the area of the residential zone is proportionally divided among the four middle schools in the city based on their capacity, resulting in the following map (fig. 5).

Table 2. The number of students at the census of 2021 and the redistribution of students with the establishment of the 4th lower secondary school of Florina

	Students at 2021 census	Redistribution of Students at 4 Schools
1st Lower-Secondary	259	200
2nd Lower-Secondary	271	219
3rd Lower-Secondary	189	150
4th Lower-Secondary	-	150
Summary	719	719

We observe that the school desert has been eliminated in the area of the train station, and there is a smooth coverage of the city's neighborhoods. Now, students living in the area of the newly established school do not need to travel to other parts of the city, and the problem of the absence of school units in a densely populated part of the city is solved. Additionally, the problem of the lack of classrooms in the existing schools is also solved by splitting classrooms to "create" teaching spaces, which do not meet European standards.

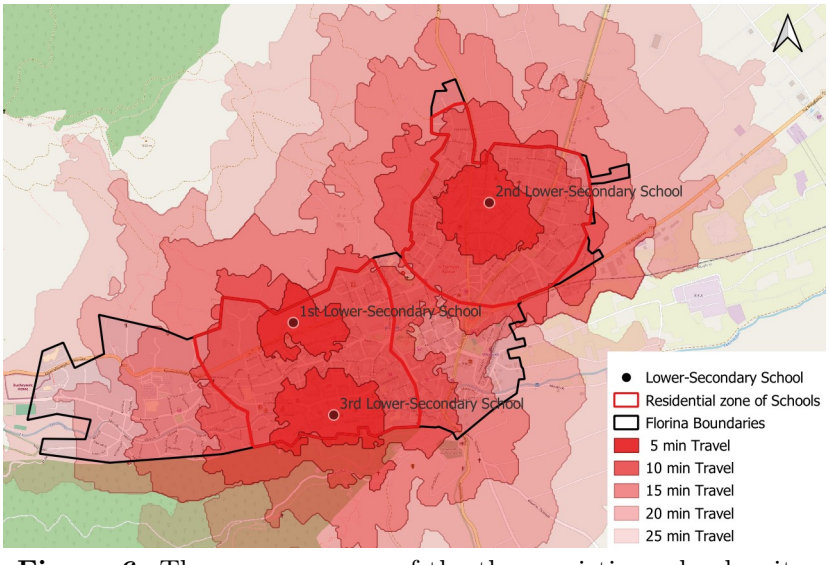

Figure 6. The coverage area of the three existing school units, removing areas outside the residential zone and eliminating the overlapping areas of the schools

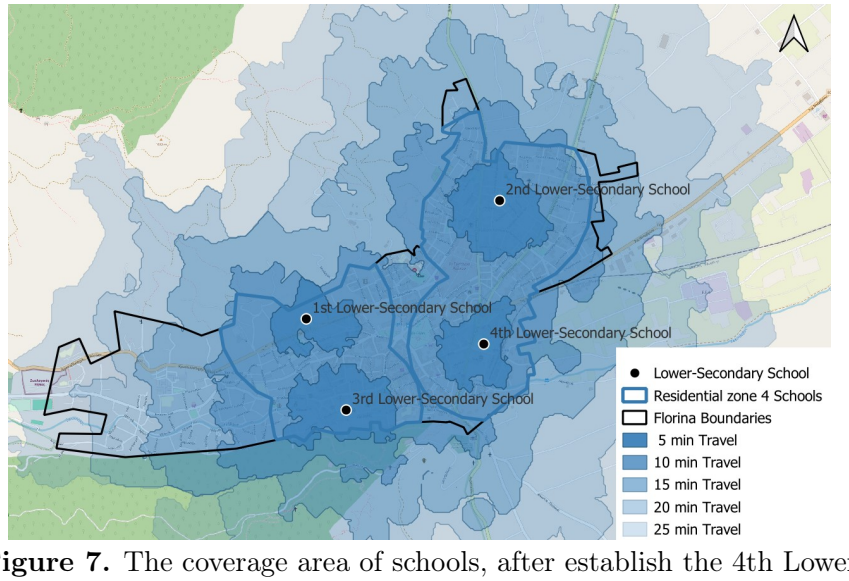

Figure 7. The coverage area of schools, after establish the 4th Lower secondary school, removing areas outside the residential zone and eliminating the overlapping areas of the schools

Comparing fig. 6 and fig. 7, in which we have removed areas outside the residential zone and we have eliminated the overlapping areas of the schools, it is evident that there is better educational coverage, at lower secondary schools, in the city of Florina, and the school desert in the area of the railway station has been completely eliminated. Only a small area remains that is distant from school units, that in Heroes Square, but due to the relatively small population status, the creation of an additional school is not necessary at this moment.

5. Conclusions

A significant gap in related literature is filled by the methodology for determining the best site for the construction of a new educational facility. This literature focuses on determining the proper sizes that various types of educational facilities should have, but it ignores the issue of where those facilities should be built. As was mentioned in the beginning, building new schools in places that are already populated is a difficult task with ramifications for both planning and policy.

The issue of where to build a new educational institution is a common one in urban practice and is often approachable through empirical methods. This technique is a significant step in creating documented planning proposals in the context of the existing operational planning practice on the planning of educational facilities. The precision and simplicity of this technique, which enable the majority of urban planners to use it, are two further noteworthy advantages.

It is important to note that this approach has several shortcomings. The first two shortcomings, are the requirement that GIS tools be used in order to apply the approach and the accessibility of demographic figures. We must, of course, stress that the availability of comprehensive geographical data in digital form and the ever-increasing usage of GIS appear to be the standards rather than the exception. Given the foregoing, it is evident that practically every city and planner may implement the aforementioned methods. A third flaw in the approach is that it makes some empirical assumptions about the shape of the areas that are not sufficiently served by education services. As a result, even though their impact was minimal in the application that was given, it is still possible that they won't be important in another. Finally, the service areas of schools overlay each other, as demonstrated by the method's implementation. It would result in the identification of the bigger service area overall if this overlay could be removed. Nevertheless, the ultimate choice about the placement of additional educational facilities is unaffected by this overlay.

NOTES

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2. Population and Housing Census Results 2021. Table A01. *Population Census 2021 – Resident population by gender and age groups, s.l.: s.n.*. https://www.statistics.gr/en/2021-census-res-pop-results

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