A GEOGRAPHIC VISUALIZATION OF THE GROWTH OF SUBURBANIZATION IN THESSALONIKI VIA MULTIVARIATE THEMATIC CARTOGRAPHY

Nikolaos Karanikolas, Pery Lafazani, Myron Myridis, Dimitrios Ramnalis

PhD Candidate, Department of Cartography, A.U.Th, karanik@topo.auth.gr
Lecturer Department of Cartography, A.U.Th, lafazani@topo.auth.gr
Professor Aristotle University of Thessaloniki, myridis@topo.auth.gr
PhD Candidate, Department of Cartography, A.U.Th, ramnalis@topo.auth.gr

ABSTRACT

The study of geographic space is complicated but also dynamic process which is associated with the data or elements that describe the geographic space of report, the statistical methods of data process and the information analysis that result from the data and, finally, the static and dynamic presentation of information with diagrams, tables, and mainly maps. The systematic recording of characteristics of region of study and also their treatment and analysis in time, was regarded essential. Moreover, the connection with the cartographic base of the region, make the cartographic management of data and information feasible. Due to the development of technology of new systems and Thematic Cartography, it is possible to achieve the multi-visualization of data and results of those statistical problems and processes. It is however more representative and perhaps easier for the study and analysis of phenomena that are examined, to include, all the data that determine these phenomena in one map. This paper combines data and methods of two researches which are elaborated in the Department of Cartography, at the Aristotle University of Thessaloniki-Greece.

1. INTRODUCTION

When studying geographic space, it is concluded that the same phenomenon for different geographic spaces (whether the diversity is related to size or refers to the “origin” of geographic space) is associated with “different” data whose size and content depend on the spatial reference unit. The study of any phenomenon (natural, economic, social, environmental or other) is always associated with the fourth dimension, the time or historic time, since each phenomenon has a past that determines the present space and works out its future.

The relation between geographic space and its data is dynamic and bidirectional. Their elaboration produces the information; that is the answers to questions related to “reading” and analyzing particular space in particular time (Lafazani, 2002).

Many times, the interaction of geographic information renders these studies more complex. The visualization – presentation of geographic information, their graphic and / or cartographic representation, are of distinguished importance and contribute to more complete comprehension of the geographic space and its functions. Moreover, it is an important aid in order to comprehend them or even an attempt, to which the norms and rules of Cartography and Statistics should be combined and maintained. Similar components can result from the comparison of different maps. However, it may be easier and more vivid to include more geographic data in a map, which is of different categories and also determine that data, in order to study and analyze the phenomena examined. Nevertheless, particular attention is essential to this Multi-parametric Mapping, because the cartographic lucidity – readability is reduced due to the increase in the number of variables and therefore the visual variables that will finally be selected for the symbolization of data should ensure that the reader have a clear reading of the maps and will also have the opportunity to come to conclusions that concern their correlation. These particular characteristics are evident in the attempts of the mapping of multiple parameters in the urban area and particularly in the study of its suburban part.
2. SUBURBANIZATION

The definition and characteristics of the suburban zone is a complex problem of geographic theory. The character of such zones is formed depending on a wider economic, social and cultural development of the city. More generally, we could say that the suburban zone is defined as the reserve of the urban centre land, where a usual time distance from the Central Business District (C.B.D.) is at least 30 minutes (Karanikolas, 2000). The bonds and dependence of the urban zone with the centre are usually such, that the development and character of the city determine the physiognomy and guide the growth of the urban zone.

Suburbanization should be faced as a phenomenon at the development of a city in a following growth stage. It is a socio-economic process arisen from the contemporary problems of urban structures and social reactions of bourgeois towards them. The term “suburban” refers to space with urban characteristics but outside the city limits and at such a distance where the existence of economic and social bonds with the city is possible.

3. MULTI-REPRESENTATION

The map or the diagram also function as a means of visual presentation of more phenomena, that is more than one data total, aiming at showing the relations between them. The information that results from such presentations concerns either the comparison of the total form of the portrayed data or the interrelation of their values in various spatial points, where these phenomena coexist. Similar data can result from the comparison of different maps or diagrams, where the phenomena examined are separately represented in each piece of data. However, it may be easier and more vivid for the study and analysis of the phenomena examined to include more geographic data that determine them in a map. The “traditional” ways of dealing with mapping of two or more variables of one or more geographic phenomena, are separated into two general ones. The first concerns the cartographic correlation, which is based on the combined graphic presentation of data referring to the phenomena; therefore the conclusions of their correlation result from the interpretation of one or more maps. The second and more usual way that approaches the “Multi-parametric” mapping, (that is the simultaneous mapping of many variables, of one or more phenomena), is the one of overlaying the variables (in the same map), using different symbols or techniques.

The first and relatively more popular older method (Dickinson, 1973), introduces the production of a series of maps where on each map only one variable of the area of study is represented. Any comparison or interaction of phenomena – variables studied, is concluded through the comparison of the related maps. The method is applied where the variables...
studied are measured in different units, for example in a geographic study, the rates of mortality, the population density, the per capita income etc are shown. As it can be seen, it is exceptionally doubtful in practice if the visual comparison of the maps is able to produce the export of conclusions on the dependence, identification, correlation, interaction (or non-interaction) of the variables. After extensive trials concerning the comparison of isopleths’ maps McCarthy & Salisbury’s study (1961) led to the conclusion that the visual comparison of such maps is able to provide reliable results, only in the case where the degree of the mapped phenomena correlation is high enough. However, this is usually tough work, especially when the compared maps are not in the same scale, projection or generalization degree. The cost of the cartographic production is higher and the comparison of the variables is more difficult, when the number of the compared maps increases.

Referring to the second method, the mapping - overlaying of the variables (on the same map) is achieved by using different symbols or techniques, such as the use of semi-transparent symbols, especially when the phenomena to be mapped increase. Dots, area and proportional symbols or the area symbols and isopleth lines are, perhaps, some of the most effective ways (Robinson et al. 1995). The choice of the appropriate mapping of the phenomena takes place in two phases (Nakos, Philippakopoulou, 1991); in the first phase, the data of each phenomenon are dealt with as if they were the only objects of graphic output. In the second phase, the two ways of graphic presentation (of the two phenomena) are examined concerning the visual contrast they create with their coexistence on the same map, as well as whether the result of their combined graphic presentation is readable and within the limits of the rules of visual perception.

When people read color graphs and other data graphics, they are working with perceptual dimensions of color, even though we may have specified our colors using a mixture system like RGB. Map readers are seeing and thinking about color as ‘light desaturated blues,’ ‘dark saturated oranges,’ ‘dark grays,’ etc. Thus, we can make the most of your graphics by using these perceptual dimensions in ways that parallel the logical structures of data (Brewer, 1999).

The effort of the simultaneous cartographic representation of three or more area phenomena – variables or of one phenomenon of three variables -such as the cartographic representation of the percentage of the economically active or ‘working’ population in the three economic sectors- is quite complex. In this case, the phenomenon is separated into three equal categories; each of them corresponds to one of the three colours (Cyan, Magenta & Yellow). The participation of each phenomenon in the phenomenon is represented by proportionally mixing the three colours that were mentioned before, so that a new colour can be formed; as for the quantity of basic colours used, it will be proportionate to the values of the corresponding variables. (Figure 2).

![Figure 2: Three color mixture and percentage mixture ratio in CMY color model](image)

However, when there is a considerable difference in the extrema values of the variables, or even if the variables do not have the additional dimension reported before or have different measurements, then such a method may not be advisable. When the values of the three variables do not have the additional dimension and/or have different measurement, then it is possible to follow a similar method. The variable values ‘triads’ can be graphically represented in a graph of three axes (3D). Every variable corresponds to each axis X, Y, Z. Moreover, when corresponding a colour to each variable (Cyan – Magenta – Yellow or Red – Green – Blue), then the three-dimensional graphic is turned into the known colour cube (Ramnalis, 2002). In each of its eight base vertexes the following colours are corresponded: Red, Green, Blue, Cyan, Magenta, Yellow, Black & White. The acmes of the cube are separated into equal intervals, for example 6 and as a result, there are 216 chromatic tints (6^3=216). Each value triad corresponds to one of the 216 smaller cubes – one of the 216 colors (Figure 3).
Most of the time, it is possible for the appearance of a high value of a phenomenon in a rather limited area to ‘be lost’ in the choropleth representation. For the simultaneous mapping of quantitative data and for the reduction of the symbols on a map, another way of representing a total is the ‘area enlargement’ of the spatial reference unit, according to the values of the phenomenon to be represented, which are called Cartograms, which are combined with choropleth representation.

These possibilities are under review concerning their application for the study of the Surbanization of the Urban District of Thessaloniki.

4. AREA OF STUDY

The study focused on a specific area of the Prefecture of Thessaloniki. Thessaloniki is situated in the central district of the Region of Macedonia. After the census in 2001, the population of the city was 800,764 persons (75.7% of the whole Prefecture); the Urban District of Thessaloniki is the second urban centre in Greece - in size and population - after the Urban District of the Capital of Greece. It is also the main point of the development of the whole of Northern Greece, with international prestige. It is one end of the main developmental and residential axis of the country (Athens – Thessaloniki), it is also an important railway and road junction for Northern Greece with the rest of the Region and the Balkan countries. Moreover, the historical harbor and the International Airport of Thessaloniki serve large areas of the region and the inland Balkan regions (Figure 4).

4.1 The Urbanization Process in Thessaloniki

Generally, the built-up growth of the wider urban and suburban areas and the metropolitan centers mostly follow a model known as ‘urban term’. This model is formed through the following four stages, not necessarily in this order (Loukakis, 1999): a) Urbanization, b) Suburbanization, c) Reurbanization, d) Centrification. The Urbanization stage started mainly after the end of the 2nd World War and continued until 1980. During this period, the population of the Urban District of Thessaloniki increased considerably (from 302,635 people in 1951 to 702,107 people in 1981). Together with the significant accumulation of population, there were other negative features with this stage, such as poor living conditions, transportation and traffic problems, excessive increase in habitation density, thick building, increase in land value, and even serious environmental problems.

In conclusion, the Urban District of Thessaloniki, directly and multidimensionally influences a greater geographic area that spreads much further than its administrative borders, because of its dynamism and rapid development. The part of this area that is mostly under the influence of the Urban District of Thessaloniki is the “suburban zone” of Thessaloniki (Figure 5).
Figure 4: Prefecture of Thessaloniki and the Area of study
4.2 Data Collection

The necessary data for the study of the phenomenon is a total of quantitative and/or qualitative characteristics that refer to the geographic space or result from it. Typically, because the geographic data is complicated or indistinct, the intrinsic nature of the geographic data should become comprehensible, in order to prepare maps offering all the essential information; this preparation is accomplished through various operations. Firstly, the correlation of the position in the data, that is their geographic classification, is necessary. The geographic classification is an inherent quality of all the territorial data and is also assumed as a fact, even if the position assessment is not always manageable.

The population and its development, its characteristics and the correlations in it, constitute the basic variable of a suburban settlement progress in combination with the rest of the demographic characteristics. The types of data required for the analysis of phenomena such as the ones studied at the moment, vary. Usually, a human-geographic multivariable approach is required, since there is a possibility for the high increases in population not to mean suburbanization but geometric growth of the city. Characteristics such as primary and derivative demographic, social, economical and others were collected for the present study. More specifically, some of the data used, was the population in different times – censuses for each spatial reference unit, the population densities, the categorization of employment into different economic sectors and the distribution of labour in the sectors above. Moreover, data concerning the educational level of the people living in the area of study – which is a particularly important social phenomenon - were used; this element contributes to the understanding of all the characteristics of the area. In addition, data concerning today’s urban regime and construction activity according to records and information received after ‘interviews’ mainly with people working in the public services of the city, was also collected. Last but not least, more data was used in order to create the indicators referred to above; that data is related to supplies to residents, such as substructures for water supply,
transportation network, educational and welfare services, hospitalization, cultural and sports supplies, public order, services and organizations and finally other services such as banks.

Data processing and the correlation of all the elements used, is considered to be essential especially for analyses of that type. Many times, the interaction of variables makes these studies more complex. The information that results from such depictions either refers to the comparison of the portrayed data total form or to the correlation of their values in various points of space, where these phenomena exist.

4.3 Multivariate Cartography for Thessaloniki

In order to observe the development of Suburbanization in Thessaloniki, the designing of an automated tool in which the descriptive and territorial information referred above coexists and intercorrelates, has been considered necessary. The organization of this automated tool, its enrichment with various territorial levels and also the visualization of data and its treatments, offer a possible follow-up which is multi-dimensional, continuous and diachronic.

At a total theoretical level for the evolution of the demographic values, a constantly increasing tendency in the population of the Suburban Zone of Thessaloniki (S.Z.T.) is concluded. When examining data for the Suburban Zone of Thessaloniki, parallel to the progress of demographic evolution in the Urban District in the entirety of the Prefecture and the country, during the same period (Table 1) we see the unequal demographic evolution in the S.Z.T., in relation to other totals. More particularly, during the first decade the populations in the S.Z.T. and in the Prefecture of Thessaloniki simultaneously indicate a particularly high increase (26.7% and 22.7% respectively (phenomena of attraction and repatriation of the metropolitan centre); although the increase of the S.Z.T. (19.2%) is higher than the average in the country (11.1%), it is still comparable to the average. On the contrary, during the second decade (1981 – 1991) the image radically changes, whereas the U.D.T. rate of change suddenly loses its power (6.1% and 8.6% respectively). The corresponding rate of the S.Z.T. duplicated (from 19.2% to 38%). Finally, in the last decade (1991 – 2001) there is a population explosion of the suburban zone, with a total increase of 84.4%, while the S.D.T. is still under low increase (6.9%), although the total of the prefecture increases by 11.7%. The particularly intense differences in the alteration rates could easily lead to the conclusion that there was a high transfer of population towards the S.Z.T., by the U.D.T. inhabitants and also by inhabitants of the Prefecture (and even beyond it), who finally chose the suburban settlements as places to live, due to the appeal of the metropolitan centre.

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<td>22.7%</td>
<td>871.580</td>
<td>8.6%</td>
<td>946.864</td>
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<td>5.3%</td>
<td>10.259.900</td>
<td>6.9%</td>
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Table1: Demographic Evolution of Thessaloniki

For the representation of the population increase in the S.Z.T. and its correlation with economical and social characteristics, the cartogram of the population on each stage was chosen as a base map. Cartograms are maps with an area or distance distorted to represent something different than an area or a distance (Dougenik et al, 1985) The Avenue code used in this application (Changming D. & Lin L., 1999), listed in the appendix of Jackel’s paper (1997) represents a practical application of algorithms presented by Olson and Dougenik et al. in the Professional Geographer. Therefore contiguous cartograms were created and combined with the choropleth representation of the other phenomena. With this method we have the substitution of pie symbols representing cardinal numbers (that refer to areas accelerated. In this way the value of the phenomenon was sized up more effectively, though ‘sacrificing’ cartographic information. For this reason special attention is essential to the analysis of social phenomena, when it is based exclusively on cartographic interpretation.

On the following multi-variable maps the population increase in the Urban District of Thessaloniki is clearly shown by means of the cartogram, while the transfer of labour from Primary to Tertiary Economic Sector is easily recognized especially in its South part. More generally, a gradual decrease in activity of the primary sector was observed through the decades, while the secondary and tertiary sectors were active, especially in areas where there was a concentration of population; this is evident through cartographic correlation. Nowadays, the decrease of the primary sector reaches shrinkage or even eclipse levels, whereas the tertiary tends to be the main employment sector of the urban population (Figure 6).
Figure 6: Demographic and Economic Sectors Evolution
Figure 7: Map Correlation of Educational Level and Economic Sectors
Concerning educational level, what is necessary to note is that during the whole historical paths of the “urban” areas, one of the characteristics of populations in those areas, in contrast with the rest of the country, was a rather higher educational level of their inhabitants. The progress and change of an area from rural to urban is expected to be followed by a respective progress of its inhabitants’ education indicators. There have been such changes in the suburban zone of Thessaloniki, especially in the last decade 1991 – 2001. Via maps we can observe the quadruplication of the secondary and tertiary education graduates, in combination with a sub-duplicate of illiteracy; this data indicates a considerably positive progress, although the percentage of the primary education graduates remains high. The discovery above is confirmed by the positive correlation of high level education and high employment percentage in the tertiary economic sector. Besides, positive correlations appear in high employment proportions in the primary economic sector of an area in the S.Z.T., while phenomena of low educational level among the inhabitants of the same area also existed (Figure 7).

Via cartographic interpretation and with no use of complex statistic methods, it is obvious that the increase of suburban people’s educational level coexists with the tertiarism of their employment; this happens in the three decades examined.

5. CONCLUSIONS

The mapping of many variables on the same map naturally increases the information degree on the map. Many times we are led to the mapping of many variables on the same map in order to compare - correlate their variables more effectively, while the problem of decreasing the cost of their production is also dealt with. As mentioned before, the comparison of variables is more effective when they are represented on the same map than on different ones, especially when the maps compared are not of the same scale, projection or generalization. The cost of the cartographic production is higher and the comparison of the variables more difficult when the number of the maps to be compared increases. The result has positive and negative sides. The complex representation of so many pieces of data is among the positive sides, giving a direct visual access to the territorial structure of the phenomenon we are interested in and also offering better understanding of the intercorrelations of the variables mapped. However, the readability of such maps is under criticism sometimes. The number and variety of symbols on the same map should be studied, so as to achieve a readable map and not to deal with problems such as not finding some information it includes due to its multi – complexity and lack of understanding the statistic and/or cartographic method that led to the relevant result.

The combination of all the methods presented in the present paper and also the graphic variables that will finally be chosen for the symbolism of this data should ensure the reader that they will have a clear reading of this map and also the opportunity of being led to conclusions related to their intercorrelation. The more the number of variables mapped is, the less the cartographic clearness – readability is. Therefore the elaboration of multicomplex creates confusion rather than ease, something that should be considered carefully so as not to end up in a possible communicative failure which could be a result of the simultaneous representation of many variables on the same map; this could lead to the use of such maps only by highly specialized users. Therefore, most maps of this kind do not address to common map readers, but they are a tool for special analysts such as geographers, urbanists, city planners, surveyors, cartographers etc. Moreover, special attention should be given to the creation of a very analytical legend on such maps, while their reading should be facilitated by the table or diagram presentation of the visual variables content. This might increase the map readability level and therefore the communication between the map and the reader.

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CV of the Presenter

Ramnalis Dimitrios

- Rural & Surveyor Engineer, School of Engineering, Aristotle University of Thessaloniki (2000).
- PhD Candidate Department of Cartography, A.U.Th. (2003).
- Member of Hellenic Cartographic Society (2002).