

Kalivas, Dionissios; Giotis, Anastasios

Conference Paper

Development of a Gis Tool for Studying Territorial Impacts of Road Corridors

46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean", August 30th - September 3rd, 2006, Volos, Greece

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Kalivas, Dionissios; Giotis, Anastasios (2006) : Development of a Gis Tool for Studying Territorial Impacts of Road Corridors, 46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean", August 30th - September 3rd, 2006, Volos, Greece, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/118500>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

DEVELOPMENT OF A GIS TOOL FOR STUDYING TERRITORIAL IMPACTS OF ROAD CORRIDORS

Dionissios Kalivas¹ and Anastasios Giotis²

¹Assistant Professor, Agricultural University of Athens, 118 55 Athens, Greece,
e-mail: kalivas@aua.gr

²MSc GIS, Survey Engineer, Research Institute of Urban Environment and Human Resources of Panteion University, 176 71 Athens, Greece, e-mail: tgiotis@panteion.gr

Abstract

In this paper a Geographical Information System programme has been built to analyse and present the territorial impacts of P.A.TH.E. (Patra – Athens –Thessalonica - Eyzonoi) international road in the area around it, in Greece, using social, economic and transport indicators.

Using the Visual Basic programming and MapObjects components, a user-friendly GIS programme is developed which everyone, with no knowledge to geodatabases, has the ability to use it. It has the capability to retrieve, interpret and render the statistical and cartographical features on the map, applying functions and provide suitable tools such as add layer (shapefile, grid, cad, image, coverage, etc.), zoom in, zoom out, pan, full extent, buffer, overlay, intersection, dot density patterns for polygons, calculation of statistics, identify, printing, copy and features classification. These tools are needed in order to generate specialized solutions for desktop mapping and spatial analysis. Moreover the application is enhanced with simple and useful interfaces to everyone who wants to correlate geographical and statistical information. The developed GIS has been used to study the territorial impacts in six hundred and four municipalities (ninety-three of them are crossed by the road) which are contained in twenty - three counties around the P.A.TH.E. road. The administrative division NUTS V (municipality) has been selected as geographical level for the analysis.

All the municipalities have been separated in three categories:

- the first contains the municipalities which the road crosses,
- the second includes the municipalities which are included in the same county with the municipalities in the first category but the road does not pass through them and
- in the third belongs municipalities that are in neighbour counties of the second.

Nine indicators (total and by sex population changes, population density, employment and unemployment rates, net migration, mobility, road density and land use) in four different time periods (1971, 1981, 1991 and 2001) have been used to study the spatial impacts of P.A.TH.E.

1. Introduction

In the last two decades (1980s and 1990s), many people agree that GIS technology is not something new. Longley et al. (1999) propose that when computer systems started to develop in the late 1950s the first computer systems, which use maps, appeared in the market. GIS technology is a join of development combining CAD, remote sensing, digital cartography and database systems. All of these comprise separate technologies of GIS systems. Early GIS and automatic cartography systems used data files with geographic information, directly without need to use database management systems. Nowadays the GIS science is based in the programming development.

There are several important reasons that a programmer may choose to develop an application with MapObjects (developed by Environmental Systems Research Institute, 1999) rather than other GIS programs. MapObjects render many benefits to developers such as great flexibility which allows developers to built customized application. The smaller memory footprint or RAM requirements, allows streamlined procedures which create quick and efficient applications. Moreover with MapObjects developers can add mapping components to enhance existing applications, build lightweight data viewing applications, create customized mapping and develop simple query-based applications that easily enable access to data generated by sophisticated GIS solutions (Dongquan et al., 2003).

A large number of programs and applications are available (e.g GIS by ESRI, 1999, Dongquan, Haifeng et al., 2003, Shih – Lung & Xiaohong, 2003, Arampatzis et al., 2003, Thong & Wong, 1998, Ziliaskopoulos & Travis, 2000, Gainey & Johnson, 2000, Carapacchio & Tenaglia, 1998) concerning the programming science and especially with MapObjects (creation of queries and presentation of statistical and geographical data).

Arampatzis et al. (2003) approach attempts to present a decision support system in connection with a geographical information system for the analysis and evaluation of urban transport policies. This program evaluates traffic road and estimates the impacts of traffic policies. GIS system can better enhance the real presentation of the network transport, giving more emphasis in the user – interface.

Moreover SITAP is a clear and complex geographical database, on Italian areas from the Ministry of Cultural and Environmental Sources, which joins the geographical data with the catalogue elements, stored as tables, image and texts (Carapacchio & Tenaglia, 1998). This program manages different types of information (spatial and descriptive data) related with the environmental resources, stores maps at different scales, can be easily updated, includes the basic spatial tools (buffer, identify, zooming) and is available over the internet.

Additionally Thong et al. (1997) developed a new geographical information system for urban transport planning in the area around South – East Kowloon. This GIS database includes tools for comparison scenario between the existing and the future network changes in the key study area, a database which captures different types of data, urban transport networks simulations in both two and three dimensional forms. The research had four basic objectives, to build a GIS database system with transport data, to estimate the future impacts of the road networks, to manage the data of the study area and to create an implementation on the web server.

On the other hand, there are examples (Katsios and Tsatsaris, 2005) which are referred to spatial indicators in relation to corridors.

The spatial development research unit of the Aristotle University of Thessaloniki, has produced a research project for the spatial impact in the Egnatia international road in Greece which has relationship with the spatial development and cohesion. Three

groups of indicators have been calculated. In the first group are calculated social-economic indicators like useful population, unemployment rates, population changes, population density, chain of urban centers, GDP per capital, level of development and welfare, etc. The second group presents environmental indicators such as land use pressures, destroyed forest areas, people who display in the noise, atmospheric population, etc. The indicators in the third group have relationship with the transport network (Kafkalas, 2005).

Furthermore during the developmental process of the ESDP (European Spatial Development Prospective), it became clear that the scientific basis for policy making needed to be improved. In particular, it was necessary to select indicators for spatial development and suggest possible strategic directions, which should be followed up and elaborated in policy terms. The program was also a test exercise, intending to provide insights on how a possible future European Spatial Planning Observatory Network (ESPON) could be organized and what could be expected of it. As a result, it has build a large number of maps which illustrate basic indicator types of rural-urban regional settings, mean elevation about sea level, Euclidean distance to the centre of gravity of population in Europe, population changes per ten years, productivity in EU, territorial integration, agriculture intensification and transport network changes (ESPON, 2002).

The basic aims of this paper are:

- The creation of a GIS programme, with MapObjects components using Visual Basic programming language.
- The development of simple and useful interface in the GIS program which is familiar to everyone who wants to use and calculate the statistical data.
- The accomplishment of relationships between maps and statistical information for giving GIS solutions.
- The presentation of the territorial impacts in P.A.T.H.E. road with maps and the analysis of the spatial indicator results.
- The social – economic dimension in the study area concerning the sustainable development.

2. The development of the GIS Program using MapObjects

MapObjects use a set of ActiveX objects which can be used to implement mapping functionality in any application. These contain an ActiveX control which is called Map control and a set of Active X automation objects. ActiveX covers a wide range of distributed computing technologies and is generally grouped into three categories ActiveX controls, ActiveX documents and ActiveX components. An ActiveX control is a software component which allows adding specific functions within an application that is an ActiveX container. An ActiveX object is a programming object which is accessed through an ActiveX server (Dongquan et al., 2003). MapObjects has five types of objects: map display objects, projection objects, geometric objects, data access objects and geometric objects.

Geometric objects have different type of entities like polygons, points, rectangles and lines. These kinds of objects create a large number of functions in maps. Data access objects open and add layers and work with database tables. Also the objects are needed to control the presentation of map layers. At the same time maps can be projected and map layers with differing projections can be connected with projection objects. Address-matching objects are used for geocoding. If there is layer information on a map, the programmer works with Map Control, Layers Collection, Maplayers (vector data), Imagelayer (raster data) and a tracking – layer objects such as dynamic event data. It is important to mention that each of them has methods and properties of its own (Ralston, 2002).

Example of ActiveX containers and ActiveX servers is Visual Basic program. For the database program is important to mention that the application can have access to the functionality by using a set of interfaces within ActiveX procedures. An ActiveX container application can use one or more ActiveX control with Visual Basic.

The programmer creates the graphical user interface (GUI) and writes code to describe what happens when the user interacts with the GUI. These notifications, called events, are passed into the program by Windows (Microsoft) operating system (Halvorson, 1999).

Regarding the MapObjects, it is necessary to explain some generally powerful functions and procedures which are the main part of programming languages and especially in Visual Basic. Their names are Windows Application Program Interface (API). Visual Basic is an analytical programming language with a large number of powerful applications. On the other hand, it must be referred that Visual Basic cannot contain every commands and functions which programmers need. Its properties are closely linked to Windows styles and properties although it cannot create dynamic libraries itself.

Using the Visual Basic programming and MapObjects components, an intelligent GIS programme is developed. It has the capability to retrieve, interpret and render the statistical and cartographical features on the map, applying functions and provide suitable tools such as add layer (shapefile, grid, cad, image, coverage, etc.), zoom in, zoom out, pan, full extent, buffer, overlay, intersection, dot density patterns for polygons, calculation of statistics, identify, printing, copy and features classification. Moreover the application is enhanced with simple and useful interfaces which correlate geographical and statistical information.

The developed GIS programme contains eleven forms (startform, mapform, idform, addfield, intersect, bufferf, indicators, statistics, sumvariable, report and fmrlayerprop), three modules (ApiModule, modUtility, modStringHandler) and four class modules (clsDrawsymbol, clsMapTip, clsRecSet, rclass). All these forms are accomplished within one of the latest advances in computer software: components.

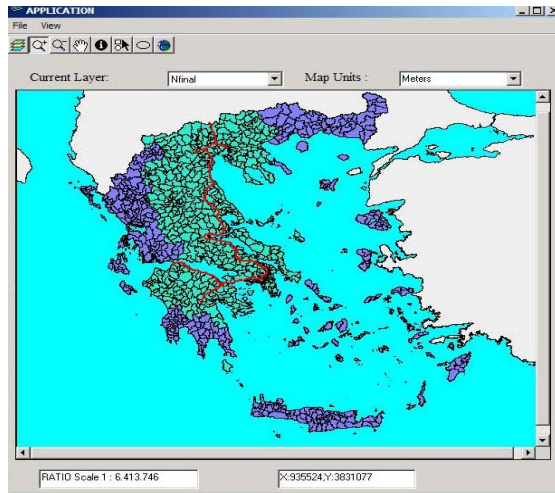
Components are parts of existing programming capable of being incorporated into programs. For this reason, through the Visual Basic toolbar (project-components), it is used the following controls: ESRI Mapobjects 2.2, ESRI Mapobjects Legend Control, Microsoft Common Dialog 6.0, Microsoft FlexGrid Control 6.0 (SPE), Microsoft Windows Common Controls 6.0 (SP4), Microsoft Windows Common Controls-2.5.0 (SP2), Microsoft Tabbed Common Controls 6.0 (SP5), which are important for the programming development.

In Table 1 is presented an analytical description of the developed forms.

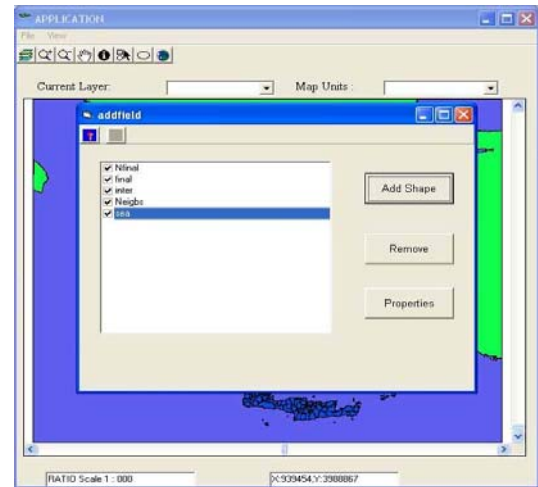
FORMS	DESCRIPTION
Start form	An introduction form which gives information on the programme, the application and who has created it.
Map form	The basic form of the programme which contains the map, suitable tools such as add layer, zoom in and out, pan, full extent, buffer, intersection, spatial selection, save set, calculation of statistics and indicators, identify, printing, copy, export map, map units and scale.
Addfield form	With this form the user has the ability to add different kinds of data like shape files (*.shp), coverages (*.adf,*.tat,*.pat,*.rat), images (*.bmp; *.tif), grid (hdr.adf) and cad drawings (*.dwg,*.dxf) in the map. The layers are presented in the list box.
FrmLayerProps form	This is the property form in which the user has the capacity to classify the features for the current theme. There are three methods (unique value, single symbol and classes) that can be used concerning the kind of theme (polygon, line, point).
Id form	This form includes the name and the value of each current selected feature.
Statistics form	The values which are calculated in this form are: the minimum value of the selected field, the maximum value of the field, the mean value of the field, the standard deviation value of the field, the sum of the values and the coefficient of variation value.
Indicators form	Through this form the user calculates nine spatial indicators like net migration, total, male and female population changes per ten years (2001 – 1991, 1991 – 1981, 1981 – 1971), population density, unemployment rate, employment rate, net mobility for each census year (2001, 1991, 1981, 1971) and road density (2001).
Intersect form	Within the intersect form, users have the ability to collect features in a layer based on their relationship to features in another layer. The programme needs to check the collection for two layers: the active layer and the intersect layer.
Buffer form	This form works only if there are two or more layers in the basic map and there is an active layer. The system allows user to select the overlay layer and a summation variable where users have the ability to estimate this value through the area weighting method. The form contains the feature of the overlay layer, the intersect layer and the buffer distance (km)
Sumvariable form	This form includes all numeric variables in the overlay layer's which used in the buffer form.
Report form	This form contains a text box which describes the name of the summation variable and the estimation values of the buffer field.

Table 1. Analytical description of the developed forms.

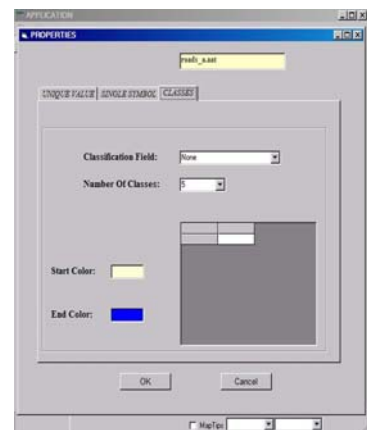
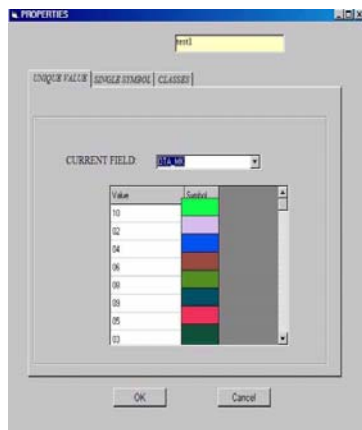
Map form is presented in figure 1(a). Figure 1(b) displays the Addfield form, figure 1(c) appears the FrmLayerProps form, figure 1(d) presents the Statistics form and figure 1(e) shows the Indicators form.



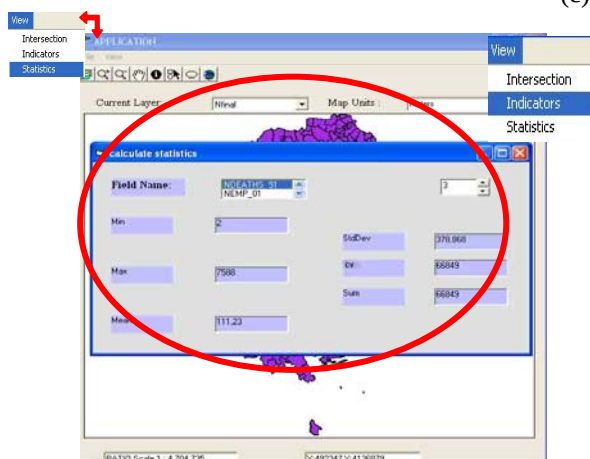
(a)



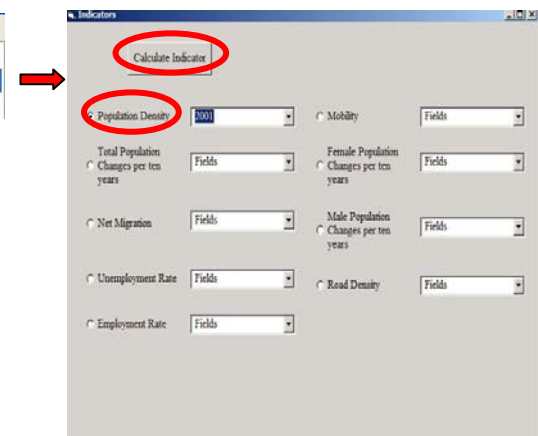
(b)



(c)



(d)



(e)

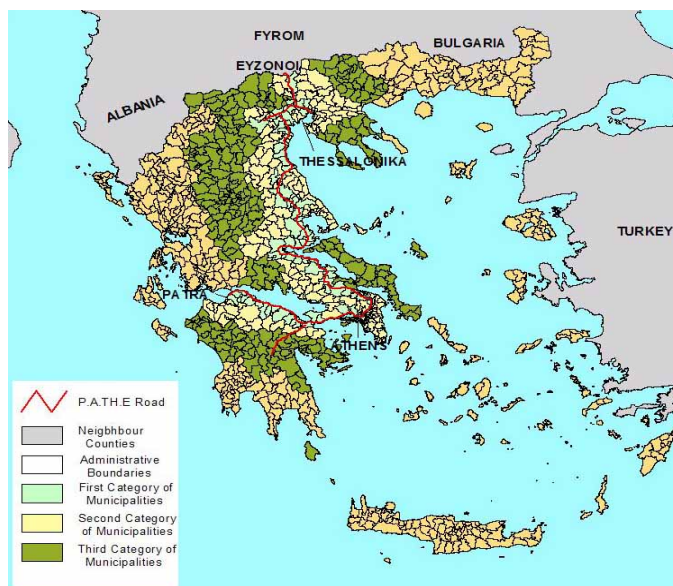
Figure 1. (a): Map form, (b):Addfield form with the list box, (c): FrmLayerProps form, (d): Statistics form, (e): Indicators form.

3. The P.A.TH.E. Corridor and its spatial impacts

The developed GIS has been used to study the territorial impacts in six hundred and four municipalities (ninety-three of them are crossed by the road) which are contained in twenty - three counties around the P.A.TH.E. (Patra, Athens, Thessalonica and Eyzonoi) road. The administrative division NUTS V (municipality) has been selected as geographical level for the analysis.

All the municipalities have been separated in three categories:

- the first contains the municipalities which the road crosses ($g=1$),
- the second ($g=2$) includes the municipalities which are included in the same county with the municipalities in the first category but the road does not pass through them,
- the third ($g=3$) belongs municipalities that are in neighbour counties of the second category.



Map 1. The division of 604 municipalities of the study area in three categories.

The used data can be separated in two categories: statistical and cartographical. It is important to mention that the most of them were not in digital format. There were some parts of the P.A.TH.E. road before the 1980. These pertained in the roads which join Patra with Athens, Athens with Thessalonica and Eyzonoi. The corridor had started to construct at the end of the 1986. As a result we consider the territorial impact for the following census years: 1971, 1981, 1991 and 2001 (study decades). The application uses the following data:

- Censuses of total and by sex population for the study decades.
- The censuses of migration, deaths, births.
- The number of employment and unemployment inhabitants.
- The length of P.A.TH.E. corridor per municipality.

The Hellenic Military Geographic Service, the Institute of Urban Environment and Human Resources at Panteion University, the Department of Topography at the Technological Education Institute (TEI) of Athens and the Ministry for the Environment Physical Planning and Public Works are the sources which offer the cartographical data. The basic source which grants the statistical data is the National Statistical Service of Greece.

For the investigation of the spatial impacts of the study area, it is calculated the following indicators concerning the availability of data:

- Total and by sex population changes (e.g. $(\text{pop01}-\text{pop91}) \cdot 100 / \text{pop01}$) per ten years (1971-1981, 1981-1991, 1991-2001).
- Population Density (inhabitants per km^2) for each census year (1971, 1981, 1991, 2001).
- Net Migration per ten years (1971-1981, 1981-1991, 1991-2001). It calculates by bringing together census and mortality data and can be calculated for ten year period t to $t+10$ as follow:

$$\text{NM}^{(t, t+10)} = p^{(t+10)} - p^{(t)} - (B^{(t, t+10)} - D^{(t, t+10)}),$$
 where $P^{(t)}$: population of area at the start of the decade, $P^{(t+1)}$: population of area at the end of the decade, $B^{(t, t+10)}$: number of births over the decade, $D^{(t, t+10)}$: number of deaths over the decade (Gregory, 2000).
- Net mobility. This indicator tells about the balance between births and mortality. It is a net number which can be calculated for each census year as follows:

$$M(t) = \text{birth}(t) - \text{deaths}(t),$$
 where t is the study year.
- Unemployment rate (number of unemployed persons per active population) for each census year (1971, 1981, 1991, 2001).
- Employment rate (number of employed persons per active population) for each census year.
- Density road (length of road per municipality) in 2001.

Moreover it is important to mention that the study area has divided in two parts: the first part includes the municipalities which are between Patra and Athens and the second part contains the municipalities which are between Athens and Eyzonoi.

4. Results

4.1 Population Density

The population density (see figure 2) has the largest rates in Athens and Thessalonica municipalities. The municipalities which are the capitals of each county present high population density. Also the counties around Thessalonica county present high density in all study period. In all study area, the municipalities which are in the second category have the largest average population density compared with the municipalities which are included in the first category. The areas (g=3) which are in neighbour counties of the second category have low average density because these areas are found in a long distance from the centre of the road, because the most of them are semi-mountain, mountain areas and because a large part of asphalt roads, which are connected with the P.A.TH.E. road, are not in good condition. This means that the municipalities which are in the second category are more suitable for someone to live (lower cost of living than the areas which are in the first category, the distance between the axis of the road and centre of each municipality (g=2) is short) and developed more rapidly than the other municipalities.

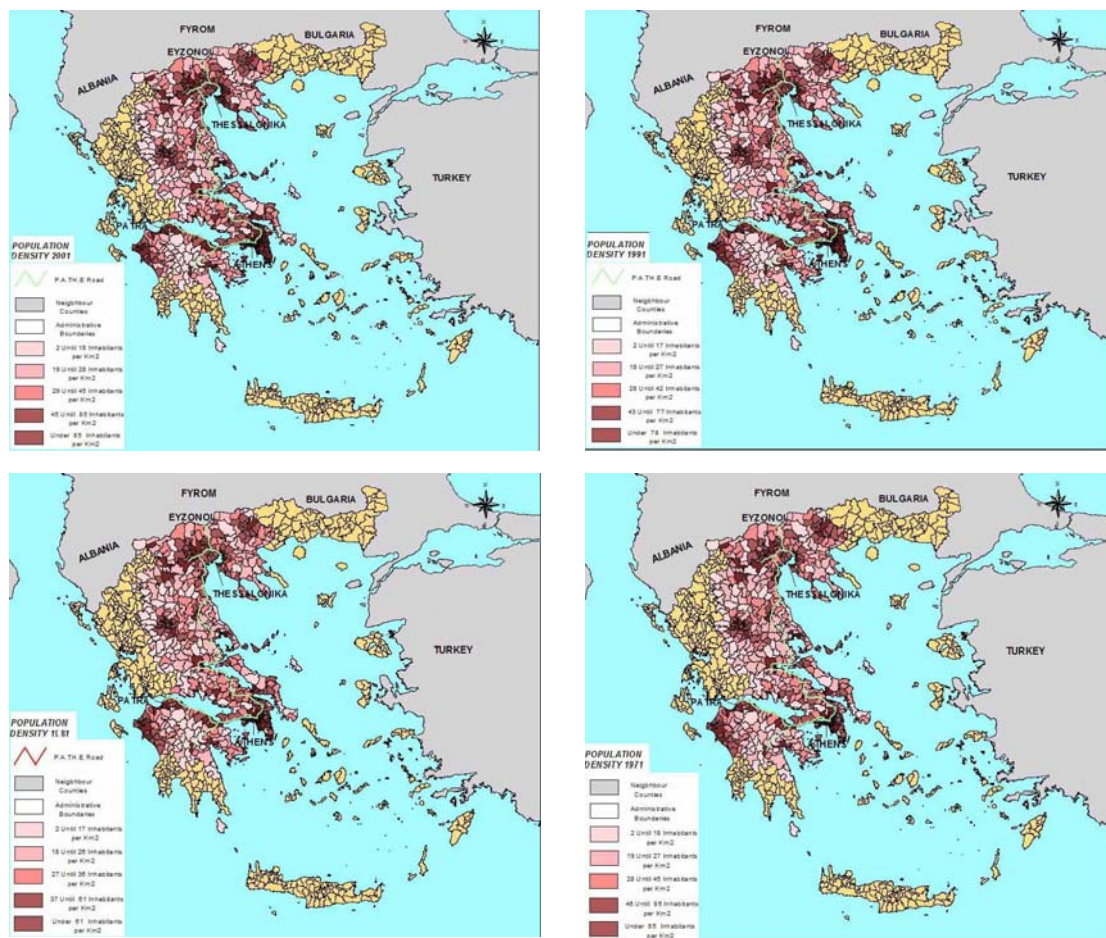


Figure 2. Population density in 2001, 1991, 1981, 1971.

In general, between Patra and Athens (see diagrams 1, 2, 3, 4) the average population density in all categories of municipalities (g=1, g=2, g=3) has the largest rates in regard to the municipalities between Athens and Eyzonoi. Especially for the areas which are in the first category the mean rate is 1638 inhabitants per km² in 1971

(Patra-Athens) and continues with an upward tendency of the average rate the next decades. The same positive upward tendency has the rates of the municipalities which are included in the second and third categories. In this part of the road, the areas of the second category have higher rates than the areas of the first category. The municipalities of the third category present lower mean rates concerning the previous two categories. On the other hand, the coefficient of variation value in the municipalities which are in the first two categories decreases between 1971 and 2001. This shows that the amplitude of the values is shortened and the large fluctuation has been eliminated because these areas are around the road and they got developed more than the other areas ($g=3$). In the areas which are in third category the values in 2001 are higher than the values in 1971. This fact shows that the incongruities in these municipalities have increased.

Moreover, the areas which are in the second part of the road (Athens-Eyzonoi) display respectively relations among them as it happens for the municipalities of different categories in the first part of the road. As regards of the coefficient of variation prices in the municipalities which are in the first two categories have decreased between 1971 and 2001 and for the areas which are in the third category the values fluctuate in the same values in all study period. This presents that the large fluctuation of population density has been eliminated.

Then the mean population density in the study area between Patra and Athens present higher mean than the rate between Athens and Eyzonoi. This happens because some parts of the P.A.T.H.E road were made before the 1985. The road had be created and repaired at the end of the 1986 especially in the area which links Patra with Athens. Because the second part of the road is still under construction, the areas around it are less developed.

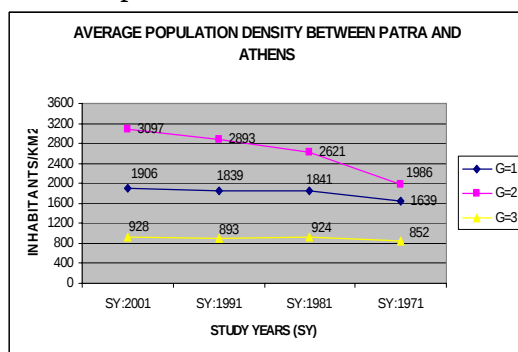


Diagram 1. Average Population Density between Patra and Athens.

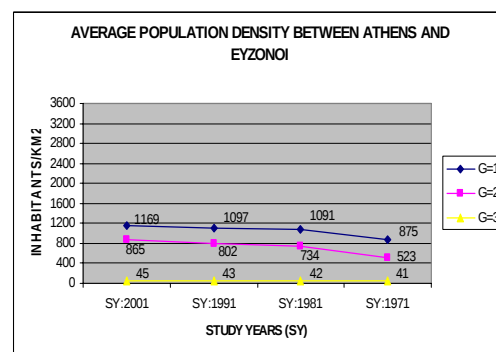


Diagram 2. Average Population Density between Athens and Eyzonoi.

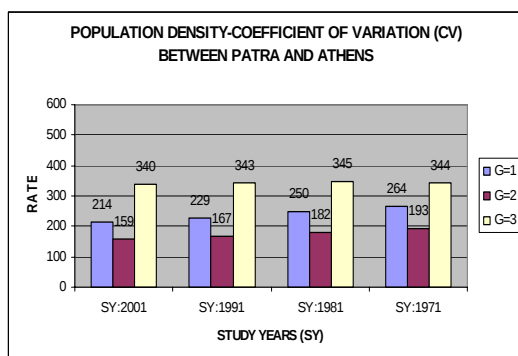


Diagram 3. Coefficient of Variation between Patra and Athens.

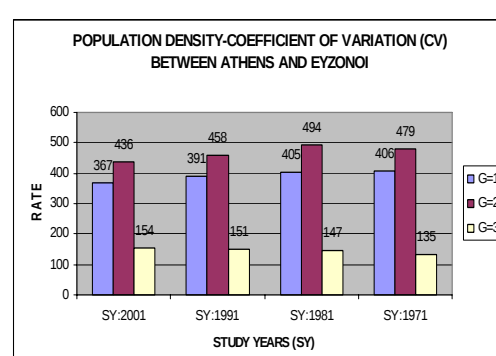


Diagram 4. Coefficient of Variation between Athens and Eyzonoi.

Additionally, it is important to mention that Larisa (g=2, lowland area), Karditsa (g=3, semi-mountain area) and Trikala (g=3, semi-mountain area) counties have high density rates all the years. This happens because in these three counties live the largest number of the Greek farmers. The municipalities (g=3) in North Greece (Kozani, Kastoria and Grevena) have lower population density in 2001 in relation to 1971, 1981 and 1991.

4.2 Total and by Sex Population Changes per ten years

The greater percentage of the municipalities (g=1) have positive total, male and female population changes (see figure 3) in all study period except for some municipalities which are contained in the following counties: Larisa (1981-1971, 1991-1981), Magnisia (1991-1981, 2001-1991), Pieria (1991-1981, 2001-1991), Patra, Korinthos. Generally the average total and by sex population changes present positive values in the first two categories of municipalities. The third category of study areas presents negative average rate in the first study decade. The next two decades the average values are positive. The average changes are greater in the first two categories than the third in which the values are lower.

The municipalities between Patra and Athens which are found in the first and second category (see diagrams 5, 6) present higher positive average rates (total and by sex population changes) compared with the areas (g=1, g=2) between Athens and Eyzonoi. The municipalities in the third category follow the same rate as previous.

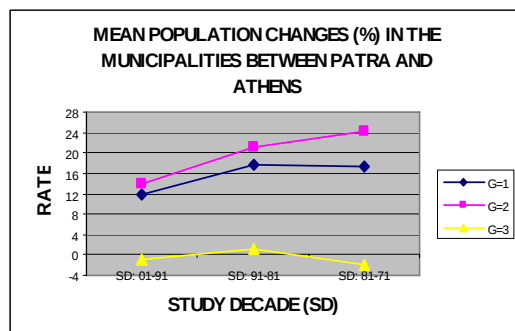


Diagram 5. Mean population changes between Patra and Athens.

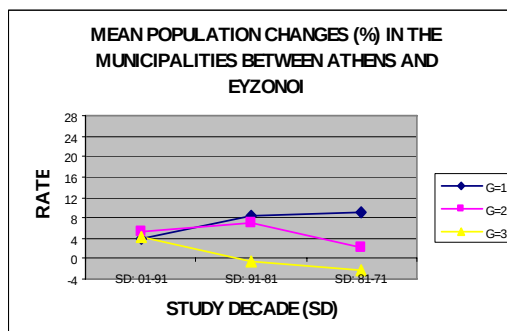


Diagram 6. Mean population changes between Athens and Eyzonoi.

On the other hand, the coefficient of variation in the municipalities with g=1 and g=2 between Patra and Athens is lower than that of the municipalities of Athena and Eyzonoi in the previous three indicator. The amplitude of values in the municipalities (g=1, g=2) in the second part of the road (Athens-Eyzonoi) is higher than the values of the first part. This means that in the areas between Patra and Athens, the fluctuations of population changes are less in connection with the municipalities between Athens and Eyzonoi (this part of the road have too much great values).

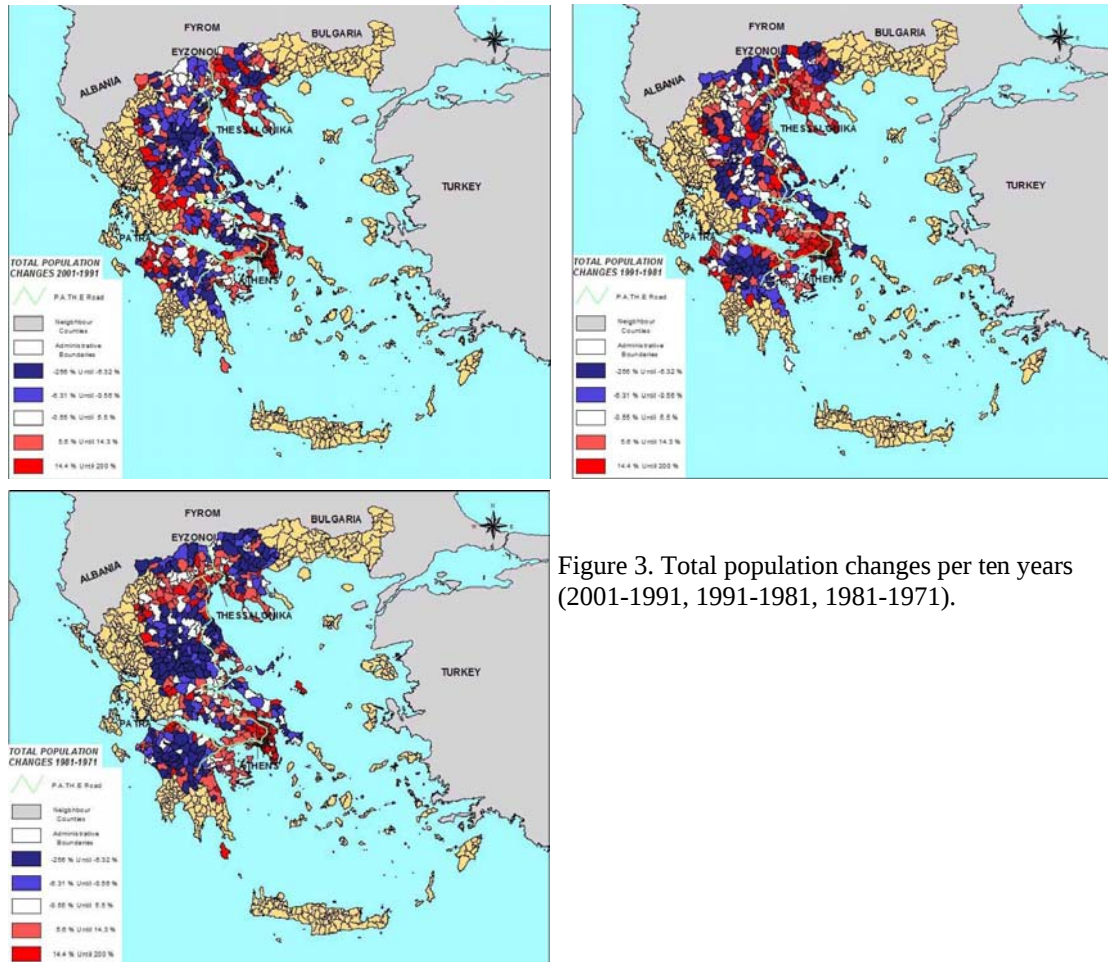


Figure 3. Total population changes per ten years (2001-1991, 1991-1981, 1981-1971).

4.3 Employment and Unemployment Rates

First of all, one decade before (1971) the beginning of the P.A.T.H.E road construction, the employment rate fluctuated in high numbers in the areas which are crossed over by the road.

The municipalities between Patra and Athens which are contained in the first category ($g=1$) present lower average unemployment rate (see diagrams 9, 10) in regard to the areas between Athens and Eyzonoi in all study years. The average employment rate (see diagrams 7, 8) displays respectively results as previous in all study area. In the municipalities which are included in the second category, the average unemployment rate increases whereas the employment rate decreases. The average values of employment rate in first category in the study areas are greater than the values in the second category. If the mean unemployment in the two parts of the road for the municipalities with $g=3$ is compared among them, it is showed that the municipalities which are between Athens and Eyzonoi have greater rates than the areas between Patra and Athens. The mean employment rate in the third category presents the lowest level of values in all areas. As a result, in the areas which are in the first category, there are more jobs for the people to work. The municipalities which are in the third category have unemployment problems (mountain areas, no suitable road infrastructures, phenomenon of migration).

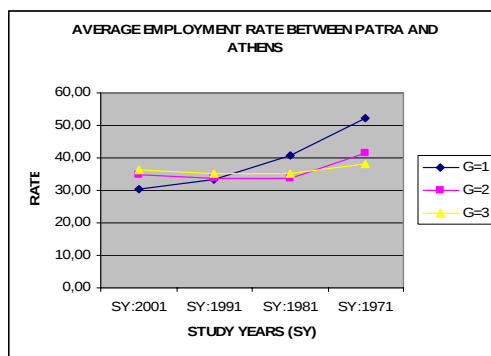


Diagram 7. Average Employment Rate between Patra and Athens.



Diagram 8. Average Employment Rate between Athens and Eyzonoi.

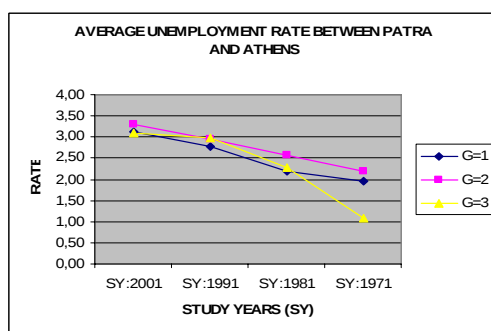


Diagram 9. Average Unemployment Rate between Patra and Athens.

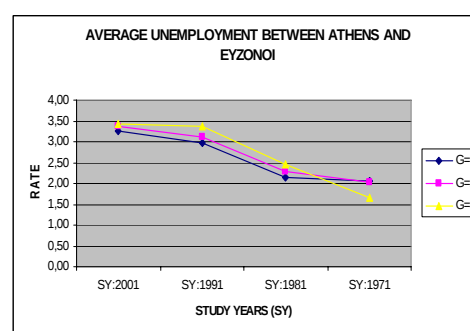


Diagram 10. Average Unemployment Rate between Athens and Eyzonoi.

4.4 Mobility and Net Migration

Firstly in the municipalities of the first category ($g=1$), the mobility has positive rate in all study period (1971, 1981, 1991 and 2001). Athens municipality had positive rate in 1971 but the next study years (1981, 1991 and 2001) the mobility was negative. On the other hand, in Thessalonica municipality during all study period the value of the rate is positive. In the areas which are contained in the second and third category the values of mobility were positive. In 1981 and in 1991 a large number of municipalities had negative rates in regard to 1971. In the North West municipalities (mountain areas) the mobility has increased in 2001, acquiring positive values. Secondly, the net migration for the municipalities of the first category has positive values between 1971 and 1981 and the next decade the values continuous to increase. Also the municipalities of the second and third categories which are between Patra and Athens present mainly negative net migration rate. Between Athens and Eyzonoi the areas continue to present the same values as previously in 1971-1981 and 1991-2001 decades. Concerning the net migration, in the decade 1981-1991, is observed small changes in relation to the first decade.

In 1971 the average mobility rate (see diagrams 11, 12) in the municipalities of the first category, which are between Patra and Athens, is higher than in the municipalities which are included in the second and the third category.

Therefore in the areas which are included in the second category of municipalities, the average rate decreases in 1981 and in 1991 but the final decade the rate increases in

connection with the values of the previous decades. The municipalities that are in the third category have the lower mean mobility rates than the areas which are in the other two categories of municipalities. Generally the mean values of the mobility in all categories of municipalities are greatest in 1971 compared with the other study years. The next two decades the average values considerably reduce in all categories and especially in the municipalities which are in the first category. In 2001 the average rates growth again but the values fluctuate in the same level with the values in 1981. The last three decades the number of censuses display that the rate of total births have dramatically decreased regarding with the deaths which increase in Greece. As a result the areas which are included in the first two categories (near the road, rural and semi-mountain areas) the mobility rate has lower decrease in compared with the municipalities which are in the third category (mountain areas, migration phenomena, etc.).

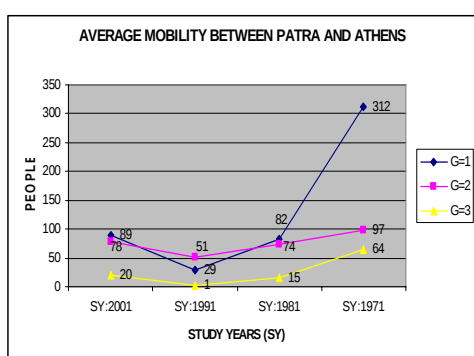


Diagram 11. Average Mobility between Patra and Athens.

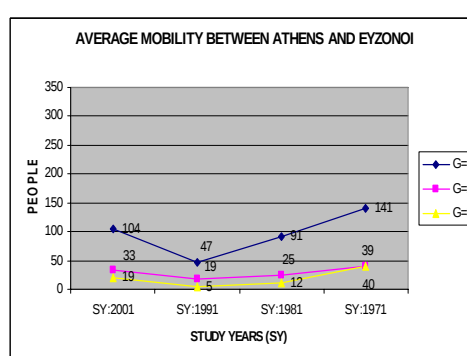


Diagram 12. Average Mobility between Athens and Eyzonoi.

Comparing the mobility rates of the two parts of the road, it can be observed that in the first category of the municipalities the average values (see diagrams 11,12) between Athens and Eyzonoi are largest than the rates between Patra and Athens apart from the first study year (1971) which happens the opposite. Also the average rates for the areas which are in the second and third categories are higher for the municipalities which are between Patra and Athens than the areas which are included between Athens and Eyzonoi.

It is important to refer that the areas which are in the first category of the municipalities between Athens and Eyzonoi are mainly rural areas. This means that these areas attract more people compared with the correspondingly areas of the first part of the road. On the contrary the areas between Patra and Athens which are included in the first category of municipality are semi-mountain and mountain areas. Furthermore in the other two categories of the study areas the rates are largest between Patra and Athens than the areas between Athens and Eyzonoi.

On the other hand, the net migration presents the population changes in an area caused by migration over a set period. Net migration does not explain where people come from or go to. Between the two parts of the road the mean rates of net migration presents the following results (see diagrams 13, 14):

- Between Athens and Eyzonoi the rates are positive and greatest than the rates between Patra and Athens in the first category of municipalities in all study period except for the second study decade in the first part of the road at which the average value has negative rate.
- The second category of areas displays the largest rates in the first two decades between Patra and Athens than the municipalities which are between Athens and

Eyzonoi. But the next decade (1991-2001), the average value of migration is greater in the second part of the road.

- Moreover in the decades 1971-1981 and 1991-2001 the municipalities, between Patra and Athens that are in neighbour counties in relation to the second category of areas has largest rates than the rates of the areas that are in the second part of the road. Between 1981 and 1991 the previous phenomenon presents opposite results.
- In the study area, the municipalities of the third category have the lower rates and the areas of the second category display the largest rates in all study period, except for the second part of the road in the decade between 1971 and 1981 (the largest values are in the first category of areas).
- The previous results show that the areas which are in the third category (mainly mountain areas) have the lower net migration rate. But it is important to mention that the specific indicator has substantially increased in the final decade (1991-2001) compared with the first study decade (1971-1981). Furthermore the municipalities which are included in the second category pull more people who live in the mountain areas than the municipalities which are crossed by the road. This may be happened because in the areas which are included in the second category the cost of the life is cheaper than the areas which are in the first category. As a result the people do not prefer to live beside the road but around it.

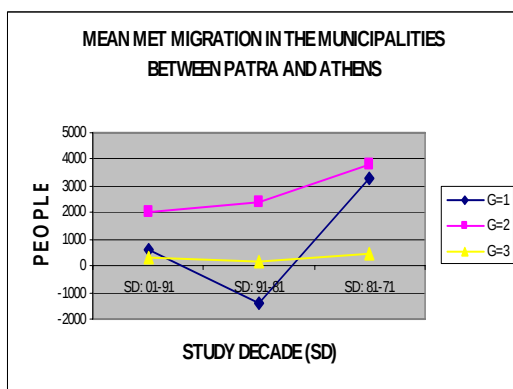


Diagram 13. Mean Net Migration between Patra and Athens.

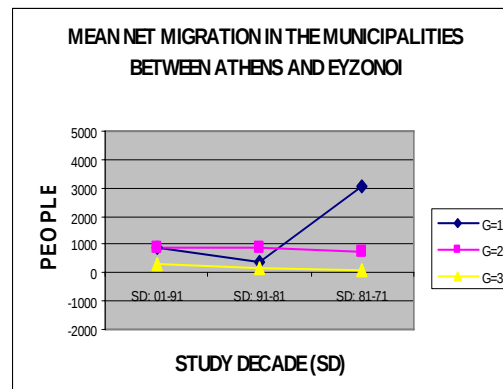


Diagram 14. Mean Net Migration between Athens and Eyzonoi.

Finally it is necessary to have an image about the road density. The value of this indicator concerns the length of the road and to the area in each municipality ($g=1$). The municipalities of Patra, Athens and Thessalonica have the greatest values (up to 1, 1%). In a large number of the municipalities the values fluctuate between 0,26% and 0,55%.

5. Conclusions

The developed programme collects, analyses digital and statistical data, uses basic programming and spatial tools for each field and designs maps within the calculation of indicators. Furthermore the user has the ability to select and create new layers, to use different kind of map units (meters, decimal degrees, feet and unknown) and to present the X, Y coordinates, to draw features classification with different colours and to create forms which describe the results of the overlay and buffer method (calculate the intersection values of buffer and overlay layer). Also it is useful for each user (no licence is needed), has friendly and understandable interface and its cost is very low. He or she has the ability to create thematic maps and calculate indicators via statistical data for each geographical entity.

Using the programme, eight indicators (total and by sex population changes, population density, employment and unemployment rates, net migration, mobility, road density) in four different time periods (1971, 1981, 1991 and 2001) have been used to study the spatial impacts of P.A.T.H.E. corridor.

The indicators describe the social – economic dimension in the study area concerning the sustainable development and the social cohesion in each municipality. The study area includes 604 municipalities (NUTS V level) which have divided in three categories. The analysis of the study area can be characterised as spatiotemporal and it has produced in three dimensions (space, time and distance). The sedulous research has the following basic results:

- The municipalities which are the capitals of each county present high population density. Athens and Thessalonica municipalities have the largest density rates. The municipalities around Thessalonica county present high density in all study period. The municipalities which are in the second category have the largest average population density compared with the municipalities which are included in the first category. Between Patra and Athens the average population density in all categories of municipalities has the largest rates compare with the municipalities between Athens and Eyzonoi. The mean population density in the study area between Patra and Athens are higher than the mean rate between Athens and Eyzonoi.
- The North West municipalities (g=3) present low population density. The municipalities (g=3) in North Greece (Kozani, Kastoria and Grevena) have lower population density in 2001 in relation to 1971, 1981 and 1991.
- The areas which are in the third category have fewer rates than the other municipalities which are included in the first and second category of them.
- In the second part of the road the net migration rates are positive and greatest than the rates between Patra. The second category of areas presents the largest rates in the first two decades between Patra and Athens than the municipalities which are between Athens and Eyzonoi.
- The average mobility rates for the municipalities which are in the second and third categories are higher for the areas which are included between Patra and Athens than the areas which are included between Athens and Eyzonoi.
- The areas which are in the first category has positive mobility rate in all study period except for some municipalities in Patra, Larisa, Pieria and Eyzonoi counties in 1991 and in 2001 which have negative rate.
- The average values of employment rate in first category in the study area are greater than the values in the second category. The mean employment rate in the third category presents the lowest level of values in all areas.

References

- Arampatzis, G., Kiranoudis, C.T, Scaloubacas, P. and Assimacopoulos, D. (2003), **A GIS – based decision support system for planning urban transportation policies**, European Journal of Operational Research.
- Carapacchio, F. and Tenaglia, P. (1998), **SITAP: The Geographical Database of Italian Cultural and Environmental Resources**, 13th ESRI European User Conference, Italy 7-9 October 1998.
- Dongquan, Z., Haifeng, J., Shengtong, C., Bing, T. (2003), **Development of MOIMS on environmental data distribution**, Vol. 24, Issue 3, pp. 145-149.
- European Spatial Planning Observatory Network (2002), **Territorial Impact of EU Transport and Ten Policies (2002 – 2004)**, Transnational Project Group 2.1.1 by ESPON (<http://www.espon.lu>).
- Gainey Kevin and Johnson Tim (2000), **Faster, Flexible Redistricting Application Built with MapObjects**, Environmental Systems Research Institute, Inc.
- GIS by Environmental Systems Research Institute (1999), **Building Applications with MapObjects, GIS and Mapping Componets**, Environmental Systems Research Institute, Inc (<http://www.esri.com>).
- Gregory, Ian. N, (2000), **An evaluation of the accuracy of the areal interpolation of data for the analysis of long-term change in England and Wales**, Geocomputation 2000.
- Halvorson Michael (1999), **Microsoft Visual Basic 6.0 Step by Step**, Microsoft Press.
- Kafkalas, G. (2005), **Spatial Impacts Observatory at Egnatia Road**, Spatial Development Research Unit, Aristotle University of Thessaloniki, Greece.
- Katsios, I., Tsatsaris, A. (2005) **Cartographical methodologies in calculating spatial indicators supported by GIS and errors on choropleth maps: Applications in demographic and land use indicators**, TOPOS Review of spatial development planning and environment, 24-25/2005, pp. 81-107.
- Longley, P.A., Goodchild, M.F., Maguire, D.J., Rhind, D.W. (1999), **Geographic Information Systems and Science**, John Wiley & Sons, LTD.
- Mizuno Hiroshi (1998), **An Enterprise GIS Application Package for Japanese Local Government**, Environmental Systems Research Institute, Inc.
- Ralston, B.A. (2002), **Developing GIS Solutions with Mapobjects and Visual Basic**, Onword Press – Thomson Learning.
- Shaw, S.L., Xin, X. (2003), **Integrated land use and transportation interaction: a temporal GIS exploratory data analysis approach**, Journal of Transport Geography, Vol. 1, No 1, pp. 103 – 115.
- Thong, C. M. and Wong, W. G. (1997), **Using GIS to design a traffic information database for urban transport planning**, International Journal of Computer, Environment and Urban Systems, Vol.21, No. 6, pp. 425- 44.
- Ziliaskopoulos, A., Waller S.T. (2000), **An Internet-based geographic information system that integrates data, models and users for transportation applications**, International Journal of Transport Research Part C, vol.8, No.6, pp.427-444.