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# Visualization of trends and tendencies based on a spatial analysis as a demonstrator for a Local Information System (LIS) based on a sample region

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## **ABSTRACT**

The topic is Visualization of trends and tendencies based on a spatial analysis for a local information system (LIS). Consequently, the paper is going to seek possibilities in implementing visualization, spatial analysis and local information system.

First, by analyzing the data of tourism and road networks in a sample region, it builds a simple relation between the two parameters and predicts the impact of tourism on the road networks in the next five years (2013–2017). Various software are analyzed and evaluated in order to get results of feasibility, both open source and non-open source, especially in the aspect of visualization of the spatial data.

The aim is to provide sample scenarios by altering one or more parameters, to visualize the impact on a region. Further more, it contributes to decision-making about the development of the tourism and road networks. The sample region is Bulgaria and the result shows that in Bulgaria, in the next five years, on the assumption has limited impact on the national roads network.

Another emphasis of the paper is evaluation of GIS application in the performance of displaying spatial statistical data, especially the trends and tendencies.

Afterwards, an ideal Local Geographical Information System will be forwarded based on the performance of visualization of the spatial statistics. Meanwhile the possibility of implementing multiple relationships is also described.

We also give suggestions about the Bulgaria national road networks and possibilities of development of local geographical information system (LGIS).

Key words: Bulgaria roads, roads capacity, visualization of spatial data, GIS software, LGIS

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## **ABBREVIATIONS**

ARIMA: Auto regressive Integrated Moving Average

ARMA: Auto regressive Moving Average

bn: Billion

CEFTA: Central European Free Trade Agreement

GIS: Geographical information system

LGIS: Local Geographical information system

LIS: Local information system

MTITC: Ministry of Transport, Information Technology and Communications

NSI: National Statistical Institute

OCED : Organization for Economic Co-operation and Development

OGC: Open Geospatial Consortium

QGIS: Quantum GIS

SLD: Styled Layer Descriptor

SPSS: Statistics Package for Social Science

WMS: Web Map Service

WFS: Web Feature Service



# INTRODUCTION

## Background

During the past few years, tourism is one of the important sectors of Bulgaria economy. According to the statistics of World Bank, the number of international tourism arrivals was climbing gradually from the year 2003 to 2011 (Fig. 1). In contrast, the construction of the national road networks of Bulgaria did not developed at roughly the same speed, instead, the length of different types of road networks increased slightly (Fig. 2). Therefore, the purpose of

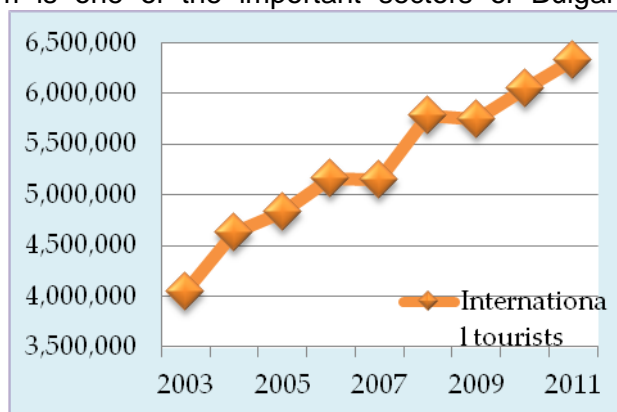


Figure 1. Number of international tourists, 2003 - 2011

this paper is to analyze the influence on the road networks caused by increasing number of tourists, more specifically, in the next five years, if the development of the road networks match the developing rate of tourism. The principal focus is on traffic load generated by tourism and its impact on road networks.

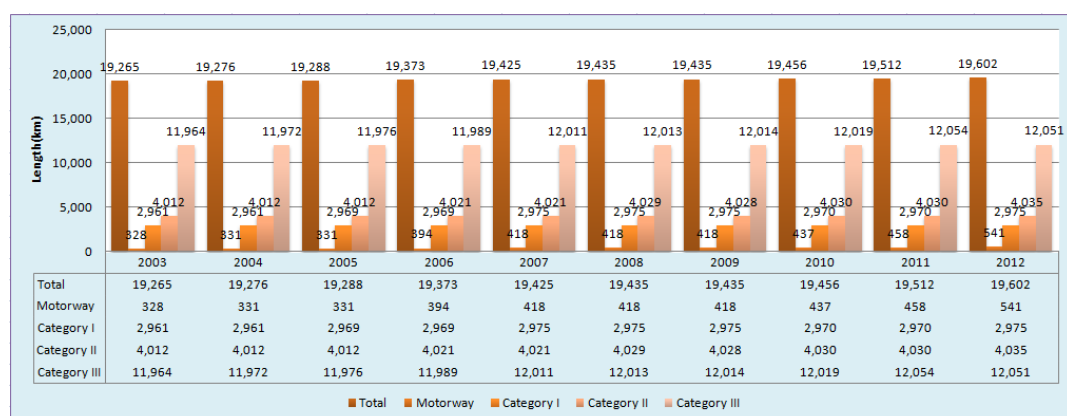


Figure 2. Length of national roads in Bulgaria, 2003- 2012

Due to the economic crisis from 2008, the GDP<sup>1</sup> growth of both Bulgaria and

<sup>1</sup> GDP, Gross domestic product

European Union has dramatically decreased and hit the bottom in 2009. In the year 2012, the GDP growth is 0.8% (Fig. 3). However, the growth rate is increasing slowly and much lower than the level before the economic crisis. We believe that it is significant and possible to arise the GDP after the economic crisis. The three main economic sectors of Bulgaria are Agriculture, Industry and Service. Figure 4 indicates the proportion of the three main sectors of GDP, obviously, the Service sector take about beyond 60% of the total value added. What should be mentioned is that tourism is one part of service industry and from the Figure 1 we can tell the economic crisis didn't reduce the passion of tourists visiting Bulgaria. Thus, Bulgaria is a huge potential tourism market which can bring huge positive economic effect.

The transport sector in Bulgaria is of an exceptional importance for raising the competitiveness of national economy and for providing services to its citizens (MTITC, 2010). Meanwhile, the development of the transport sector is a paramount importance for enhancing Bulgaria's tourism. Further more, transport plays an important role in the development of every modern society as a means for economic development and a prerequisite for achieving social and regional cohesion.

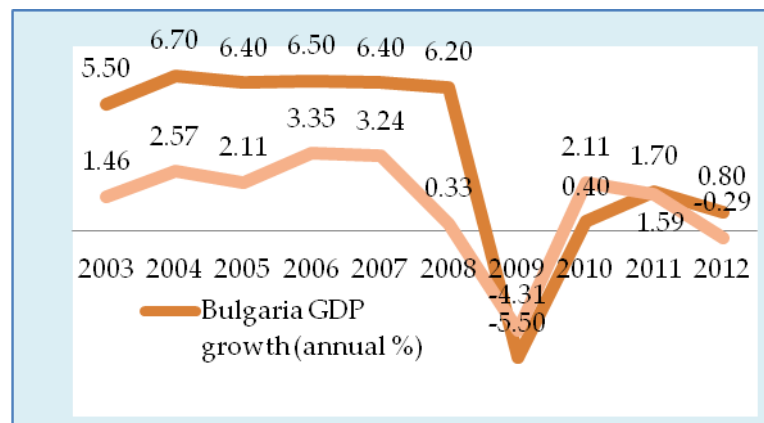


Figure 3. GDP growth of Bulgaria and European Union

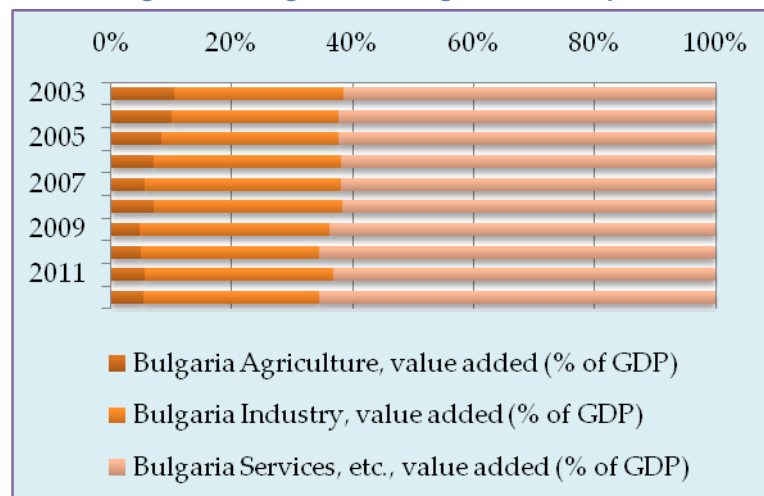


Figure 4. Bulgaria Economy Sectors

relations between national roads network and tourism, more problem come up:

How to visualize and reflect the trends and tendencies?

Which technology is existing?

Which technology can contribute to achieving the goals of this topic?

Which application or software is appropriate?

How to visualize the spatial data based on a LIS?

How to combine LIS and GIS?

## Objectives:

The purpose of this study is to contribute to the visualization of trends and tendencies based on a spatial analysis. Once we get the results of the spatial analysis about the

## Structure

Chapter 1. Bulgaria Overview: This paper begins with a detailed statement about Bulgaria including Geographic cultural information, administration partition and economic status, especially tourism and transportation system. Also a short description about how we get data from LIS? What data from LIS can be used in GIS?

Chapter 2. Capacity analysis: This chapter focus on the spatial analysis based on the statistical data from LIS. In order to get the capacity with different aspects, various analysis methods are described.

Chapter 3. Software analysis: In this chapter, we evaluate and analyze different GIS application and their feasibility in the aspect of visualization of the results from former chapter. Four software with their own features are estimated. Moreover, the advantages and disadvantages are pointed out for visualization with screenshots of the processing steps. This sector is also prepared for the next chapter.

Chapter 4. Ideal LGIS: Depending on the analysis of Chapter 3, an ideal LGIS structure is described and what should be taken into consideration when a LGIS is being establishing.

Chapter 5. Discussion and conclusion: In the last chapter, we are going to conclude and discuss the final project and forward the possibilities of future researches.

<b>Introduction</b> <ul style="list-style-type: none"><li>- Background</li><li>- Objectives</li><li>- Structure</li><li>- Methodology and Data Sources</li></ul>	<b>Chapter 2: Capacity Analysis</b> <ul style="list-style-type: none"><li>- Intensity analysis: Intensity = vehicles/ day</li><li>- Density analysis: Density = length/area</li><li>- Density analysis: Density = tourist number/length</li></ul>	<b>Chapter 3: Software Analysis</b> <ul style="list-style-type: none"><li>- QGIS analysis</li><li>- GeoServer analysis</li><li>- GeoPublish analysis</li><li>- StatSilk analysis</li><li>- Further analysis of StatSilk</li></ul>	<b>Chapter 4: Ideal LGIS</b> <ul style="list-style-type: none"><li>- Structure of LGIS</li><li>- Feature of LGIS</li><li>- Suggestions</li></ul>
<b>Chapter 1: Bulgaria Overview</b> <ul style="list-style-type: none"><li>- General information of Bulgaria</li><li>- Tourism in Bulgaria</li><li>- Transportation system of Bulgaria</li></ul>			<b>Chapter 5: Discussion and conclusion</b> <ul style="list-style-type: none"><li>- Results of the project</li><li>- Further research</li></ul>

Figure 5. Thesis structure

## Methodology and Data Sources

Normally, a complete Geographical Information System (GIS) has five main components: GIS experts, Software, Hardware, Data and Process; However, we try to combine GIS with LIS.

### What is local information?

*Local information is statistics sorted in a relatively small region, such as provinces, cities, blocks and so on.*

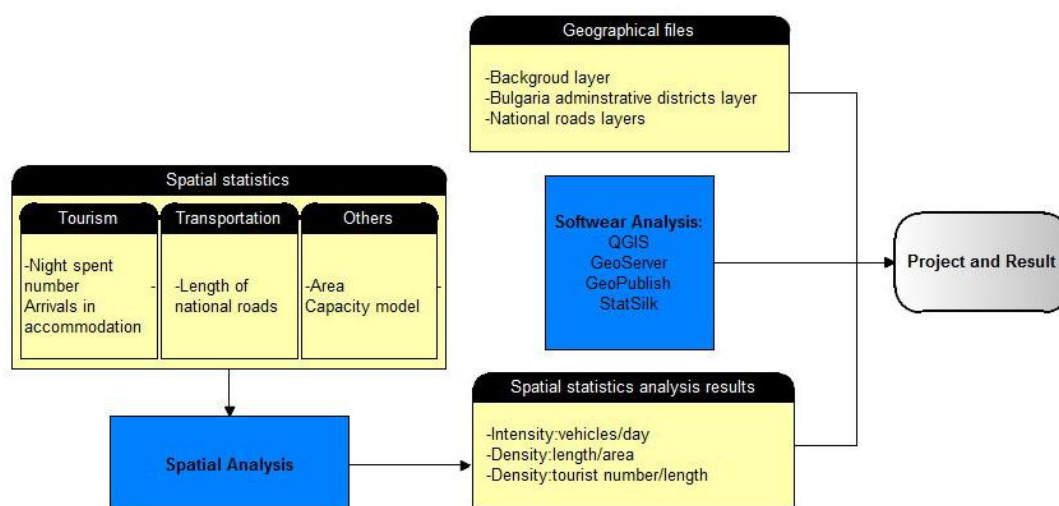
As we can see, the data sources include two parts:

Geographical data<sup>2</sup>:

- *Bulgaria\_admin-a.shp*: Polygon feature; contains shapes information about 28 administrative districts of Bulgaria;
- *motorway.shp*: Linear feature; motorways of Bulgaria with names and length;
- *primary.shp*: Linear feature; primary roads of Bulgaria;
- *secondary.shp*: Linear feature; secondary roads of Bulgaria;
- *tertiary.shp*: Point feature; accommodation information
- *camping.shp*: Point feature; camping points information
- *places.shp*: Point feature; places where accommodation is provided

Statistical data<sup>3</sup>: statistical data about the tourism and road categories listed below;

- Average annual population by districts, municipalities and places of residence<sup>4</sup>;
- The length of national roads by road categories and districts<sup>5</sup>;
- Accommodation establishments by statistical zones, statistical regions and by districts<sup>6</sup>.



### Figure 6. Procedures of the project

Procedures (Fig. 6): As shown in Figure 6, the first step is collecting data. However, not all the data is necessary, we need to extract useful information for analysis. We aim to find the spatial relations between the data, that is, combine the statistic data and geographical data together. After a second analysis, we get the result of the analysis, for this analysis, it is "In the next five years, where do the roads meet the requirements for tourism increase and where not? ". At last, the results will be visualized in a cartographic application.

Another significant part of this paper is software. The final work tries to show the result of analysis in four different software<sup>7</sup>:

- QGIS
- StatSilk
- GeoServer
- Geopublish

<sup>2</sup>The detailed description and explanation of data sources see also the Chapter 1

<sup>3</sup> Detailed description and explanation see also the Chapter 3

<sup>4</sup> From National Statistical Institute of Bulgaria (NSI), <http://www.nsi.bg/>, indicator: population

<sup>5</sup> From NSI, <http://www.nsi.bg/Indicators>: Total, Motorway, Category I roads, Category II roads, Category III roads and road connections by crossroads and junctions: Unit: kilometers

<sup>6</sup> From NSI. Among the table, the data about night spend numbers and arrivals in a accommodation establishments numbers are used for analysis

<sup>7</sup> Detailed description and explanation see also chapter 3

## Chapter 1: Bulgaria Overview

The aim of this chapter is to provide an overview of Bulgaria, in terms of Geography, Culture, Economy, Tourism and Transportation.

### 1.1 General information

As the sample region, Bulgaria (The Republic of Bulgaria) is a developing country in Southeastern Europe. In north it is bordered by Romania and Serbia and Macedonia to the west, Greece and Turkey to the south and the Black Sea to the east. The area of the national territorial area of Bulgaria is about 110910 square kilometers with a coastlines which is 378 kilometers long.

Bulgaria is a unitary state. It includes 27 provinces and a metropolitan capital province (Sofia–Grad) (Fig. 7). All areas take their names from their respective capital cities. Most of the analysis is based on districts level.



Figure 7. Bulgaria administrative districts

## 1.2 Economic information

Figure 8 shows some basic information about Bulgaria economy in the year 2011. The GDP and GNI had a similar tendency from the year 2003 to the year 2011. Due to the Financial crisis of 2007–2009, the GDP and GNI of Bulgaria decreased dramatically around the year 2009 but recovered from 2010. Before 2008, the four other indicators, the GDP growth (annual %), GDP per capita growth (annual %) have a stable growth beyond 6% but suddenly a dramatically decline from 2008 and hit the bottom in the year 2009 which were -5.5% and -5.02% separately; the GNI growth (annual %) and GNI per capita growth (annual %) decreased rapidly from 2008 to 2010 and continued to decreased slightly afterwards and between 2004 and 2007.

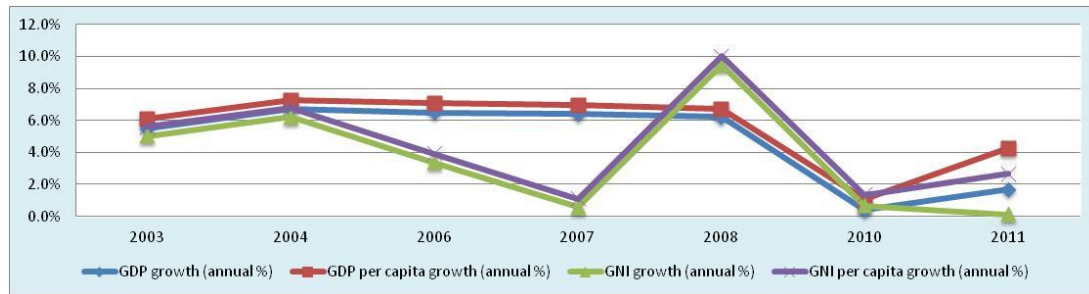


Figure 8. GDP And GNI growth rate annual, 2003-2011

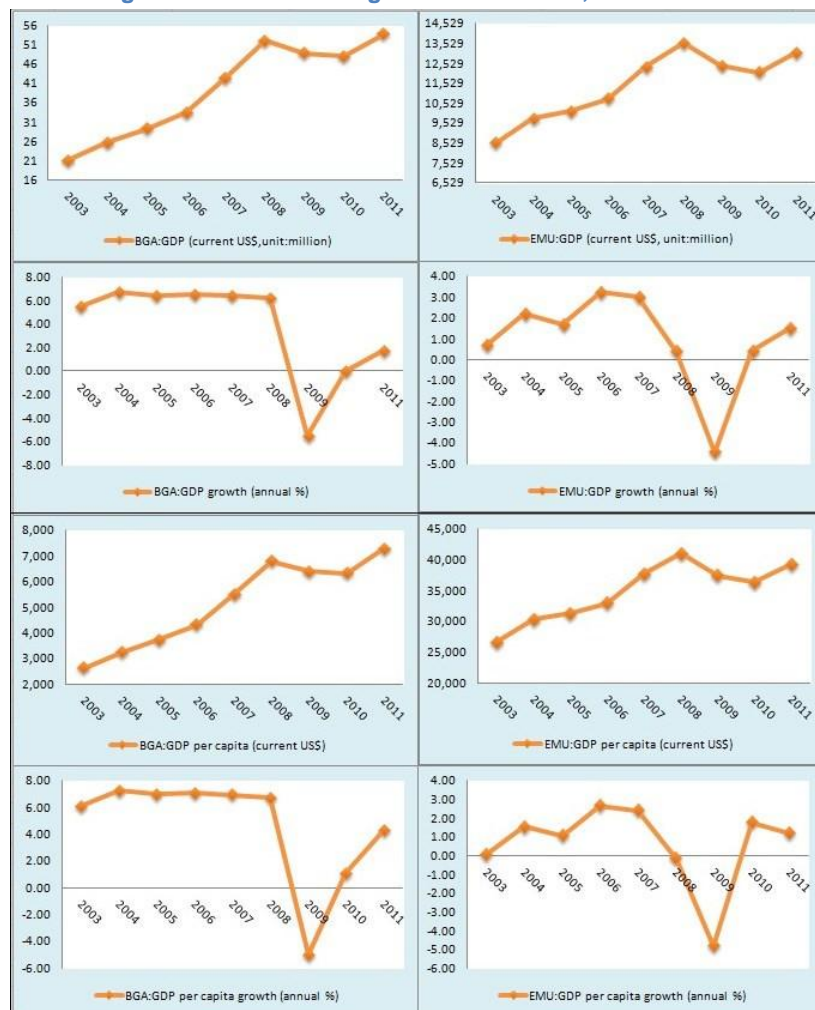


Figure 9. GDP comparison between BGA and European Monetary Union, 2003–2011



In the Figure 9 we can tell the trends of GDP of Bulgaria and EMU<sup>8</sup> have similar shape, increased from 2003 to 2008 followed by a decline until 2010.

What's more, the growth of GDP of Bulgaria was higher than those of Europe from 2003 to 2009 and in 2010 both hit the bottom after a rapidly decrease followed by a sharply recovery.

Though Bulgaria is one member of European Union after 2005, the GDP per capita of Bulgaria is much smaller than the GDP per capita of average Europe. However, in the year 2003, the number is only about 10% but with a stable rise, in the year 2010, the ratio is above 18% which is almost two time more. But the gap is still huge.

As we all know, GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. It's an important indicator for the economy and development level of one country or one region.

So, as a developing country, Bulgaria has the potential to increase it's economy. Bulgaria has traditionally been an agricultural country, roses, yogurt and wine has always been renowned in the international market. Industry currently are mainly based on food processing and textile, also tourism has been developed in recent years. Bulgaria is one members of the CEFTA<sup>9</sup> organization.

## **1.3 Tourism**

### **1.3.1 Tourist attractions**

Nowadays, tourism is one of the most powerful and largest developing sectors of economy. Especially in highly developed countries, tourism brings a big positive economic influence on not only the economic market but also providing plenty of job opportunities. Also the tourism in Bulgaria is one of the most developing sectors during the past decades. The potential development of tourism for Bulgaria is huge which benefits from its diverse tourism resources.

The main tourist attractions of Bulgaria are:

- The Sofia–Grad and Sofia district: The city of Sofia is the capital and the largest city of Bulgaria, and also the centre of politic, economy and culture. As a world-famous garden city, the streets, squares and residence are surrounded by green. It is also known for the hot springs, there are several hot springs and the temperature is about 40°C. What's more, there are also some mineral springs for citizens and tourists.
- Eastern region: The Eastern regions including three districts, Dobrich, Warna and Burgas. Every year the Black Sea resorts the 380km coastlines beaches and water springs attract millions of tourists.
- Southern-west region: This region is main resort for snow sports, especially

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<sup>8</sup> EMU: European Monetary Union

<sup>9</sup> CEFTA: Central European Free Trade Agreement

in the area of Bansko.

- Central region: As Sofia and the Eastern region are main attractions, most tourists travel through Bulgaria from West to East which is driving the development of tourism of the central region. This region is undeveloped but with great potential.

### 1.3.2 Tourism conditions and economic effects

According to the statistical data from World Bank<sup>10</sup> (Fig. 10), the numbers of arrivals has a Gradually upward trend. In the year 2003, there were 4,000,000 tourists, when it comes to 2011, the number reached to 6,300,000. Meanwhile, the numbers of departures begins with 3,400,000, after a peak reached in 2008 it has a declining trend and finally ends with a number of 3,800,000 which means, there are more and more tourists travel to Bulgaria and stay there after the year 2008. What's more, the financial crisis didn't affect the tourism of Bulgaria, in contrast the passion of international tourists to Bulgaria is increasing.

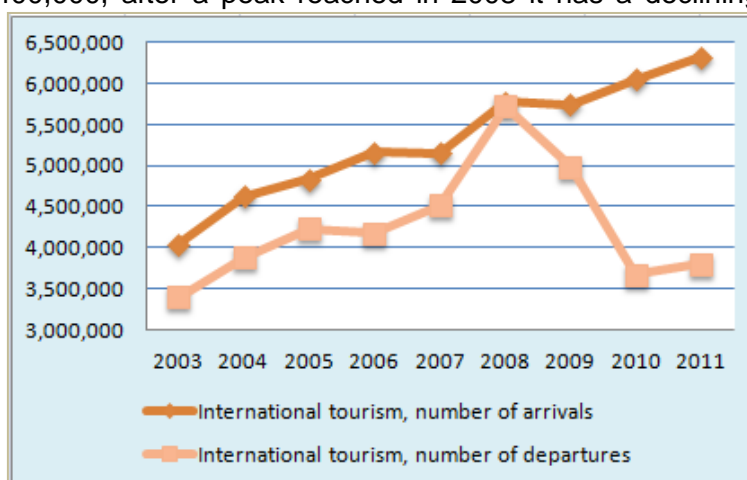


Figure 10. Number of international tourists of BGA, 2003-2011

Another set of statistical data from NSI (Fig. 11) indicates that compared to 2008, in 2012 there were 25,000 more bed places<sup>11</sup> available in Bulgaria. What's more, tourists have about 300,000 choices which is a benefit and basic guarantee for the development of tourism. In addition, these bed places can provide about 60 millions beds in total annually. Meanwhile, approximately 20 millions tourists visited Bulgaria in 2012 which increased stably from 2009 by 8%–11% (Fig. 12). However, the usage rate of beds is below 0.4 though it is increasing gradually from the year 2009. Nowadays, the usage rate of the beds is around 0.35. We wonder if the usage rate climbed to 0.7, it will bring the tourism market a huge profit (Fig. 13).

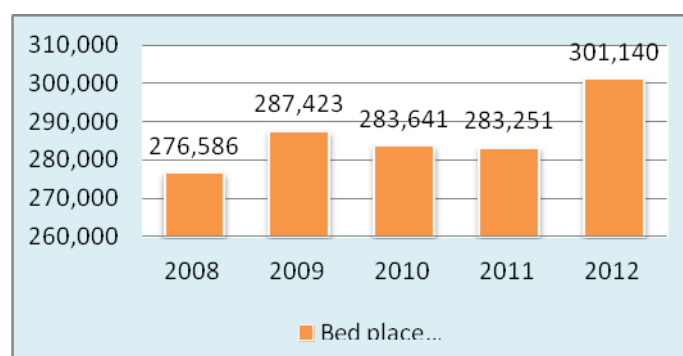


Figure 11. Bed place number in BGA, 2008–2012

<sup>10</sup> The World bank, <http://databank.worldbank.org>

<sup>11</sup> Places with more than 30 beds are counted

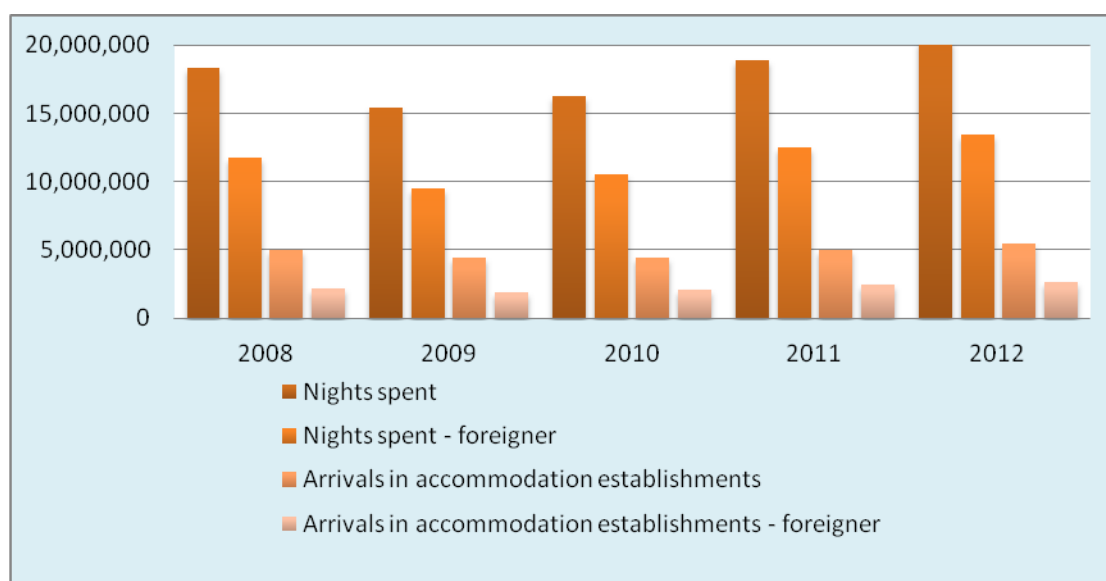


Figure 12. Numbers of tourists, 2008–2012

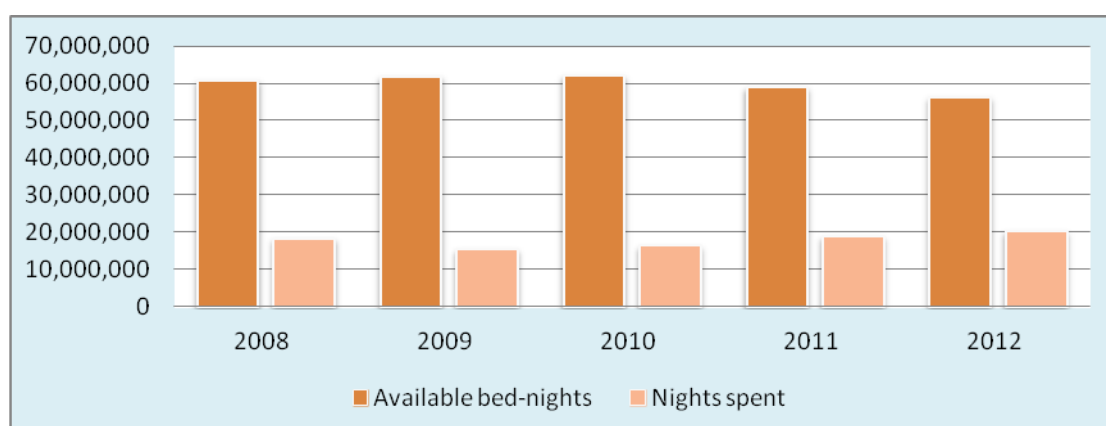
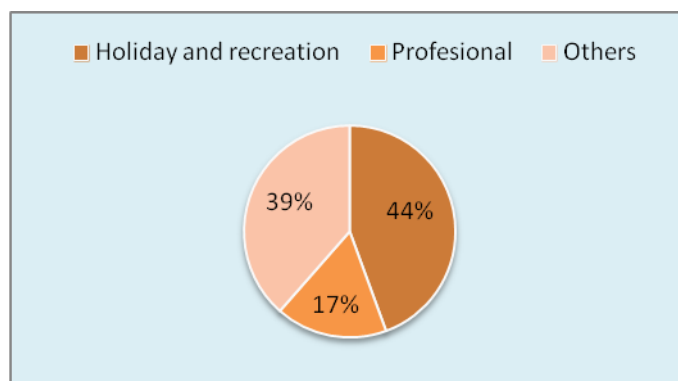


Figure 13. Usage of the beds in accommodations, 2008–2012

Other information about tourists shows that from 2009 both the numbers of night spend and arrivals in establishment increased and more and more foreign tourists come to Bulgaria. These foreign tourists come to Bulgaria for different purposes, in the first quarter of 2013, 44% of foreigners visit Bulgaria for Holiday and recreation, 18% for professional and others including as guests, transit and other purposes take a proportion of 39% (Fig. 14). The Table 1 lists main visitors grouped by nationalities, most of the tourists come from Balkan region and eastern Europe, for example, Macedonia, Greece and Romania. Nevertheless, it attracts tourists from all over the world.



**Figure 14. Visit purpose by foreigners in the first quarter 2013**

TOTAL	613821	235963	531971
Macedonia	114955	9674	15480
Greece	107521	49526	89973
Romania	85480	42892	116139
Serbia	80583	5148	34758
Turkey	46315	32219	161294
Russia	39671	7945	16086
United Kingdom	31069	8341	6049
Germany	14991	18637	15277
Ukraine	14374	3420	25673
Israel	10633	740	480

**Table 1. Numbers of foreigners grouped by nationality**

Tourism as an important economic sector in Bulgaria contributes to the revenues of the country. As shown in the Figure 15, the revenue from night spends has an extremely similar trend as other tourism indicators above. After a decline in 2009, the revenue begins to arise by 5% to 12% and reaches about 8 billion Lev<sup>12</sup>. It is obvious that over the past decades Bulgaria has enjoyed a substantial growth in income from tourism.

<sup>12</sup> Lev, currency of Bulgaria

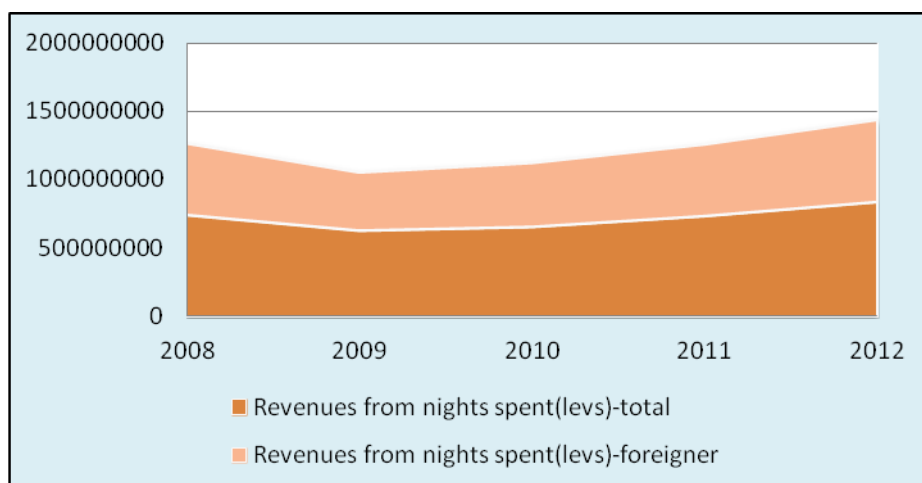


Figure 15. Revenues from nights spent, 2008–2012

In 2009, tourism contributes to 3.9% of GDP directly and 3.5% of employment. Moreover, the indirect effects were 14.8% of GDP and 13.5% of employment. Table 2 illustrates some economic indicators of tourism.

Bulgaria	2006	2007	2008	2009		2006	2007	2008	2009
Travel & Tourism Direct Contribution to GDP					Government Individual Travel & Tourism Spending				
US\$ bn <sup>13</sup>	2.162	1.784	2.031	1.902	US\$ bn	0.02	0.03	0.03	0.03
Real growth (%)	-1.1	-30.5	-1.9	-6.1	Real growth (%)	4.1	-2.1	6.4	-4.6
% share	6.5	4.2	3.9	3.9	% share	3.1	3.1	3.2	3.2
Travel & Tourism Total Contribution to GDP					Internal Travel & Tourism Consumption				
US\$ bn	7.986	6.994	8.036	7.227	US\$ bn	5.941	5.12	5.884	5.368
Real growth (%)	0	-26.3	-1	-9.9	Real growth (%)	-0.7	-27.5	-1	-8.6
% share	24.1	16.6	15.5	14.8	% share	10	6.8	6.3	7
Visitor Exports					Leisure Travel & Tourism Spending				
US\$ bn	3.266	4.088	4.741	4.17	US\$ bn	3.708	3.94	4.626	4.034
Real growth (%)	0.3	5.2	-0.1	-11.8	Real growth (%)	-1.4	-10.6	1.1	-12.6
% share	16	16.3	15.7	18	% share	4	3.2	3	2.9
Domestic Travel & Tourism Spending					Business Travel & Tourism Spending				
US\$ bn	2.65	1.005	1.109	1.165	US\$ bn	2.233	1.18	1.257	1.334
Real growth (%)	-2.2	-68.1	-4.9	5.2	Real growth (%)	0.3	-55.5	-8.2	6.2
% share	8	2.3	2.1	2.3	% share	2.4	0.9	0.8	0.9
Travel & Tourism Direct Contribution to Employment					Travel & Tourism Total Contribution to Employment				
Real growth (%)	-1.9	-31.7	-3.7	-4.1	Real growth (%)	-1.3	-27.8	-3.1	-7.2
% share	5.8	3.8	3.5	3.5	% share	21.8	15	14	13.5

Table 2. General information of Bulgaria economy

<sup>13</sup> bn: billion

## 1.4 Transportation system of Bulgaria

Transportation system plays a major role in the development of every developed and developing country. With the expansion of the economy, Bulgaria is facing a challenge to achieve a good performance of road networks. According to the National classification of economic activities, transportation including railway, road, sea, river, aviation, pipeline and urban electric transport. In Bulgaria, there are 6 main transport modes.

### 1.4.1 Railway transport

According to the data from NSI, in 2012, Bulgaria has a total length of about 4000 kilometers railway including train tracks and platforms. Among the 4,000 kilometers railway lines, 70.34% of the railway are electrified railway lines and 24.00% are double railway lines. Figure 16 indicates that the length of railway stayed stable from the year 2007. In fact, the total length of railway falls slightly which is 73 kilometers (2012) smaller than the length in 2007.

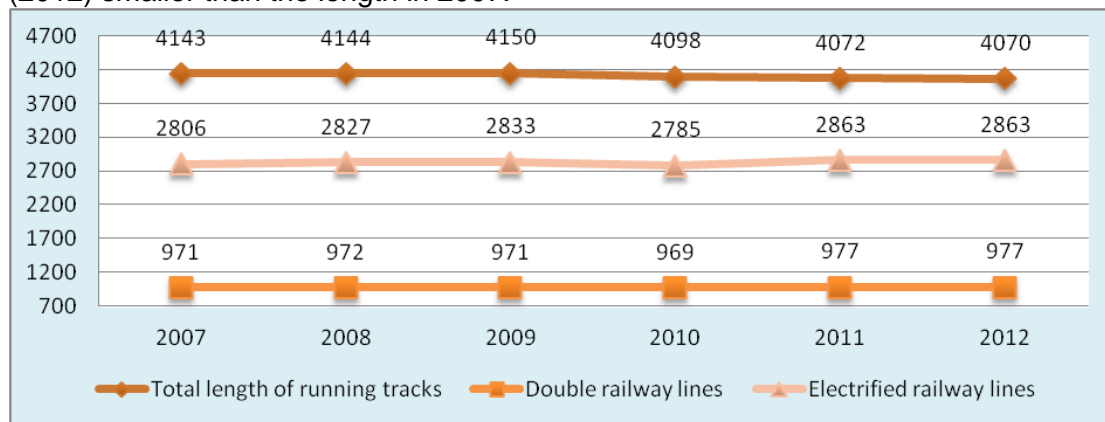


Figure 16. Railway length in Bulgaria

### 1.4.2 Road transport (National roads)

Bulgaria's national road networks can be categorized into 4 types:

#### Motorway

There are 7 Motorways in Bulgaria with a total length of 541 kilometers as well as about 200 kilometers are under construction.

The seven Motorways are listed below:

- A1(Trakia motorway): A1 motorway goes through from west to east of Bulgaria aiming to connect Sofia and administrative districts in eastern Bulgaria. A1 motorway plays a significant role in tourism, as we all know, Sofia as the capital is one of the most visited attraction in the west of Bulgaria while eastern Bulgaria the resorts along the black sea attract millions of tourists every year. The construction of A1 promotes the development of tourism due to the A1 carries thousands of passengers all over Bulgaria.
- A2(Hemus motorway): A2 is planned to connect Sofia and Varna which will go through north Bulgaria with a total planed length of 433km. Once A2 is completed, it's even longer than A1 and expected to ease the traffic of north Bulgaria. What's more, it is planned that A2 and A5 meet in Varna.
- A3(Struma motorway): A3 is planned to provide a link to Greece and connected with A6 in Sofia.

- A4(Maritsa motorway): A4 is an extended branch from A1 motorway which is planned to lead to the southern east boundary of Bulgaria and ends in Turkey.
- A5(Cherno More motorway): A5 is planned to connect Varna and A1 along the eastern coast.
- A6(Lyulin motorway): A6 is a completed motorway which aims to connect Sofia and A3.
- A7(Kalotina motorway): A7 will connect Serbia and Sofia ring roads once it's finished.

Nevertheless, some expressways are also under construction which are planned as branches of A2.

The other Three types are: Category I roads, Category II roads , Category III roads and road connections by crossroads and junctions. As shown in the Table 15, the total length of national roads and motorway are increasing gradually. In 2012, there are about 19,600 km national roads in Bulgaria among which 541km are Motorway. The length of Category I roads, Category II roads, Category III roads and road connections by crossroads and junctions are 2,975km, 4,035km and 12,000km separately.

**1.4.3 Urban transport:** Urban transport refers to public transportation like buses, trams, underground and so on in both urban and rural areas. The total length of the urban bus route network is 4,300km. In 15 cities of Bulgaria, nearly 600km trolley buses and 170 route km for trams are available (Ecorys<sup>14</sup>, 2006).

**1.4.4 Inland waterway transport:** The Danube is a river flowing along the boundary between Bulgaria and Romania. The part of Danube in Bulgaria is 470km long with three ports of national interest: Ruse, Vidin and Lom. In 2007, the total loaded and unloaded goods is about 6,620,000 tons in which 3,580,000 tons are import loaded and 839,000 tons are export unloaded, additionally, the coastal ports carried approximately 2,200 tons (Ecorys, 2006).

**1.4.5 Airports:** Bulgaria has five public airports. Two of them are located in eastern Bulgaria: Burgas airport and Varna airport, which mainly are supporting tourists arriving eastern Bulgaria in the summer period. In contrast, Plovdiv airport and Gorna Oryahovitsa Airport are located in central Bulgaria mainly serving the tourist traffic in the winter period. The last and the most important one is Sofia Airport located in the capital and western Bulgaria.

**1.4.6 Sea ports:** There are two main seaports complexes in Bulgaria, Varna and Burgas. The Sea ports take about 60% of the national importing and exporting market. In 2011, the total unloaded and loaded goods were 25,185,000 tons, which is nearly 6 times more than the inland waterway transport (Ecorys, 2006).

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<sup>14</sup> Ecorys, European research and consultancy company, <http://www.ecorys.com/>

## Chapter 2: Capacity Analysis

Recent researches point out that the development of tourism in Bulgaria suffers from a couple of serious weakness and obstacles. A report from OCED<sup>15</sup> indicates that the structure of the tourism in Bulgaria is mainly composed by seaside tourism and ski tourism which leads to low value added for Bulgaria tourism. What's more, some traditional resorts are overdeveloped that resulting in pressure on environment and carrying capacity. Additionally, the tourism market in Europe are shared by the United Kingdoms, Germany and Russia. Nowadays, Bulgaria tourism only share a limited tourism market, in order to expand its tourism market, Bulgaria faces a stiff competition. Another factor which restricts the development of tourism is seasonal demand of tourism, that is, the travel peaks in the seaside region is during summer while in ski region is winter. The number of the tourists doesn't have a sustainable development during the whole year. In this paper, we are going to analyze the relations between tourism and road networks in Bulgaria. The current transport infrastructure in the country is in a poor condition, Figure 17 shows Bulgaria spends less expenditures on maintenance of road infrastructure compared to other countries in Europe. In 2008, the expenditures on road infrastructure was 203 million Euros, in contrast, the expenditures in developed countries like Sweden, Switzerland and United Kingdoms were 858, 1,608, 5,425 million Euros separately.

It is a foresee that in order to develop the tourism market in Bulgaria, a healthy and sufficient road networks is indispensable. Not only the road networks should have the capacity to carry the increasing number of tourist with the development of tourism and prevent the traffic jam, but also the road capacity can reach the requirement of traveling need of tourists.

In next sector, the method of the analysis and the process is going to be described.

### What is road capacity?

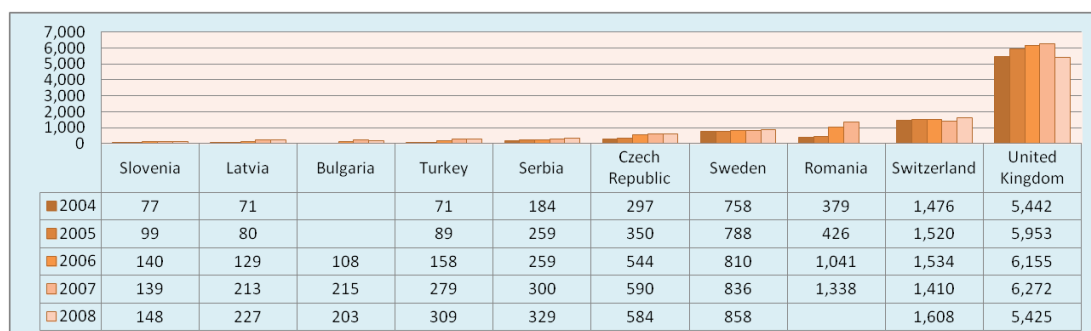


Figure 17. Maintenance expenditures in road infrastructure, 2004-2008

<sup>15</sup> OCED, Organization for Economic Co-operation and Development, <http://www.oecd.org/>



General cognizance of road capacity is the maximum number of cars the road can carry during a certain time or the number of people the roads can server(owning rate of roads). They are considered as road intensity and road density.

## 2.1 Road intensity analysis

John van Rijn in his paper " Road Capacity" indicates that the intensity of a traffic flow is the number of vehicles passing a cross section of a road in a unit of time.

**Formula:**

$$\text{Intensiy} = \frac{\text{number of vehicles}}{\text{unit of time}} = \frac{\text{vehicles}}{\text{day}}$$

In this paper, the road intensity is defined as number of vehicles/day.

Number of vehicles indicates that related to the number of vehicles can be population in a certain region, car owning rate, freight transport, tourists and so on. This paper only consider the influence brought by tourists.

As the description in Chapter Bulgaria overview, there are 6 transport modes in Bulgaria. This paper choose the national road networks (Motorway, Category I roads, Category II roads , Category III roads) as the indicator that effect the tourism.

### 2.1.1 Model

Table 3 is the model for the analysis of road intensity.

Road status	Motorway	Category I	Category II	Category III
Free	14400	7200	4200	3000
Stable A	24000	12000	7000	4800
Stable B	33600	16800	9800	6600
High dense	39600	19800	11000	7800
Near capacity	46200	21600	13000	8500
Break	50000	25000	15000	9800

Table 3. Road intensity model, unit: vehicles/day

The road status are divided into 6 conditions:

- **Free:** If the average number of vehicles passing a section of road is below the number under the given category and current status, the road status is free. Then the roads are not in ideal condition, but the car can go fast under the stated speed.
- **Stable A and Stable B:** In this paper, the ideal situation is set to Stable A, in this situation, cars on the roads have the ideal speed and the roads are utilized sufficiently. The status stable B is not ideal situation, however, if the road intensity correspond with the status table B, the roads still working in a good condition but on a risk that the traffic flow can be interrupted by emergency, for instance, car accident.

- **High dense:** In this situation, though the number of vehicles carried is much higher than the number in stable A and B, the cars can't reach the optimal speed. The tourists will spend more time on the travel which is a negative factor for the development of tourism.
- **Near capacity and Break:** Theoretically, the roads can't reach this level for the whole road networks. It's the worst condition of roads networks. Under this situation, the intervals between cars on the roads are too short which taking high risks of car accidents, traffic jam and traffic break.

We assume that the ideal road intensity status is Stable A. For instance, for the category Motorway, the ideal intensity status is maximum 24000 vehicles per day, if the number reaches 33600, the roads' condition will be high dense.

### 2.1.2 Spatial statistics analysis

For the reason that it is needed to have the number how many vehicles of tourists use the roads per day. We get the statistical number from NSI including data about the number of tourists:

- **Accommodation establishments number:** How many accommodation establishments are in Bulgaria. The data are organized in administrative districts.
- **Bed places number:** Here the bed places are places with more than 30 beds. Including hotels, hostels, camping site and so on. The data are organized in administrative districts.
- **Available beds:** The unit is night, how many beds are available during the whole year. The data are organized in administrative districts.
- **Nights spend:** The total numbers of tourists stay over night for one year. And of which how many are spent by foreigner. The data are organized in administrative districts.
- **Arrivals in accommodation establishments:** The number of tourists that arrived in the accommodation establishments per year. Additional information of foreigner arrivals. The data are organized in administrative districts.
- **Revenues from nights spent:** The unit is Levs, the local currency of Bulgaria. The term contain the information how many revenues come from the nights spent. The data are organized in administrative districts.

For the analysis, we need the number of tourists which are related to roads networks: Numbers of nights spend and arrivals. Nights spend indicates that within a year the total nights spent by tourists. From this data, depending on the road condition and the frequency the tourists use the road networks, we can calculate the tourists' effect on the road networks such as how many cars of tourists are driven on the roads per day. The number of arrivals present tourists who arrive in accommodation establishments, it is certain that every arrival is accompanied by the usage of road networks. It should be noticed that for different road types, different numbers of different region and different factors should be taken into consideration.

Meanwhile, in order to get a tendency about the relationship between tourism and road networks in the next five years, we need to predict the number of tourists. There are two prediction methods that will be introduced in the next sector.

### 2.1.3 Prediction

**ARIMA<sup>16</sup> model:** There are a variety of methods for forecasting the tourism demand, for instance, general time series model, gravity model, grey prediction model, multiple regression model and so on. Nonetheless, the predicted results were affected by the emergency situation is relatively large. In comparison, recently researches have shown ARIMA as an extension of ARMA<sup>17</sup> model by analysis of the distribution of noise probability and the deviation size of prediction in a variety of probabilities, has the advantage that getting the results without the random interference problems.

The first time prediction, we use SPSS<sup>18</sup>, a statistic analysis software to predict the tourist numbers of Bulgaria by adopting ARIMA model.

**Process:** The input data are the numbers of night spends in the range of 2008 and 2012 (Table. 4). Next we use the ARIMA model in SPSS to do prediction analysis. The main processes are shown in Figure 18:

- input the data and the variables of the year
- call the ARIMA model: Menu–Analyze–Forecasting–Create Models–Choose ARIMA model
- Set the variables to 1 in the Nonseasonal columns of Autoregressive(p), Difference Moving (d), Average (q), that is, ARIMA (1,1,1)
- Eventually, output the results

	2008	2009	2010	2011	2012
Blagoevgrad	760,022	671,656	734,639	752,002	962,067
Burgas	6,176,373	5,242,098	6,024,540	7,065,474	7,379,959
Dobrich	1,182,701	923,374	1,052,920	1,689,453	1,939,723
Gabrovo	192,485	166,229	128,869	161,194	169,767
Haskovo	102,353	90,856	101,459	96,120	97,119
Kardzhali	120,208	114,160	101,973	106,146	149,324
Kyustendil	49,570	40,353	39,914	40,362	45,476
Lovech	192,022	179,083	157,740	183,744	206,150
Montana	61,482	55,243	50,904	72,661	71,917
Pazardzhik	348,099	344,087	311,123	363,470	399,604
Pernik	43,222	33,452	26,415	17,833	23,592
Pleven	95,708	73,459	71,573	73,234	80,863
Plovdiv	732,740	609,839	631,683	669,593	789,634
Razgrad	31,439	23,228	21,431	34,046	38,925
Ruse	133,761	130,607	119,780	134,214	148,091
Shumen	53,601	41,904	37,468	54,608	64,047
Silistra	33,288	33,015	34,228	35,737	39,337
Sliven	85,042	82,700	71,872	94,177	97,289
Smolyan	512,363	414,612	392,534	467,843	496,347
Sofia	450,547	373,456	396,520	380,637	436,598
Sofia cap.	1,434,317	1,139,249	1,116,530	1,173,064	1,294,174

<sup>16</sup> ARIMA, Auto regressive Integrated Moving Average

<sup>17</sup> ARMA: Auto regressive Moving Average

<sup>18</sup> SPSS: Statistics Package for Social Science

Stara Zagora	316,229	316,097	279,375	239,273	258,702
Targovishte	38,571	31,842	32,545	39,038	37,247
Varna	4,793,207	3,879,451	4,010,898	4,488,519	4,577,820
Veliko Tarnovo	221,033	189,660	187,797	261,456	275,162
Vidin	35,413	48,492	44,344	54,659	52,249
Vratsa	51,884	54,674	42,995	57,452	72,679
Yambol	47,723	69,530	39,101	49,322	48,176

Table 4. Numbers of night spends, 2008–2012

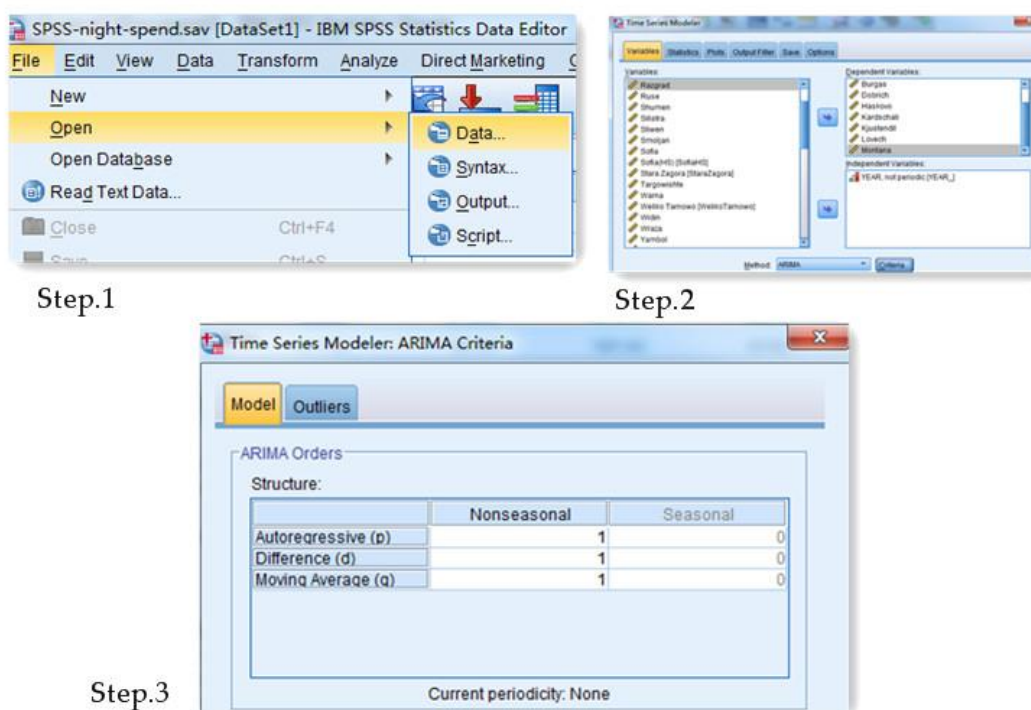


Figure 18. Process of prediction in SPSS

**Results:** The results of prediction are shown in Table 5. Due to the result of financial crisis in 2009, the largest of the prediction error in the year 2009 is beyond 10%. In comparison, the prediction error from 2010 to 2012 is mostly within 10%. But it is noticeable, the predicted number of Pernik in the year 2016 and 2017 are minus which is not possible. This method needs data of long time series, however, the data range from NSI is only for five years. The influence of economy crisis is still exist. Even so, ARIMA method is still one of the most advanced method for tourism prediction if a lot of data can be provided.

	2013	2014	2015	2016	2017
Blagoevgrad	942,406	1,062,959	1,043,504	1,163,851	1,144,602
Burgas	7,596,620	7,966,421	8,354,922	8,745,707	9,136,771
Dobrich	2,014,080	2,195,882	2,344,406	2,503,238	2,658,877
Gabrovo	155,384	146,350	139,362	133,155	127,248
Haskovo	97,969	97,607	98,253	98,061	98,566
Kardzhali	192,708	214,490	230,832	245,804	260,431
Kyustendil	42,639	43,434	40,602	41,392	38,565
Lovech	206,736	211,438	214,232	217,911	221,179

Montana	73,530	76,978	80,564	84,160	87,758
Pazardzhik	399,821	407,637	418,175	429,689	441,553
Pernik	11,474	6,448	810	-4,775	-10,364
Pleven	74,808	73,432	67,410	66,002	60,011
Plovdiv	773,490	817,997	802,114	846,362	830,737
Razgrad	38,390	40,341	41,447	42,840	44,135
Ruse	150,313	154,762	157,995	161,892	165,427
Shumen	64,022	66,412	68,174	70,100	71,983
Silistra	40,360	42,361	43,385	45,385	46,409
Sliven	96,993	100,091	103,479	106,892	110,307
Smolyan	478,066	465,565	452,656	439,776	426,893
Sofia	394,921	429,666	388,099	422,735	381,277
Sofia cap.	1,246,782	1,224,062	1,176,835	1,153,951	1,106,887
Stara Zagora	253,043	234,771	224,766	209,342	197,471
Targovishte	36,843	37,003	37,242	37,492	37,744
Varna	4,409,688	4,360,238	4,340,124	4,327,262	4,316,193
Veliko Tarnovo	281,645	294,629	309,579	325,123	340,848
Vidin	62,193	59,864	69,647	67,477	77,103
Vratsa	72,649	75,805	79,939	84,375	88,903
Yambol	38,129	39,073	32,521	31,081	26,155

Table 5. Predicted results in SPSS, 2013–2017

#### Annual growth method :

Due to the defect of ARIMA method in predicting the numbers of night spends. Consequently, we assume that the tourism of Bulgaria has a sustainable development in the next five years, that is, annual growth method. Regardless of the dramatic decrease from 2008 to 2009, the Table 6 shows the annual growth rate of night spent number from 2009 to 2012. As we can tell, the average annual growth rate of night spends is about 10% while the rate of arrivals in accommodation is 8% (Table. 7). It is assumed that the growth rate of all administrative districts is the same. Then, the results are shown in the Appendix A, in the year 2017, the total number of night spend and arrivals in accommodation are 32,616,110 and 8,072,509 separately. This data is prepared for further analysis.

	2008	2009	2010	2011	2012
Night spent number	18,295,403	15,372,406	16,261,170	18,855,331	20,252,038
Increase	-2,922,997	888,764	2,594,161	1,396,707	
Increase rate		5.78%	15.95%	7.41%	
Average increase rate					9.71%

Table 6. Increase rate of night spent, 2008–2012

	2008	2009	2010	2011	2012
Arrivals in accommodation	5,025,299	4,390,975	4,411,899	5,045,332	5,494,014
Increase number	-634,324	20,924	633,433	448,682	
Increase rate		0.48%	14.36%	8.89%	
Average increase rate					7.91%

Table 7. Increase rate of arrivals in accommodations, 2008–2012

### 2.1.4 Motorway intensity analysis

Motorway intensity analysis is based on the predicted data and roads intensity model. Through the prediction of the number of tourists, we can evaluate the effect of tourism to the whole Motorway system of Bulgaria. First, a motorway intensity effect model is established as shown in Table 8. Column Intensity shows the maximum number of cars per day for the Motorway and Column Increase shows the increase number from the former road status.

Road status	Intensity	Increase
Free	14400	
Stable A	24000	9600
Stable B	33600	9600
High dense	39600	6000
Near capacity	46200	9600
Break	50000	3800

Table 8. Motorway intensity model, unit: vehicles/day.

In the last part, we get the results of night spends and arrivals in accommodations. In fact, though they can't be used directly for judging road intensity, they are closely associated with the intensity.

When take the road intensity of motorway intensity into consideration, as the area of Bulgaria is about 111,000 km<sup>2</sup> which is a relatively small country, we assume that all motorways are an entirety. Consequently, the corresponding region is the whole country. In reality, the road intensity is affected by a lots of factors, for instance, population, freight transport, travel purpose, road conditions and so on. But this paper is aim to build a simple correlation between tourism and road networks, what's more, it is obvious that once we want the influence of road intensity caused by tourists, several aspects like tourists' behavior and motorway situation should be taken into account.

	2008	2009	2010	2011	2012
Night-spend	28,007,094	24,384,850	26,932,187	29,196,618	29,760,641
Intensity	4,796	4,175	4,612	4,999	5,096
	2013	2014	2015	2016	2017
Night-spend	32,736,705	36,010,376	39,611,413	43,572,554	47,929,810
Intensity	5,606	6,166	6,783	7,461	8,207

Table 9. Motorway intensity, unit: vehicles/day

The final statistics about the vehicles per day of tourism are calculated under some hypothesis:

- Most of the motorway has 4 lanes, each direction has two lanes<sup>19</sup>
- The average number of night spend of every tourist is 4 nights
- All of the visitors will use the motorway system
- Each visitor uses the Motorway twice at least
- Every car carries 4 visitors
- Tourism is the only indicator which effect road capacity
- The analysis region is the whole country

<sup>19</sup> A few motorway have 6 lanes

## Formula

$$\text{Intensity} = \frac{\text{vehicles}}{\text{day}} = \frac{\text{numbers of night spend} \times 2(\text{times})}{4(\text{nights}) \times 4(\text{visitors}) \times 2(\text{lanes}) \times 365(\text{days})}$$

Finally, the motorway intensity are shown in Table 9.

The Table 9 shows, in the year 2012, the road intensity of motorway of tourism was 5,096 vehicles per day. In the following 5 years, the intensity rises with a percentage of 10%<sup>20</sup>. From 2012 to 2017, there are about 3,000 vehicles more daily for the motorway intensity. As the explanation above, from the road status stable A to high dense, the intensity should increase 8,000 vehicles. In this case, it seems the result indicates that the development of tourism won't have much influence on motorway system. Even so, some facts should not be ignored. One is that we assume that in the year 2012, the road status is stable A which is the best situation, in reality, the motorway status of Bulgaria is worse than stable A, the motorway in Bulgaria suffer more pressure. In addition, owing to the relatively few maintenance expenses of motorway, the maximum intensity of each status is going to decline in the predictive period. What's more, other indicators like population, car ownership rate, freight transport are not taken into consideration. However, the ratios of intensity of tourism vehicles and maximum in 2012 and 2017 are 23% and 32%, the latter is 9% higher than 23%. Future more, regardless of the influences of other indicators, the road intensity of Motorway will increase about 600 vehicles annually and until the year 2017, the intensity is 25,511, the road status will be between stable A and stable B.

Recently research has shown the condition of the motorways in Bulgaria is in a poor condition due to the inadequate maintenance funds. Considering the current status of highways, in the year 2017, the motorway intensity will be close to high dense.

### 2.1.5 Category I intensity analysis

Like the intensity analysis for motorway, the data is also night spend of tourists. However, the regions are divided into 6 regions (Table 10<sup>21</sup>). The intensity effect model is shown in Table 10.

North Bulgaria		
North–West region	North Central region	North–East region
Vidin	Veliko Tarnovo	Varna
Vratsa	Gabrovo	Dobrich
Lovech	Razgrad	Targovishte
Montana	Ruse	Shumen
Pleven	Silistra	
South Bulgaria		
South–West region	South Central region	South–East region
Blagoevgrad	Kardzhali	Burgas
Kyustendil	Pazardzhik	Sliven
Pernik	Plovdiv	Stara Zagora
Sofia	Smolyan	Yambol
	Haskovo	

Table 10. Division of Regions for Category I Analysis

<sup>20</sup> Due to we assume that the annual growth rate of night spent is 10%

<sup>21</sup> Sofia Grad and Sofia district are in one category: Sofia

Road status	Category I
Free	7200
Stable A	12000
Stable B	16800
High dense	19800
Near capacity	21600
Break	25000

**Table 11. Road intensity model for Category I , unit: vehicles/day**

The final statistics about the vehicles per day of tourism are calculated under some hypothesis (Table. 12):

- Most of the Category I roads have 4 lanes, each direction has two lanes
- All of the visitors use the Category 1 roads
- Each visitor used the Category 1 roads in a certain region four times
- Every car carries 4 visitors
- Tourism is the only indicator which effect road capacity
- The analysis region is divided into two region
- Average night spend is 4 nights

### Formula

$$\text{Intensity} = \frac{\text{vehicles}}{\text{day}} = \frac{\text{numbers of night spend} \times 4(\text{times})}{4(\text{nights}) \times 4(\text{visitors}) \times 2(\text{lanes})}$$

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
South–East	2269	1956	2197	2551	2666	2932	3226	3548	3903	4293
North–East	2078	1670	1758	2148	2267	2493	2743	3017	3319	3651
South–West	962	799	814	832	981	1080	1188	1306	1437	1581
South Central	598	514	506	561	626	689	758	833	917	1008
North Central	210	186	169	215	230	253	278	306	337	370
North–West	80	77	70	83	87	94	102	110	119	128

**Table 12. Results of Road intensity for Category I ,2008–2017, unit: vehicles/day**

The intensity effect of tourism to the Category I roads is shown in table 13, South–East (2,666, 2012) region and North–East (2,267,2012) region have much higher capacity than other regions. In contrast, the intensity of North central and North–West region are quite low which are 230 and 83 vehicles per day separately.

To the year 2017, in east regions, there are about 1,400 vehicles more daily for the motorway intensity. As the explanation above, from the road status stable A to high dense, the intensity should increase 4,800 vehicles. Similar result to motorway, it seems the result indicates that the development of tourism won't have much influence on Category I roads system. Even so, some facts should not be ignored due to 1,400 contributes about 29% to 4,800, the percentage is higher than the total contribution of tourism to road intensity (22%, 2012).

On the other hand, owing to the unbalanced tourism, the effect of tourism is slightly in west and central regions in Bulgaria. Especially in north west region, The intensity caused by tourism is under 100 in 2012 and only 128 in the year 2017.



### 2.1.6 Category II intensity analysis

For Category II intensity analysis, Bulgaria is also divided into 6 regions. However, the numbers are arrivals in accommodations.

we assume that:

- Most of the Category II roads have 4 lanes, each direction has two lanes
- All of the visitors use the Category 2 roads
- Every arrival use the Category 2 roads in a certain region 2 times
- Every car carries 4 visitors
- Tourism is the only indicator which effect road capacity
- The analysis region is divided into 6 regions

#### Formula

$$\text{Intensity} = \frac{\text{vehicles}}{\text{day}} = \frac{\text{numbers of night spend} \times 2(\text{times})}{4(\text{visitors}) \times 2(\text{lanes})}$$

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
South–East	755	677	724	846	914	987	1066	1151	1243	1343
South–West	886	752	780	802	908	981	1059	1144	1236	1334
North–East	800	722	689	864	904	977	1055	1139	1230	1329
South Central	588	478	474	509	586	633	683	738	797	861
North Central	253	223	214	267	276	298	322	348	376	406
North–West	161	155	141	167	175	189	204	220	238	257

Table 13. Results of Road intensity for Category II ,2008–2017, unit: vehicles/day

Road status	Category II
Free	4200
Stable A	7000
Stable B	9800
High dense	11000
Near capacity	13000
Break	15000

Table 14. Road intensity model for Category II , unit: vehicles/day

The intensity effect of tourism to the category II roads is shown in Table 14, from the year 2012 to 2017, the intensity increases from 82 vehicles/day to 429 vehicles/day. Among the 6 regions, south east and south west and north east regions have the high intensity which are 1,343 (2017) ,1,334 (2017) and 1,329 (2017) vehicles per day separately. Meanwhile, the intensities of other regions are beyond 1000 vehicles per day

### 2.1.7 Category III intensity analysis

The basic regions for category III intensity analysis are administrative districts with the number of arrivals.

The statistics about the vehicles per day of tourism are calculated under some hypothesis:

- Most of the Category III roads have 4 lanes, each direction has two lanes

- All of the visitors use the Category III roads
- Each arrivals with the use of Category III roads in a certain region 4 times a day
- Every car carries 2 visitors
- Tourism is the only indicator which effect road capacity

### Formula

$$\text{Intensity} = \frac{\text{vehicles}}{\text{day}} = \frac{\text{number of arrivals} \times 4(\text{times})}{2(\text{visitors}) \times 365(\text{days}) \times 2(\text{lanes})}$$

	2012	2013	2014	2015	2016	2017
Blagoevgrad	3,775	3,890	4,005	4,119	4,234	4,359
Burgas	1,582	1,630	1,678	1,727	1,775	1,827
Dobrich	3,857	3,974	4,092	4,209	4,326	4,454
Gabrovo	4,553	4,691	4,830	4,968	5,106	5,257
Haskovo	4,645	4,786	4,927	5,068	5,209	5,363
Kyustendil	4,719	4,863	5,006	5,149	5,293	5,449
Kardzhali	4,586	4,726	4,865	5,004	5,144	5,296
Lovech	4,489	4,626	4,762	4,899	5,035	5,184
Montana	4,704	4,847	4,990	5,133	5,276	5,432
Pazardzhik	4,349	4,481	4,614	4,746	4,878	5,022
Pernik	4,766	4,910	5,055	5,200	5,345	5,503
Pleven	4,678	4,820	4,962	5,105	5,247	5,402
Plovdiv	3,801	3,917	4,032	4,148	4,263	4,389
Razgrad	4,740	4,884	5,028	5,172	5,316	5,473
Ruse	4,559	4,697	4,836	4,974	5,113	5,264
Shumen	4,691	4,834	4,976	5,119	5,261	5,417
Silistra	4,730	4,874	5,018	5,162	5,305	5,462
Sliven	4,661	4,803	4,945	5,086	5,228	5,382
Smolyan	4,275	4,405	4,535	4,665	4,795	4,936
Sofia	4,354	4,486	4,619	4,751	4,883	5,028
Sofia cap.	2,753	2,836	2,920	3,004	3,087	3,179
Stara Zagora	4,548	4,686	4,824	4,962	5,101	5,251
Targovishte	4,740	4,884	5,028	5,172	5,316	5,473
Varna	2,295	2,365	2,435	2,505	2,574	2,651
Veliko Tarnovo	4,313	4,444	4,575	4,706	4,837	4,980
Vidin	4,715	4,858	5,002	5,145	5,288	5,445
Vratsa	4,714	4,858	5,001	5,144	5,287	5,444
Yambol	4,754	4,898	5,043	5,187	5,332	5,489

Table 15. Results of Road intensity for Category III, 2012–2017, unit: vehicles/day

Road status	CategoryIII
Free	3000
Stable A	4800
Stable B	6600
High dense	7800
Near capacity	8500
Break	9800

**Table 16. Road intensity model for Category III, unit: vehicles/day**

Administrative districts in eastern Bulgaria like Burgas, Varna, Dobrich and western districts Sofia and Blagoevgrad have the highest intensity. For most districts, the effect intensity is under 1,000 vehicles per day, particularly, in north west regions. The distribution of other districts are not regular, except district Plowdiw has a higher intensity about 999 vehicles per day, the effect caused by tourism are not so obvious.

### 2.1.8 Conclusion

In the case the tourism is the only indicator which effect the roads intensity, the analysis results indicates that the effect of the tourism to roads intensity is limited. Due to the factors which can influence the intensity are various, in further research, more indicators can be included. For instance, population and vehicles and ownership. We can assume that the intensity is also contributed by population and vehicles ownership. More specifically, take the motorway of the year 2012 as an example, we assume the motorway intensity is 24,000 (vehicles/day), among 24,000, 5,096 are contributed by tourism, the left are contributed by population and vehicles ownership. From the year 2012 to 2017, the results are shown in Table 17 to 20.

	2012	2013	2014	2015	2016	2017
Tourism	5,096	5,606	6,166	6,783	7,461	8,207
Car ownership	18,904	19,478	20,053	20,627	21,202	21,828
Motorway Intensity	24,000	25,084	26,219	27,410	28,663	30,036

**Table 17. Results of intensity including other indicators for Motorway, 2012–2017,unit:vehicles/day**

	2012	2013	2014	2015	2016	2017
North–West	12,000	12,373	12,748	13,124	13,501	13,912
North Central	12,000	12,397	12,798	13,205	13,617	14,067
North–East	12,000	12,682	13,410	14,187	15,020	15,934
South–East	12,000	12,738	13,529	14,380	15,295	16,300
South–West	12,000	12,502	13,024	13,567	14,135	14,756
South Central	12,000	12,452	12,917	13,396	13,890	14,430

**Table 18. Results of intensity including other indicators for category I , 2012–2017,unit:vehicles/day**

	2012	2013	2014	2015	2016	2017
South–East	6,000	6,228	6,461	6,701	6,948	7,216
South–West	6,000	6,227	6,461	6,700	6,946	7,214
North–East	6,000	6,227	6,460	6,699	6,945	7,213
South Central	6,000	6,211	6,427	6,646	6,869	7,113
North Central	6,000	6,196	6,394	6,594	6,795	7,015

North–West	6,000	6,191	6,383	6,576	6,771	6,983
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**Table 19. Results of intensity including other indicators for category II, 2012–2017,unit:vehicles/day**

	2012	2013	2014	2015	2016	2017
Blagoevgrad	3,775	3,890	4,005	4,119	4,234	4,359
Burgas	1,582	1,630	1,678	1,727	1,775	1,827
Dobrich	3,857	3,974	4,092	4,209	4,326	4,454
Gabrovo	4,553	4,691	4,830	4,968	5,106	5,257
Haskovo	4,645	4,786	4,927	5,068	5,209	5,363
Kyustendil	4,719	4,863	5,006	5,149	5,293	5,449
Kardzhali	4,586	4,726	4,865	5,004	5,144	5,296
Lovech	4,489	4,626	4,762	4,899	5,035	5,184
Montana	4,704	4,847	4,990	5,133	5,276	5,432
Pazardzhik	4,349	4,481	4,614	4,746	4,878	5,022
Pernik	4,766	4,910	5,055	5,200	5,345	5,503
Pleven	4,678	4,820	4,962	5,105	5,247	5,402
Plovdiv	3,801	3,917	4,032	4,148	4,263	4,389
Razgrad	4,740	4,884	5,028	5,172	5,316	5,473
Ruse	4,559	4,697	4,836	4,974	5,113	5,264
Shumen	4,691	4,834	4,976	5,119	5,261	5,417
Silistra	4,730	4,874	5,018	5,162	5,305	5,462
Sliven	4,661	4,803	4,945	5,086	5,228	5,382
Smolyan	4,275	4,405	4,535	4,665	4,795	4,936
Sofia	4,354	4,486	4,619	4,751	4,883	5,028
Sofia cap.	2,753	2,836	2,920	3,004	3,087	3,179
Stara Zagora	4,548	4,686	4,824	4,962	5,101	5,251
Targovishte	4,740	4,884	5,028	5,172	5,316	5,473
Varna	2,295	2,365	2,435	2,505	2,574	2,651
Veliko Tarnovo	4,313	4,444	4,575	4,706	4,837	4,980
Vidin	4,715	4,858	5,002	5,145	5,288	5,445
Vratsa	4,714	4,858	5,001	5,144	5,287	5,444
Yambol	4,754	4,898	5,043	5,187	5,332	5,489

**Table 20. Results of intensity including other indicators for Category III, 2012–2017,unit:vehicles/day**

However, the results has it's own uncertainty due to the hypothesis of the road intensity is Stable A which in fact the real intensity of Bulgaria national road networks is between Stable B and high dense. What's more, other indicators like tourists behavior, industry, freight transport also have influence on the roads intensity.

In conclusion, for the roads intensity, if the current road situation is stable A, the developing tourism won't impose huge influence on the roads intensity. Even so, as mentioned above, considering the current roads intensity, the intensity might be close to high dense.

## 2.2 Density analysis<sup>22</sup>

The result of intensity analysis approximates the relations between tourism and motorway system in Bulgaria. Meanwhile, the results indicates that if the current situation of Bulgaria motorway system is status stable A, the development of tourism won't bring about much pressure on the motorway system. However, the result is a general analysis about the whole country due to the model used for the analysis doesn't take the length and location into consideration.

In order to specify the analysis result, another method is introduced to the analysis, which is, density analysis. As we all know, different kinds of different roads have it's own service radius, and the capacity of different sectors of roads varies too. By applying density analysis, we can calculate the road density of every administrative district.

The basic principle of density analysis is:

$$\text{Density} = \frac{\text{length(km)}}{\text{area(km}^2\text{)}}$$

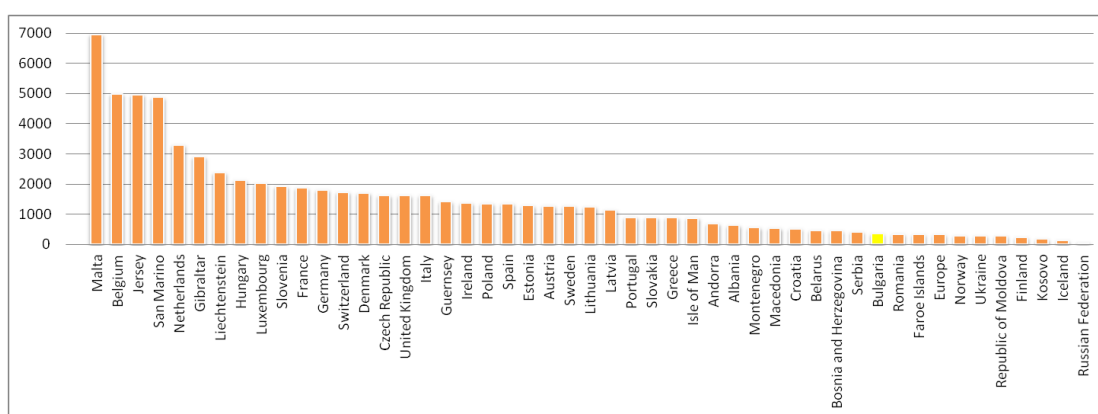


Figure 19. Density of national road networks of european countries, 2011, unit:km per 1000 km<sup>2</sup>

Compared to other countries in Europe, Bulgaria has a relative low road density about 362 km per 1000 km<sup>2</sup> which is a bit higher than the Europe average (321.36 km/1000km<sup>2</sup>) (Fig. 19).

By applying the length–area density function, we get the results of the density which is shown in Table 21. The density of the national roads is beyond 178 km per 1000 km<sup>2</sup>. Moreover, it is obvious that during the year from 2004 to 2012, the density of the national road density is mainly locate between 170km per km<sup>2</sup> to 210 km per km<sup>2</sup>, others are between 140 and 170 despite Blagoevgrad (100km per 1000 km<sup>2</sup>). The density of 6 regions<sup>23</sup> indicates no significant difference, however, the density of northern regions (190) are higher than the southern regions (170). Meantime Gabrowo, Pernik, Targowishte and Widin have higher development level. By comparison, the national road networks of Montana, Burgas and Blagoevgrad have low density. However, we must admit total length is not sufficient and accurate for density analysis due to the server capacity of different types of roads are different.

<sup>22</sup> Unless stated, the unit of the numbers in this chapter is km per 1000 km<sup>2</sup>

<sup>23</sup> Division of regions see Table 11.

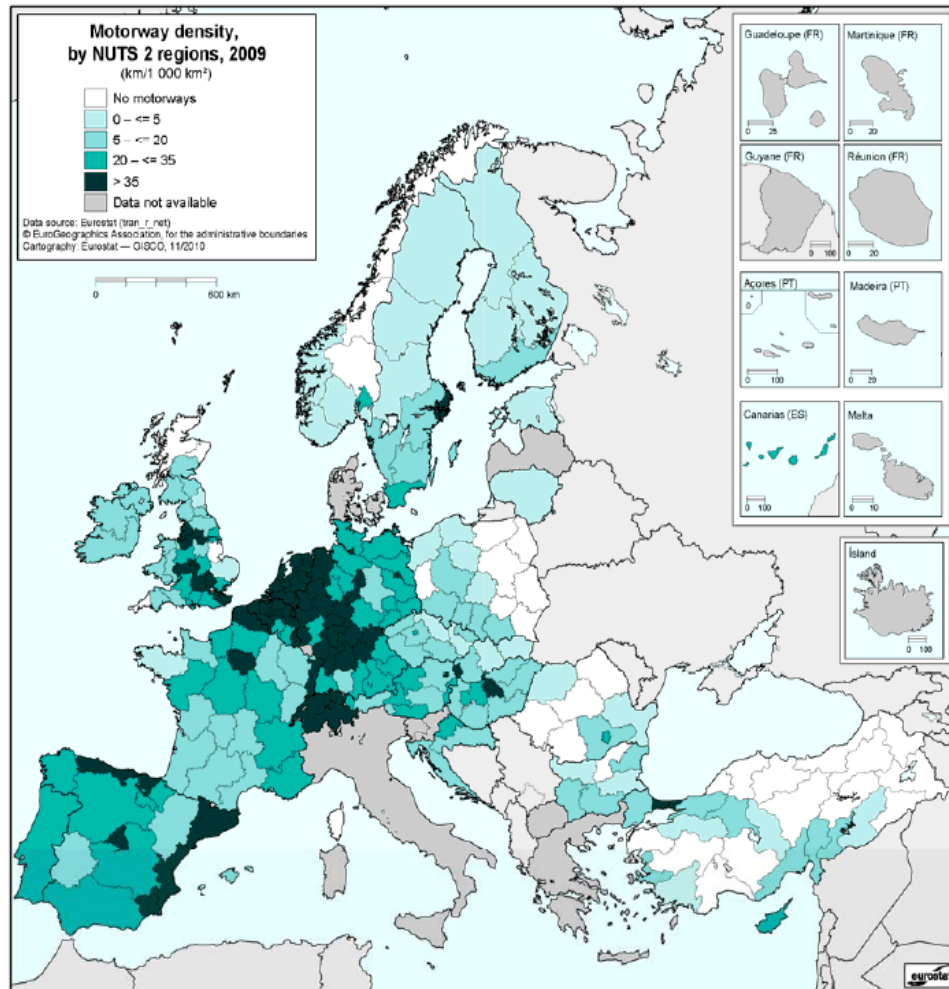
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
<b>Bulgaria</b>	<b>179</b>	<b>179</b>	<b>179</b>	<b>180</b>	<b>180</b>	<b>180</b>	<b>180</b>	<b>180</b>	<b>181</b>	<b>182</b>
<b>North Bulgaria</b>	<b>188</b>	<b>188</b>	<b>188</b>	<b>188</b>	<b>188</b>	<b>188</b>	<b>188</b>	<b>188</b>	<b>188</b>	<b>189</b>
<b>North–West region</b>	<b>178</b>	<b>178</b>	<b>179</b>	<b>179</b>	<b>179</b>	<b>179</b>	<b>179</b>	<b>179</b>	<b>179</b>	<b>179</b>
Vidin	206	206	206	206	206	206	206	206	206	206
Vratsa	167	167	170	170	170	170	170	170	170	170
Lovech	176	176	176	176	176	177	177	177	177	176
Montana	162	162	162	163	163	163	164	164	164	164
Pleven	178	178	178	178	178	178	178	178	178	178
<b>North Central region</b>	<b>199</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>200</b>
Veliko Tarnovo	202	202	202	202	202	202	201	201	201	201
Gabrovo	233	233	233	233	233	233	233	233	233	233
Razgrad	193	193	193	193	193	193	193	193	195	195
Ruse	188	188	188	188	188	188	188	188	188	188
Silistra	182	182	182	182	183	183	183	183	183	183
<b>North–East region</b>	<b>185</b>	<b>185</b>	<b>185</b>	<b>186</b>	<b>186</b>	<b>186</b>	<b>186</b>	<b>186</b>	<b>186</b>	<b>187</b>
Varna	190	190	190	190	190	190	190	190	190	190
Dobrich	175	175	175	175	175	175	175	175	175	175
Targovishte	208	208	208	208	208	208	208	208	208	210
Shumen	168	168	168	172	173	173	173	173	173	173
<b>South Bulgaria</b>	<b>170</b>	<b>170</b>	<b>170</b>	<b>171</b>	<b>172</b>	<b>172</b>	<b>172</b>	<b>172</b>	<b>173</b>	<b>175</b>
<b>South–West region</b>	<b>174</b>	<b>174</b>	<b>174</b>	<b>174</b>	<b>174</b>	<b>174</b>	<b>174</b>	<b>174</b>	<b>177</b>	<b>177</b>
Blagoevgrad	104	104	104	104	104	104	104	104	104	104
Kyustendil	194	194	194	194	194	194	194	194	194	194
Pernik	222	222	222	222	224	224	224	224	233	233
Sofia	175	175	175	175	175	175	175	175	178	177
<b>South Central region</b>	<b>178</b>	<b>178</b>	<b>178</b>	<b>178</b>	<b>179</b>	<b>179</b>	<b>179</b>	<b>180</b>	<b>180</b>	<b>180</b>
Kardzhali	193	193	193	193	199	199	199	199	199	203
Pazardzhik	171	171	171	171	171	171	171	171	171	171
Plovdiv	166	165	165	165	165	165	165	165	165	165
Smolyan	164	164	164	164	164	164	164	164	164	164
Haskovo	196	196	196	196	196	196	196	199	199	199
<b>South–East region</b>	<b>158</b>	<b>159</b>	<b>159</b>	<b>162</b>	<b>163</b>	<b>163</b>	<b>163</b>	<b>163</b>	<b>163</b>	<b>169</b>
Burgas	144	144	144	150	150	151	151	151	151	151
Sliven	155	155	155	155	155	155	155	155	155	168
Stara Zagora	156	160	160	164	169	169	169	169	170	174
Yambol	177	177	177	177	177	177	177	177	177	182

Table 21. Density of total national roads, 2003–2012, unit: km per 1000 km<sup>2</sup>

Thus, it is necessary to get the density of each type of roads.

### 2.2.1 Motorway density(length/area)

Figure 20 is a map shows the motorway density by NUTS<sup>24</sup> in 2009. From the map we can tell there is a gap between East Europe and Western Europe. The former region is not well developed than the later one. And the density of Bulgaria are mainly less than 20 kilometers per 1000 square kilometers.



**Figure 20. Motorway density by NUTS 2 regions, 2009**

Owing to the motorway system is low developed, the motorway coverage rate is only 11.8% (Service radius 50km, Fig. 21). As is shown, the motorway of Bulgaria gathers mainly in the south and also in the central region of Bulgaria and eastern Bulgaria. In the northern Bulgaria there is few motorway especially in the central Bulgaria.

<sup>24</sup> NUTS, Nomenclature of Territorial Units for Statistics, <http://ec.europa.eu>, the regions are divided based on NUTS 2(basic regions for the application of regional policies)



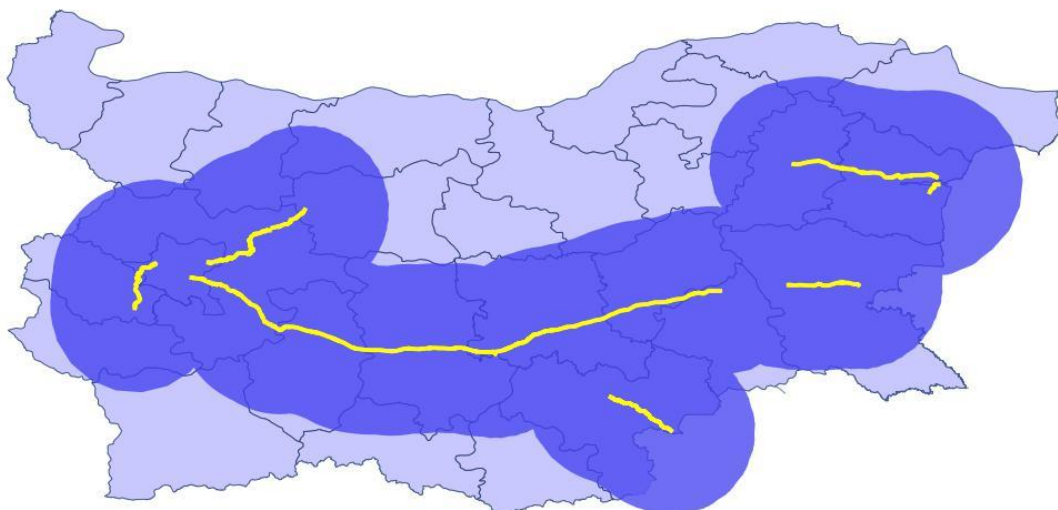


Figure 21. The coverage service area of motorway in the case service radius is 50km

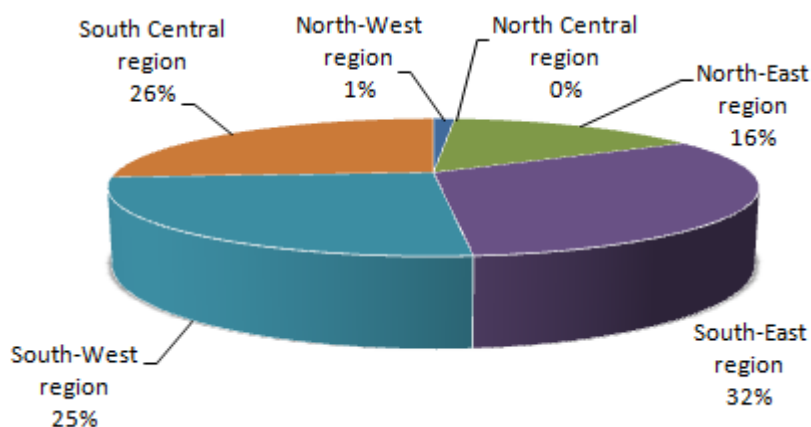


Figure 22. Distribution of motorways

The pie chart demonstrates the distribution of motorways. Among the 6 sub regions, South–East, South Central and South–West regions occupy the majorities of Motorways with percentages of 32%, 26% and 25% separately. Then, 17% of the motorways is shared by North regions.

In detailed, the density of 5 administrative districts Sofia (including the Sofia–Grad and the Sofia district), Pazardzhik, Stara Zagora, Sliven and Varna are beyond 11km per 1000 km<sup>2</sup>. In comparison, northern and Southwestern has no motorways.

	Varna	Sofia	Stara Zagora	Sliven	Pazardzhik	Plovdiv
Motorway density	15.44	15.26	14.29	12.91	11.79	8.05
	Shumen	Haskovo	Yambol	Burgas	Pernik	Lovech
Motorway density	7.41	7.36	5.34	4.53	3.70	1.65

Table 22. Motoray density, length–area density method, 2012



### 2.2.2 Category I density (length–area)

As shown in Table 23, in Sofia region, North central and East Bulgaria, the density is higher than 30 km per 1000km<sup>2</sup>. The distribution of Category I roads is along the motorways or in the administrative districts along the ones with motorways. The exceptions are Ruse and Kardzhali.

	2008	2009	2010	2011	2012
<b>North–West region</b>	<b>20.30</b>	<b>20.30</b>	<b>20.30</b>	<b>20.30</b>	<b>20.30</b>
Vidin	24.97	24.97	24.97	24.97	24.97
Vratsa	15.79	15.79	15.79	15.79	15.79
Lovech	25.05	25.05	25.05	25.05	25.05
Montana	14.10	14.10	14.10	14.10	14.10
Pleven	21.61	21.61	21.61	21.61	21.61
<b>North Central region</b>	<b>31.02</b>	<b>31.02</b>	<b>31.02</b>	<b>31.02</b>	<b>31.02</b>
Veliko Tarnovo	32.89	32.89	32.89	32.89	32.89
Gabrovo	39.86	39.86	39.86	39.86	39.86
Razgrad	21.56	21.56	21.56	21.56	21.56
Ruse	40.36	40.36	40.36	40.36	40.36
Silistra	20.62	20.62	20.62	20.62	20.62
<b>North–East region</b>	<b>33.30</b>	<b>33.30</b>	<b>33.30</b>	<b>33.30</b>	<b>33.30</b>
Varna	35.94	35.94	35.94	35.94	35.94
Dobrich	17.57	17.57	17.57	17.57	17.57
Targovishte	30.61	30.61	30.61	30.61	30.61
Shumen	53.58	53.58	53.58	53.58	53.58
South Bulgaria	16.78	16.78	16.70	16.70	16.78
<b>South–West region</b>	<b>30.31</b>	<b>30.31</b>	<b>30.31</b>	<b>30.31</b>	<b>29.96</b>
Blagoevgrad	13.52	13.52	13.52	13.52	13.52
Kyustendil	28.62	28.62	28.62	28.62	28.62
Pernik	32.85	32.85	32.85	32.85	32.85
Sofia	42.94	42.94	42.94	42.94	42.12
<b>South Central region</b>	<b>19.28</b>	<b>19.28</b>	<b>19.05</b>	<b>19.05</b>	<b>19.59</b>
Kardzhali	26.64	26.64	26.64	26.64	30.49
Pazardzhik	13.64	13.64	13.64	13.64	13.64
Plovdiv	20.78	20.78	20.78	20.78	20.78
Smolyan	0	0	0	0	0
Haskovo	29.46	29.46	28.54	28.54	28.54
<b>South–East region</b>	<b>30.31</b>	<b>30.31</b>	<b>30.31</b>	<b>30.31</b>	<b>30.31</b>
Burgas	32.22	32.22	32.22	32.22	32.22
Sliven	24.38	24.38	24.38	24.38	24.38
Stara Zagora	32.69	32.69	32.69	32.69	32.69
Yambol	28.47	28.47	28.47	28.47	28.47

Table 23. Category I density, length–area density, unit: km per 1000 km<sup>2</sup>, 2008–2012

### 2.2.3 Category II density (length–area)

High dense roads are concentrated on northern central Bulgaria (42.63, 2012) and Northern west (40.18, 2012). Despite of that, Category II roads in central Bulgaria which are along motorways have a higher density than other regions. More details are shown in the Table 24.

	2008	2009	2010	2011	2012
<b>North–West region</b>	<b>40.24</b>	<b>40.24</b>	<b>40.24</b>	<b>40.24</b>	<b>40.18</b>
Vidin	30.71	30.71	30.71	30.71	30.71
Vratsa	61.82	61.82	61.82	61.82	61.82
Lovech	18.43	18.43	18.43	18.43	18.19
Montana	43.93	43.93	43.93	43.93	43.93
Pleven	46.15	46.15	46.15	46.15	46.15
<b>North Central region</b>	<b>42.70</b>	<b>42.63</b>	<b>42.63</b>	<b>42.63</b>	<b>42.63</b>
Veliko Tarnovo	30.53	30.31	30.31	30.31	30.31
Gabrovo	13.90	13.90	13.90	13.90	13.90
Razgrad	62.37	62.37	62.37	62.37	62.37
Ruse	56.87	56.87	56.87	56.87	56.87
Silistra	53.17	53.17	53.17	53.17	53.17
<b>North–East region</b>	<b>32.20</b>	<b>32.20</b>	<b>32.20</b>	<b>32.20</b>	<b>32.47</b>
Varna	11.18	11.18	11.18	11.18	11.18
Dobrich	51.23	51.23	51.23	51.23	51.23
Targovishte	42.14	42.14	42.14	42.14	43.73
Shumen	21.95	21.95	21.95	21.95	21.95
<b>South–West region</b>	<b>30.50</b>	<b>30.50</b>	<b>30.50</b>	<b>30.45</b>	<b>30.50</b>
Blagoevgrad	23.78	23.78	23.78	23.78	23.78
Kyustendil	18.18	18.18	18.18	18.18	18.18
Pernik	27.10	27.10	27.10	27.10	27.10
Sofia	40.93	40.93	40.93	40.81	40.93
<b>South Central region</b>	<b>34.57</b>	<b>34.57</b>	<b>34.66</b>	<b>34.71</b>	<b>34.75</b>
Kardzhali	23.75	23.75	23.75	23.75	23.75
Pazardzhik	46.70	46.70	46.70	46.70	46.70
Plovdiv	38.66	38.66	38.66	38.66	38.66
Smolyan	33.57	33.57	33.57	33.57	33.57
Haskovo	27.06	27.06	27.43	27.62	27.80
<b>South–East region</b>	<b>38.94</b>	<b>38.94</b>	<b>38.94</b>	<b>38.94</b>	<b>38.94</b>
Burgas	33.78	33.78	33.78	33.78	33.78
Sliven	57.95	57.95	57.95	57.95	57.95
Stara Zagora	42.08	42.08	42.08	42.08	42.08
Yambol	26.39	26.39	26.39	26.39	26.39

Table 24. Category II density, length–area density, unit: km per 1000 km<sup>2</sup>, 2008–2012

### 2.2.4 Category III density(length–area)

The distribution of category III is totally different from motorways, obviously, in the regions with motorways, the density is much lower than regions without motorways. Nevertheless, for regions without motorways, the closer it's to motorway, the higher the density is (Table 25).

	2008	2009	2010	2011	2012
<b>North–West region</b>	<b>116.72</b>	<b>116.78</b>	<b>116.93</b>	<b>117.04</b>	<b>117.04</b>
Vidin	150.52	150.52	150.52	150.52	150.52
Vratsa	92.06	92.06	92.86	92.86	92.86
Lovech	131.61	131.61	131.61	131.61	131.61
Montana	105.21	105.48	105.48	106.02	106.02
Pleven	110.31	110.31	110.31	110.31	110.31
<b>North Central region</b>	<b>125.00</b>	<b>125.00</b>	<b>125.00</b>	<b>125.34</b>	<b>125.34</b>
Veliko Tarnovo	138.24	138.24	138.24	138.24	138.24
Gabrovo	179.37	179.37	179.37	179.37	179.37
Razgrad	108.96	108.96	108.96	110.89	110.89
Ruse	90.63	90.63	90.63	90.63	90.63
Silistra	109.24	109.24	109.24	109.24	109.24
<b>North–East region</b>	<b>112.59</b>	<b>112.59</b>	<b>112.66</b>	<b>112.66</b>	<b>112.73</b>
Varna	126.99	126.99	126.99	126.99	126.99
Dobrich	106.06	106.06	106.27	106.27	106.27
Targovishte	135.15	135.15	135.15	135.15	135.55
Shumen	89.78	89.78	89.78	89.78	89.78
<b>South–West region</b>	<b>94.62</b>	<b>94.62</b>	<b>94.62</b>	<b>95.75</b>	<b>95.60</b>
Blagoevgrad	66.21	66.21	66.21	66.21	66.21
Kyustendil	147.49	147.49	147.49	147.49	147.49
Pernik	164.24	164.24	164.24	169.16	169.16
Sofia	77.61	77.61	77.61	78.91	78.55
<b>South Central region</b>	<b>118.84</b>	<b>118.84</b>	<b>118.84</b>	<b>118.79</b>	<b>118.79</b>
Kardzhali	148.62	148.62	148.62	148.62	148.62
Pazardzhik	98.71	98.71	98.71	98.71	98.71
Plovdiv	97.13	97.13	97.13	97.13	97.29
Smolyan	130.90	130.90	130.90	130.90	130.90
Haskovo	135.32	135.32	135.32	135.13	134.95
<b>South–East region</b>	<b>87.13</b>	<b>87.13</b>	<b>87.18</b>	<b>87.49</b>	<b>87.43</b>
Burgas	80.76	80.76	80.76	80.76	80.76
Sliven	72.86	72.86	72.86	72.86	72.86
Stara Zagora	83.57	83.57	83.77	84.94	84.75
Yambol	0.12	0.12	0.12	0.12	0.12

Table 25. Category III density, length–area density, unit: km per 1000 km<sup>2</sup>, 2008–2012

In order to evaluate the overall roads situation of one administrative district, a comprehensive analysis is needed which combine the relations of all categories. Due to the density results of total road length show no significant difference all over Bulgaria (Table 21), a analysis about the comprehensive density is forwarded.

## 2.2.5 Comprehensive density (length–area)

For the comprehensive density, every category is given a weight depending on the intensity model (Category I as the standard). The weights are shown in table 26. Table 27 is the result of comprehensive analysis. Administrative districts which have better national road networks like Sofia, Varna and Pernik top the density list. Meanwhile, Montana, Smolyan and Blagoevgrad's national road networks are in the end.

	Motorway	Category I	Category II	Category III
Weight	2	1	0.6	0.4

Table 26. Weight of national roads. Category I as the standard

	2008	2009	2010	2011	2012
<b>North Bulgaria</b>	<b>101.60</b>	<b>101.60</b>	<b>101.63</b>	<b>101.69</b>	<b>101.74</b>
<b>North–West region</b>	<b>91.87</b>	<b>91.89</b>	<b>91.95</b>	<b>91.99</b>	<b>91.96</b>
Vidin	103.61	103.61	103.61	103.61	103.61
Vratsa	89.70	89.70	90.02	90.02	90.02
Lovech	92.05	92.05	92.05	92.05	91.91
Montana	82.54	82.65	82.65	82.87	82.87
Pleven	93.42	93.42	93.42	93.42	93.42
<b>North Central region</b>	<b>106.63</b>	<b>106.59</b>	<b>106.59</b>	<b>106.73</b>	<b>106.73</b>
Veliko Tarnovo	106.51	106.38	106.38	106.38	106.38
Gabrovo	119.95	119.95	119.95	119.95	119.95
Razgrad	102.57	102.57	102.57	103.34	103.34
Ruse	110.74	110.74	110.74	110.74	110.74
Silistra	96.22	96.22	96.22	96.22	96.22
<b>North–East region</b>	<b>109.24</b>	<b>109.24</b>	<b>109.27</b>	<b>109.27</b>	<b>109.46</b>
Varna	124.32	124.32	124.32	124.32	124.32
Dobrich	90.74	90.74	90.82	90.82	90.82
Targovishte	109.95	109.95	109.95	109.95	111.06
Shumen	117.49	117.49	117.49	117.49	117.49
<b>South Bulgaria</b>	<b>98.00</b>	<b>98.00</b>	<b>98.55</b>	<b>99.40</b>	<b>102.14</b>
<b>South–West region</b>	<b>98.08</b>	<b>98.08</b>	<b>98.08</b>	<b>100.58</b>	<b>100.10</b>
Blagoevgrad	54.27	54.27	54.27	54.27	54.27
Kyustendil	98.53	98.53	98.53	98.53	98.53
Pernik	114.80	114.80	114.80	124.98	124.16
Sofia	126.46	126.46	126.46	129.52	128.62
<b>South Central region</b>	<b>98.47</b>	<b>98.47</b>	<b>100.00</b>	<b>100.01</b>	<b>100.57</b>
Kardzhali	100.34	100.34	100.34	100.34	104.19
Pazardzhik	104.72	104.72	104.72	104.72	104.72
Plovdiv	98.94	98.94	98.94	98.94	99.00
Smolyan	72.50	72.50	72.50	72.50	72.50
Haskovo	107.55	107.55	113.85	113.89	113.92
<b>South–East region</b>	<b>97.37</b>	<b>97.37</b>	<b>97.39</b>	<b>97.51</b>	<b>106.02</b>
Burgas	93.85	93.85	93.85	93.85	93.85

Sliven	88.30	88.30	88.30	88.30	114.11
Stara Zagora	111.72	111.72	111.80	112.27	120.41
Yambol	93.05	93.05	93.05	93.05	103.72

**Table 27. Comprehensive density, length–area density, unit: km per 1000 km<sup>2</sup>, 2008–2012**

In conclusion, the development and construction of Bulgaria national road networks are unbalanced. Particularly, the region of Sofia, east costal regions and motorway regions enjoy a high development level of national road networks. The reasons are obvious. As we all know, Sofia regions as the economic and industry center of Bulgaria has well–developed national road networks. Additionally, motorways contribute most to the national road networks with it's supporting roads to make sure the traffic load in control. Further more, Eastern costal regions are tourism resorts and the concentration area of tourists. However, among the three districts (Dobrich, Varna and Burgas), only Varna (124.32) has a comprehensive density beyond 100, that is, Varna has a better national road networks than Dobrich (90.82) and Burgas (93.82). Thus, it is necessary to improve the roads in Dobrich and Burgas.

Then it comes up with a question, how to construct the national road networks. The method introduced above calculates the density based on the length and area. By the analysis, we get the result about comprehensive density which indicates the development level of the national road networks. Theoretically, the higher the density is, the better condition is. However, we can't tell if the density meet the requirement of different aspects. In order to judge if the density of national road networks also meet requirements of certain aspects, we need a further analysis.

## 2.3 Density: Tourists number – length of roads

In this paper, we are going to analyze if the national road networks still meet the requirements with the increasing tourism in the next five years. More specifically, how much the national road networks are needed as the development of tourism from the year 2013 and 2017, which regions doesn't need to improve and which regions do.

Consequently, another road density is defined as the average population per kilometer. It means the higher the density is, the more pressure the roads have. We get the density results related to the increasing number of tourists<sup>25</sup>. From the year 2013 to 2017, we assume the number of tourists increase by 10% annually and the national roads network stay in the same situation.

### Formula

$$\text{Density} = \frac{\text{tourist numbers}}{\text{area(km}^2\text{)}}$$

#### 2.3.1 Motorway number/length density

The night–spent number/length density had a decline from 2008 and recovered from the year 2010. In 2012, the night–spent number/length density of most districts was still below the night–spent number/length of 2008. For instance, the tourist–length density of Varna was 65,299 night–spent/km in 2008 and decreased to 51,615 person/km in the following year. After three years, the night–spent number/length was about the same level as 2008 with a density of 65,337 night–spent/km. Due to the hypothesis that the number of night spent rises at a rate of 10% every year while the length of roads remain the same, the night–spent number/length density is climbing at the same rate at the same time. (Appendix C)

#### 2.3.2 Category I roads number/length density

The values of tourist–length density is from one extreme to another. In eastern Bulgaria, especially Varna Dobrich and Burgas, the tourist–length density was beyond 10,000 person/km. In contrast, the lowest density was 37.7 night–spent/km (2012) of Pernik which located in the western Bulgaria. The average night–spent number/length density was about 4,500 person/km in 2012. With the number of tourist increasing at 10% annually, the density reaches 7,968 person/km in 2017. (Appendix D)

#### 2.3.3 Category II roads number/length density

distribution of the category II tourist–length number density is similar to Category I . The regions with high dense concentrated in the eastern Bulgaria. Meanwhile, central Bulgaria has a relative higher density than Northwestern Bulgaria. (Appendix E)

#### 2.3.4 Category III roads number/length density

As is shown in Appendix E, in 2012 the first three highest administrative districts were Burgas (9,681), Varna (7,944.6) and Dobrich (2,873) followed by Blagowgrad (1,024). The density of other districts were below 1000 person/km. from the year 2008 to 2012, the average first decreased to 788 then increase again and reached 1116, that is, the pressure on the Category III roads has increased in the past five 5 years regardless of the economy crisis. (Appendix E)

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<sup>25</sup> Night spent number

### **2.3.5 Conclusion**

For this paper, there is only one factor, that is, tourism. Thus, the analysis is about the density increase related to the number of night spent. Theoretically, the factors affecting road density are diverse, not only population, road conditions and tourism, other aspects like industry, motorization should also be taken into consideration. In the future researches, more indicators will be added in the analysis.

## Chapter 3: Software Analysis

In last chapter, we have analyzed the national road network of Bulgaria and predict the intensity and density from the year 2013 to 2017. Though we list tables to show the results, the data reflected above are not clear to viewers, that is, the tables can't bring the viewers a direct visual expression. In this paper, we seek the optimal solutions for visualizing the spatial data by estimating different software. The visualization effect should be understood by the viewers quickly, accurately and directly.

### Analysis objectives

When talking about the methods of data expression, it is generally acknowledged that the form of table is better than text, figure and chart are better than table for expression of data. Take the result of analysis (length/area density, Category I roads,) as the example. From the text description, after reading we get some information about the density. The biggest restriction is that only part information can be described by text, for instance, from the example we know the general density of the Bulgaria. If the viewers want to check the density of one certain administrative district, better solution is list all the density data in a table. The table can list the density in the order of alphabet or low to high or vice verse. However, one of the objectives of this paper is to visualize the trends and tendencies of spatial statistics which is a weakness of tables. In order to present the trends tendency, especially for a time serious, figures and charts are the normal options. What's more, different types of figures and charts put emphasis on different kinds of data, choosing the right chart or figure can help viewers get the information they want quickly.

However, for data containing both statistics and spatial information, though the charts and figures can reflect the numbers in different types intuitively and detailed, the spatial information are still missing. Even we can find the density of every administrative district in tables, figures or charts. The spatial relations are missing, such as how is the distribution of density? Or which regions have higher density?

In cartography, we can present the data by thematic maps so that the spatial information can be expressed. For instance, choropleth maps and proportional symbol maps. Figure 21 is a choropleth map with the night spent number (2012) of every administrative district which reflect both the statistical and spatial information. Nevertheless, compared to tables and charts, a single map has its own restrictions in displaying the time series statistical data.



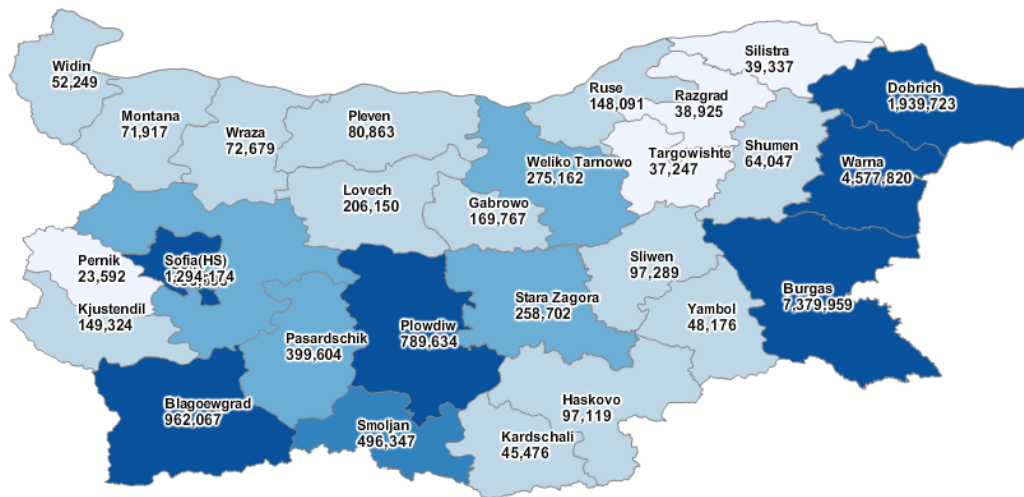


Figure 23. Night spent choropleth map, 2012

Thus, another problem for this thesis is to combine the spatial statistics and geographical features together. The purpose is to implement a visualization containing the capacity of Bulgaria roads of different time series.

### Data sources

The data are two parts:

#### 1. Spatial statistics:

Intensity	unit: vehicles/day			
roads type	Motorway	Cate I	Cate II	Cate III
period	2008–2017	2008–2017	2008–2017	2008–2017
data region	Bulgaria	6 regions	6 regions	districts
Length/area density	unit: vehicles/day			
roads type	Motorway	Cate I	Cate II	Cate III
period	2008–2012	2008–2012	2008–2012	2008–2012
region	districts	districts	districts	districts
others	Total	Comprehensive		
	2003–2012	2008–2012		
Night–spent/length density	unit: night spent/ length			
roads type	Motorway	Cate I	Cate II	Cate III
period	2008–2017	2008–2018	2008–2019	2008–2020
region	districts	districts	districts	districts

Table 28. Spatial data list of three capacity analysis

#### 2. Geographical features: Bulgaria administrative districts, national roads network, including:

Name	Description
BGAbg.jpeg	A raster layer used as a background which is a topographical map
BGAadmin_a.shp	A vector layer contains the administrative districts of Bulgaria

BGAadmin_b.shp	A vector layer stores borders geographical information
BGAmotorway.shp	Motorways are stored as polyline, vector layer
BGAprimary.shp	Roads correspond to the Category 1 roads saved as polyline
BGAsecondary.shp	Roads correspond to the Category 2 roads save as polyline
BGAtertiary.shp	Roads belong to Category 3 roads as polyline saved as vector features

**Table 29. Geographical data list**

### **The visualization should meet the requirements:**

- The combination of spatial data and geographical data
- Legibility: The visualization should have legibility to make the viewers get the information easily, quickly and directly

### **Design of visualization sample**

- Background layer: A raster layer about the landscape of Bulgaria as the background
- Thematic layer: A vector map layer contains data about the traffic load on the road network of Bulgaria
- Statistical layer: A layer describing the changes of the capacity in the same region as a function of space and time axis

### **Possible problems**

- The analysis of different road types depending on variable regions, that is, for different analysis, the combination of spatial and geographical data are not constant
- Generally the roads in the shapefile are discontinuous. As polyline, the roads are divided into many parts. It is unrealistic to get the capacity data for every part

The following step is to seek a software which can meet the requirements and may solve the possible problems. Furthermore, we try to estimate the performance of 4 different software in establishing the visualization of the spatial analysis. The four software are:

QGIS

GeoServer

Geopublish

StatSilk

Table below shows the general information of the four software:

	<b>QGIS</b>	<b>GeoServer</b>	<b>GeoPublish</b>	<b>StatPlanet Plus</b>
Developer(s)	QGIS Development Team	Pitney Bowes	Wikisquare software development	StatSilk
Support formats	Vector data:  ESRI shapefiles MapInfo Layer ArcInfo Coverage PostGIS Layer .ect Raster data: Arc/Info Binary Grid Arc/Info ASCII Grid Grass Raster GeoTIFF.ect	Vector data:  ESRI shapefiles Directory of spatial files Java Properties .ect  Raster data: GeoTiff,  GTOPO30,  WorldImage, ImageMosai.ect.	Vector data:  ESRI shapefiles OGC GML OGC WFS PostGIS .ect  Raster data: GeoTiff files.ect  Multimedia:  PDF documents, Images(jpg.png,gif) Videos.ect	Vector data:  ESRI shapefiles Adobe Illustrator(.ai) Adobe Flash(.swf)  Raster data: GeoTiff  Images(jpg.png,gif).ect
Features	Automatically import map from files or online Individualized map Mapping  Spatial & Attribute Data Analysis Variety extensions	Maps styled by SLD  Designed for interoperability Standard open web protocols	Publish atlas rather than maps  Support multimedia Maps styled by SLD Visualization of analysis	Visualization of analysis  Automatically import data or manually Individualized map  Adobe Flash Player and Excel based software  Publication of maps in Adobe Flash or online
Free & Price	Free	Free	Free	Free for desktop Charge for publishing online
Publish	Desktop version Online Content and Capabilities	Desktop version Internet connectivity	Desktop version Web version	Desktop version, Web version Update available
Advantages	Open source Well performance in the terms of map processing and analysis	Open source Well performance in the terms of map processing and analysis	Multimedia support Interoperability	Extensive indicators Visualization of data with different panels

	Data imported by SQL automatically .	Data imported by SQL automatically Providing WMS by the request .	.	Interactive and attractive interface  Individuation and customization Non–technical knowledge needed
Disadvantages	Weakness of presenting diagrams due to the limited plugins. No interactivity between maps and data.	Data format of Mapinfo  More focus on attributes than Analysis	Unfriendly interface  Limited functionalities	Charge for publication and updating  Relative smaller vendor than competitors like Pitney Bowes and ESRI

**Table 30. General information of 4 software**

### 3.1 QGIS Quantum GIS analysis

**Quantum GIS**, or QGIS for short, is an open source GIS application. Unlike ArcGIS only has Windows version, QGIS can be installed on various operating system. More importantly, customers can use it for free with many plugins. Though QGIS has different functions, so far, it does not have abundant documents and sometimes it may cause confusion when using it. In next part, we will try to find the useful functions for achieving the goal of the paper (Gary E. S et al. 2005).

#### Acknowledge required:

QGIS, PostgreSQL

#### Functions:

QGIS as a GIS application, has no difficulty in adding both the raster layer and vector layer. In the terms of displaying diagrams with maps, among the QGIS plugins, there are two methods allowing customers to display diagrams, 'Diagram Tab' and 'Diagram Overlay'.

The 'Diagram Tab' function provides support for pie charts and text diagrams.

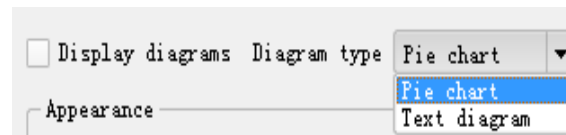


Figure 24. Function "Diagram Tab" in QGIS

The 'Diagram Overlay' Plugin allows customers to add a graphic overlay to a vector layer and provides additional and not yet implemented features to the Diagrams Tab.

#### Procedures:

- Step 1: Load vector and raster layers into QGIS,
- Step 2: Modify the features and attributes to present;
- Step 3: Add statistic data into QGIS and connect data to geographical features;
- Step 4: Show the statistic data as an overlay;
- Step 5: Export map.

#### Problems:

Generally, a complete GIS are composed by three parts. After the processing in QGIS, PostGIS can be used for importing spatial data while Web GIS Server publishing the maps and indexing the data. Considering the requirements of the paper, the values of intensity and density can be imported and connect to the geographical features by PostgreSQL, however, here the first problem occurs, for the values of intensity or density, the corresponding geographical features are administrative districts rather than the roads. What's more, the roads features as polyline are extracted from OSM are not grouped into the unit of administrative districts. For grouping roads, first we need to assign the names of administrative districts to every polyline, then merging features into groups which are in the same districts.

Another problem is the plugins provided by QGIS enable only pie chart and text diagram which are not sufficient for indicating the results of capacity analysis.

Generally, pie charts are used for illustrating numerical proportion, however, it's insufficient for comparing data across different indicators or time.

**Advantages:**

- Open source software
- The map files can be operated in QGIS directly; well performance in the terms of map processing and analysis
- The data can be imported automatically by PostSQL

**Disadvantages:**

- Weakness of presenting diagrams due to the limited plugins
- No interactivity between maps and data

**Analysis results:**

Though QGIS shows advantages in the term of analyzing data, it is not an optimal software for combining geographical features and temporal data about the capacity of roads. Thus, we try to evaluate the performance of other applications.

## 3.2 GeoServer analysis

### Introduction:

GeoServer is a free and open source implementation of a web-mapping server, offering access to data in a known set of formats and sources (Frank Hardisty, 2009 ). More important, GeoServer is designed for interoperability, it publishes data from any major spatial data source using standard open web protocols established by the Open Geospatial Consortium (OGC).

### Features and Extensions:

After importing the shapefiles and the raster layer, by using a markup language called Styled Layer Descriptor (SLD), we can style the map into a thematic map depending on the attributes of capacity. GeoServer supports accessing the several database, for instance, PostGIS and MySQL. Though a thematic map somehow represent the attributes nicely, we need to present charts which is hard to achieve in GeoServer. However, GeoServer provides many extensions which are modules with functionality. For achieving the goal for presenting maps and charts at the same time, the extension 'Eastwood Charts'<sup>26</sup> provides the possibility to adding charts to maps.

### Procedures:

1. Processing the road features in QGIS and export;
2. import the processed data source into GeoServer;
3. Create database in PostGIS and import into GeoServer;
4. Styling the layers;
5. adding charts to GeoServer by extension Eastwood Chart;
6. publish the map by Web Map Service (WMS).

### Acknowledge required:

QGIS, PostGIS, XML and Java script.

### Problems:

- In GeoServer, customers can send requests to WMS and get maps as requested. When click on a feature, we can get the attributes information of the features. However, the features are listed in tables instead of charts or figures
- The extension Eastwood Chart support for generating pie charts, bar charts, line charts and scatter plots. Among the charts, line charts have good performance in presenting a series of data. Nonetheless, the charts are over the map layers as dynamic symbolizes. The roads are covered by the charts. What's more, the line chart can only display one indicator of one administrative district which leads to blocking display
- Recent researches point a way to implement the combination of WMS and tables by Internet Graphics Server. However, the features in GeoServer and chart are not connected together, that is, no interoperability between the map and the chart

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<sup>26</sup> Eastwood Charts is an independent and open source implementation of the Google Chart API, <http://www.jfree.org/eastwood/>

**Advantages:**

- GeoServer as an open source WMS have broadest customers
- The Customers can get geographical features by send different requests to WMS
- Styling is done with SLD files which also the OGC way, for customers who are not familiar with XML, there are some open source application for generating SLD files automatically, for example, uDig<sup>27</sup>;
- The Eastwood chart extension implement functions to show various charts in GeoServer;
- The end-users only need a web browser to view the data.

**Disadvantages:**

- GeoServer requires acknowledge of more than one computer languages
- The chart extensions are not sufficient in the performance of time series data with multiple indicators

**Analysis results:**

By using GeoServer users can easily publish map data and update, delete and insert the feature data. What's more, users can share geospatial information quickly through GeoServer. Extra extensions support charts such as line chart related to the capacity of the roads. However, the charts are over layers which leads to blocking and only reflect one time series. This paper aims to visualize both the map and charts which is still can't be realized by any extensions. Developing extensions or functions for the interoperability between diagrams and GeoServer is suggested.

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<sup>27</sup> uDig is an open source desktop application framework, built with Eclipse Rich Client technology, <http://udig.refractory.net/>



### 3.3 Geopublish

#### Introduction:

Geopublish is platform-independent and Open-Source software. Meanwhile, it is also an atlas authoring system which allows easy publication of maps, documents, images, videos, and statistics in form of digital multimedia atlases. These atlases can be understood as minimal, pre-configured end-user GIS which offer selected functionality only where its meaningful. (Stefan Tzeggai, 2010)

#### Features:

The significant difference between Geopublish and GeoServer is that the output is an atlas, additional multimedia files are supported. Meanwhile, the files can also be linked to geo-objects by the user.

What's more, Geopublish supports three kinds of charts: Bar chart, linear chart and scatterplot (Fig. 25). Another feature that needs to be mentioned is multi-language, all labels, texts, HTML-pages, menu items, about-information, etc. can be translated in multiple languages.

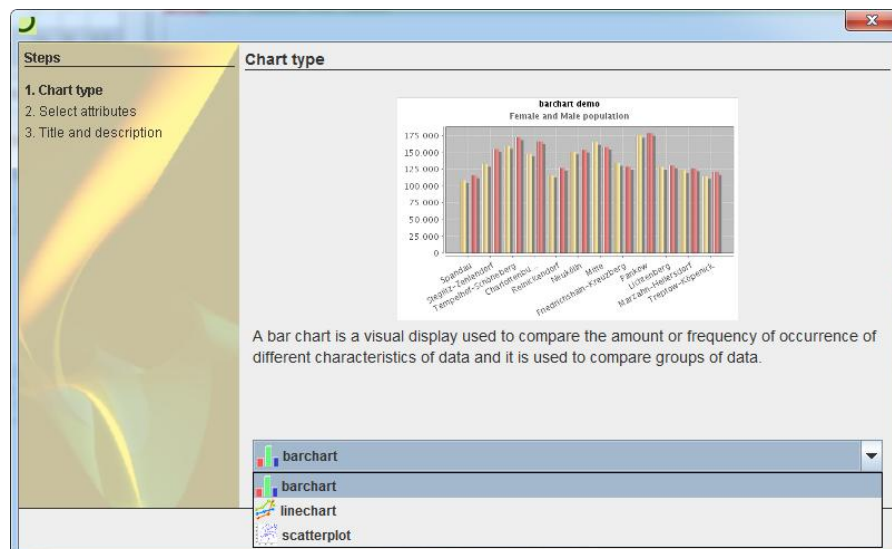


Figure 25. Charts in Geopublish

#### Main procedures:

1. Create an atlas, set the language and basic information,
2. File→import: Import the shapefiles and raster image and enter the information of the files.
3. Add an thematic map and drag the layers into the map;
4. Styling the map;
5. Manage the charts, add multimedia files if necessary;
6. Publish the atlas.

In this case, we image the roads have been grouped in QGIS, and the statistic data can be imported by PostGIS

**Acknowledge required:** Little knowledge of XML, QGIS, PostGIS

**Advantages:**

- Users can start the atlas application from any web browser
- If charts are insufficient, additional description can be added as multimedia files in the menu
- In the term of interactivity between charts and the map, when click one feature on the map, the corresponding value will be highlighted in the chart
- The bar chart supports to display the capacity values of all districts

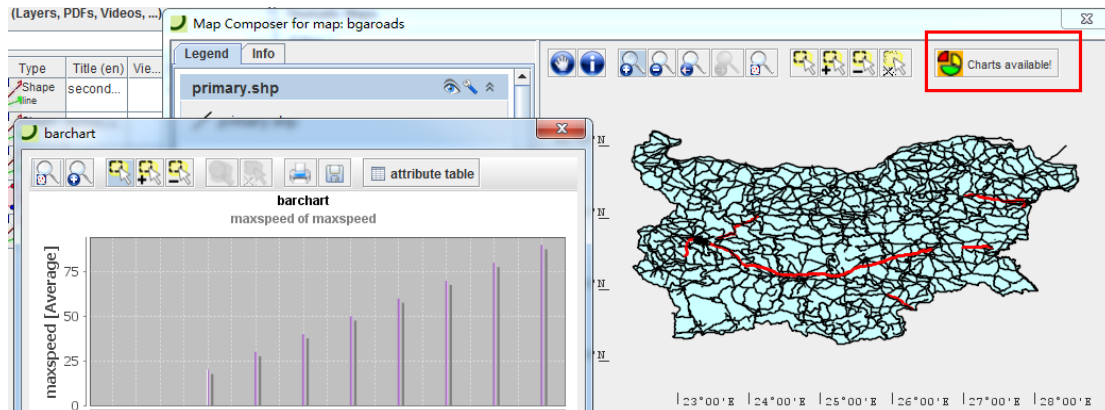


Figure 26. Interface and bar charts of Geopublish

**Disadvantages:**

- The software is still under developing, the interface is not friendly(Fig. 26)
- The linear chart only support three variables which is a limit

**Analysis results:**

In conclusion, Geopublish doesn't need special knowledge and is appropriate for widespread users, especially users without much cartographic knowledge. Due to the software is a new project, many aspects need to be developed, for instance, the interface. The multiple media and the output in the format of atlas are positive aspects. However, little attention has been devoted to the performance of statistic data as the form of charts.

### 3.4 StatSilk analysis

StatSilk is a producer of visualization and mapping software which aims to create visualizations and user-friendly interactively maps based on different needs. The software has three main products: StatPlanet, StatTrends and StatWorld. Among the three products, StatPlanet has the option of creating not only maps, but also interactive graphs and charts. Thus, we evaluate StatPlanet for its feasibility.

#### Features:

The highlight of StatPlanet is the powerful interactive and attractive interface which facilitate the visualization of the data. Another feature are the different types of visualizations including maps, bar charts, line graphs and plots. Future more, the maps and charts are connected together. In the terms of data import, unlike GeoServer, the software is based on the Excel-based data editor to create new maps and visualizations. Moreover, the application can empower organizations to better analyze data and to better disseminate and communicate information considering their needs and automates the normally complex processes of converting raw data into interactive maps and visualizations. The output of StatPlanet can be flash interactive maps and web maps.

#### Procedures:

1. Prepare the data, including the statistic data and ESRI shapefiles.
2. Import the data into Excel by Macros embedded in Excel.
3. Customizing the appearance of by selecting the interface components and changing the settings.
4. Once the steps 1,2,3 are done, the flash interactive map is finished.

**Acknowledge required:** Basic Excel knowledge, Adobe Illustrator

#### Advantages:

- User-friendly interface, no special cartographic or computer skills are compulsory
- The visualization of data can be realized in different ways with a good connection to maps

#### Disadvantages:

- The data should be organized in a specific order to make sure the spatial data can be imported through Excel Macro. StatSilk is not an open source software, in the case to publish it online or used for commercial purposes.

#### Analysis results:

StatPlanet is a powerful software with a outstanding performance of visualizing statistic data. The capacity can be visualized in both maps and charts at the same time. In contrast to the other three software, the work of importing data is being processed in the StatPlanet\_data\_editor, which is a xls file with macros. The paper aims to visualize the trend and tendency based on the capacity of the national road network. The software supports not only various charts but also animation during a certain time.

### 3.5 Software conclusion

The central aim of this paper is aiming at find a appropriate software to display spatial data and topographical data in an optimal way. Due to in recent years, the functionality of cartography has not only restricted to finding locations, showing the landscape, more and more researches are aiming at analysis of the spatial data. The spatial data are various, like census data and weather, without defining the location, the data is meaningless. Nowadays, cartography is playing an important role in different disciplines and aspects. This paper tries to seek the opportunity for cartography development in the terms of statistic and geographical data, that is, a process of information visualization.

These days, for statistic normally visualization method of information are text, tables, diagrams. Maps are more often used for geographical data in the earliest years. However, now additional metadata are added to maps in different ways, thematic maps, choropleth maps, graphic maps.

#### Software performance:

Table 31 show the evaluation of software performance in different aspects.

	QGIS	GeoServer	Geopublish	StatSilk
Formats Support	★★★★	★★★★	★★★★	★★★
Charts and diagrams	★★	★★★	★★★	★★★★★
Analysis	★★★	★★	★	★
Interoperability	★	★★★★	★★★	★★★★
Database	★★★★	★★★★	★★★★	★★
Interface	★★★★	★★★★	★★	★★★★
Visualization	★★	★★★	★★★	★★★★
Visualization effect	★	★★★★	★★	★★★

Table 31. Software performance evaluation

#### Formats Support:

All the software satisfy the requirements for importing the data, both spatial and geographical data.

#### Charts and diagrams:

All the software provide the possibility of adding charts and diagrams, However, the functions of the first three software for implementing charts are not suitable, sufficient and enough for the our goals. StatSilk has the most outstanding performance.

#### Analysis:

The analysis and visualization are processed separately. Thus, the analysis function is not important for achieving the goals.

#### Interoperability:

QGIS has barely interactivity between the users and the maps, while the other three have better performance. However, the interactivity reflected in different aspects. The interactivity of GeoServer is achieved by customer requests and protocols, in contrast, multimedia is the way of interactivity in Geopublish. It is obvious the

interactivity is a highlight in StatSilk, especially when considering the interactivity between geographical features and charts.

#### **Database:**

QGIS and GeoServer support connections to SQL, while Geopublish and StatSilk not. Geopublish provides the possibilities for multimedia while StatSilk using Macros in Microsoft Excel for connecting spatial data and geographical features.

#### **Interface:**

Among the four software, QGIS, GeoServer and StatSilk have matured interfaces which is user-friendly. In contrast, the interface of Geopublish is a bit confused, and the menu bar is not clearly.

#### **Visualization:**

All the four software provide the function of implementing choropleth map. Nevertheless, for the performance of charts, StatSilk has the best performance. Though GeoServer and Geopublish support the pie charts or linear charts as the dynamic symbols, these two still have the restriction in displaying multiple indicators.

#### **Visualization effect:**

Once the map is published, for QGIS and Geopublish, the users can't change anything of the map. On the contrary, users can change the colors and values of legend in StatSilk, meanwhile, by choosing the indicators or the types of charts, the users can get different visualized maps. The Customers can get geographical features by send different requests to WMS. WFS<sup>28</sup> supports customers to view the information of the layers and features.

#### **Conclusion:**

For this paper, there are four indicators reflects the capacity of the national roads networks. Regardless of StatSilk, the other three software can't satisfy the requirements for showing multi-indicators. Thus, we choose the StatSilk for further analysis.

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<sup>28</sup> WFS: Web Feature Service

## 3.6 StatSilk further analysis

According to the comparison of the software above, we are going to implement the visualization of the spatial statistics in StatSilk for further analysis.

### 3.6.1 Procedures

1. Prepare the ESRI shapefiles and import the map files by StatPlanet\_data\_editor:

- Copy the map files (Bulgarien\_Admin\_a.dbf, Bulgarien\_Admin\_a.shx) into the sub-folder "map"
- Run the file "update\_map.bat", it will rename the map files automatically
- Open the StatPlanet\_data\_editor file. Click on the button 'Setup shapefile' and select the "map.dbf" file in the map folder. Then choose the 'ID' column and 'name' column

2. Importing data

- The array of data needs to follow an exact same structure
- Click the button 'Import data' and select the excel file, the data will be imported automatically
- Save the data by clicking the button save data

1. Adjust the project:

- Legend
- Map position
- Charts options. ect

2. Run StatPlanet to see the results with the spatial data.

The result is a choropleth map (Fig. 27), meanwhile, charts panels are placed in the top, the data can be visualized in bar charts, linear charts and dot charts. When choosing the district, the district will be highlighted both in choropleth map and charts, vice versa.

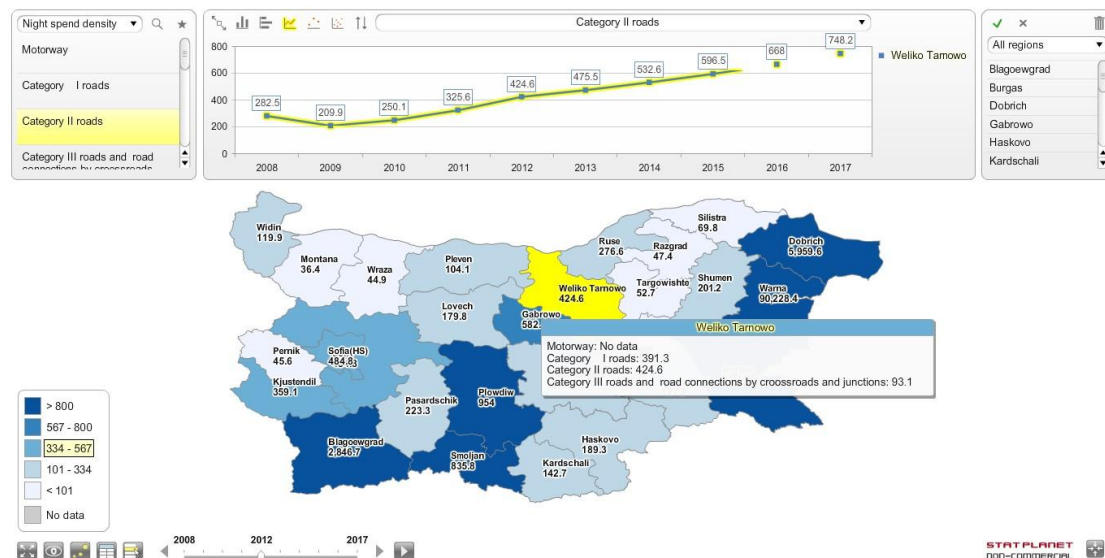


Figure 27. Screenshot of the project by StatPlanet

However, as we can tell, the project is a choropleth map without the national roads due to only one shapefile can be imported. Thus, it comes up with a problem: "How to import more than one shapefile in StatPlanet?"

Thus, we can merge the roads with the administrative districts into one shapefile. However, the roads are polyline features, before we merge the roads, the roads should be buffered to polygon.

Then we do the steps above again, the result is shown in Figure 28, the problem is the roads features are covered by the regions. Though we want to change the orders, the StatPlanet doesn't provide the possibility of re-arranging the orders of the layers.

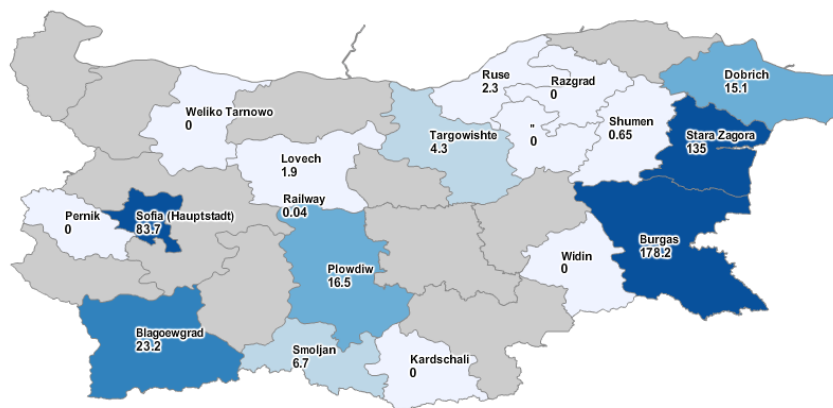


Figure 28. Screenshot of the project by StatPlanet

Thus, an alternative is to use the Flash map edition of StatPlanet. Due to The Flash map edition enables the users to re-arrange the order of map areas.

#### 1. Converting a shapefile map into a vector format for Adobe Flash.

- The shapefile map first need to be converted into Adobe Illustrator vector files using software such as ArcGIS or MAPublisher. Then we get the Adobe Illustrator (AI) files

- Then open the Adobe Illustrator file in Adobe Flash and export the image as a Flash SWF file

*Import:*

The shapefile maps are BGAadmin\_a.shp, BGAadmin\_b.shp, BGAmotorway.shp, BGAprimary.shp, BGAssecondary.shp, BGAtertiary.shp;

*Export:*

BGAadmin\_a.swf, BGAadmin\_b.swf, BGAmotorway.swf, BGAprimary.swf, BGAssecondary.swf, BGAtertiary.swf

2. Insert the flash map in Adobe flash.
  3. Break apart the shapes of the map, this step aims to get the polygon features as components.
  4. Convert the components one by one and convert each of them into a Movie Clip and assign an instance name to each of the movie clips. The instance names are used for defining the actual names later in the StatPlanet Data Editor.
  5. Publish the map as a SWF file. The following step is to copy and paste this file into the folder.
  6. Linking the map in StatPlanet Data Editor
- Unlike the shapefile version of StatPlanet, the flash version requires users to insert the 'real names' of your map regions in StatPlanet\_data\_editor.xls, and then the 'instance names' or codes which you used in the map file (map.swf).
7. Then we can import and insert the data from a file with specific structure as described before.
  8. Once the data has been added, press the button 'Save data'. Now we can open the StatPlanet.exe or StatPlanet.html to see the results.
  9. Others: Changing the position and size of the map and other options.



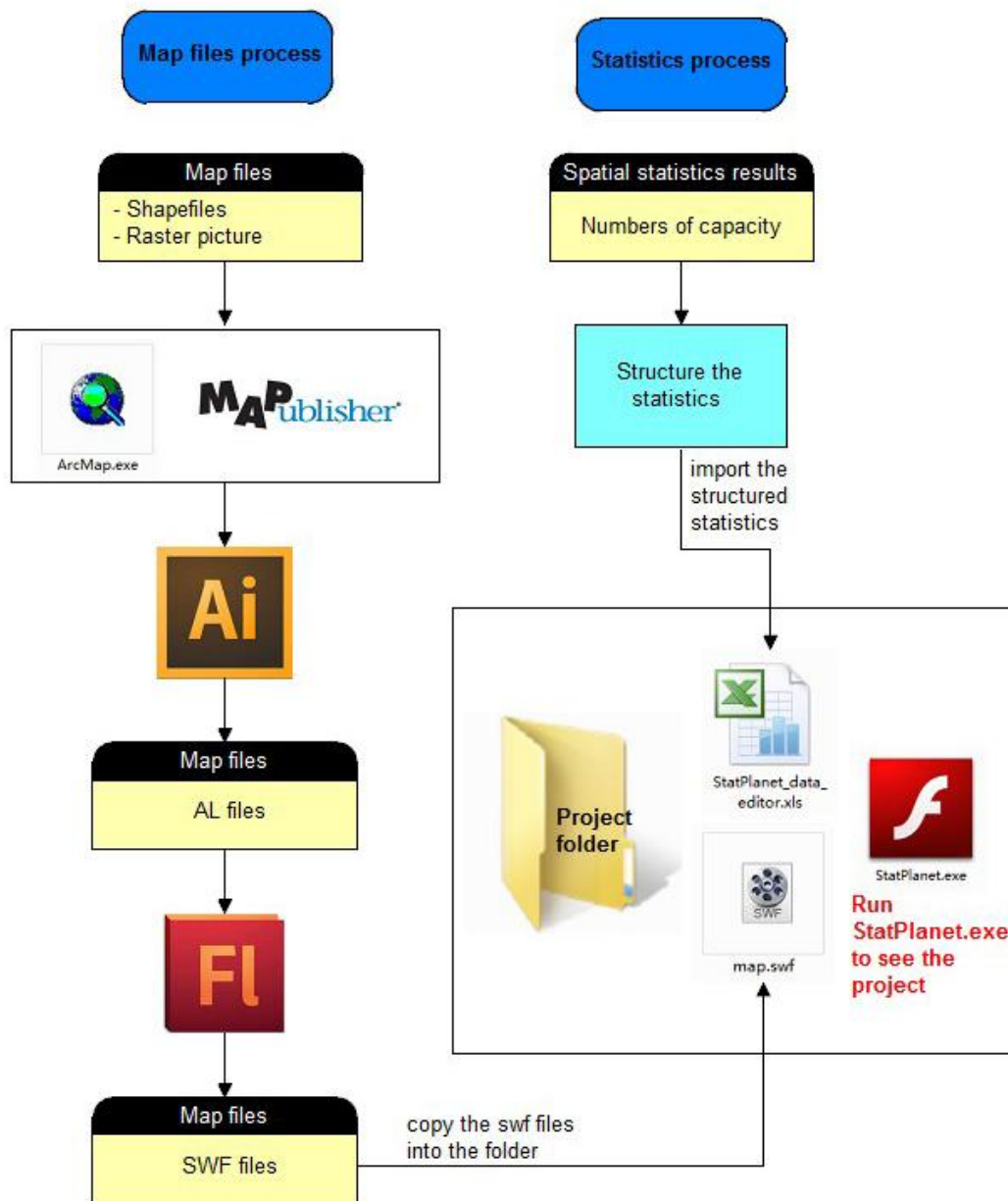


Figure 29. Procedures of the project in StatSilk

### 3.6.2 Project analysis

#### Features:

#### Help Screen

The project is a flash based map, first, it starts up with a help screen (Fig. 30), this setting can be stetted in the setting sheet and is helpful for users who are not familiar with this software. However, this function can be cancelled in the settings.

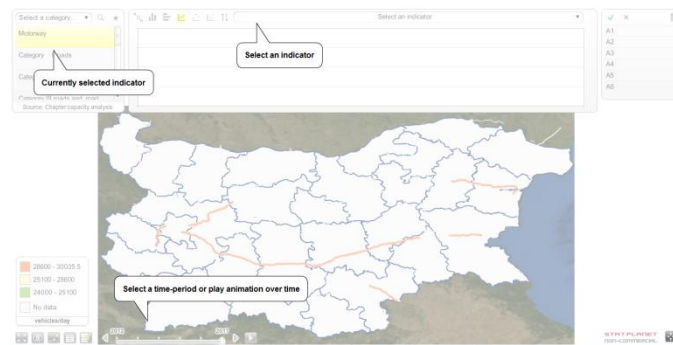


Figure 30. Screenshot of Help screen in StatPlanet

## Main Interface

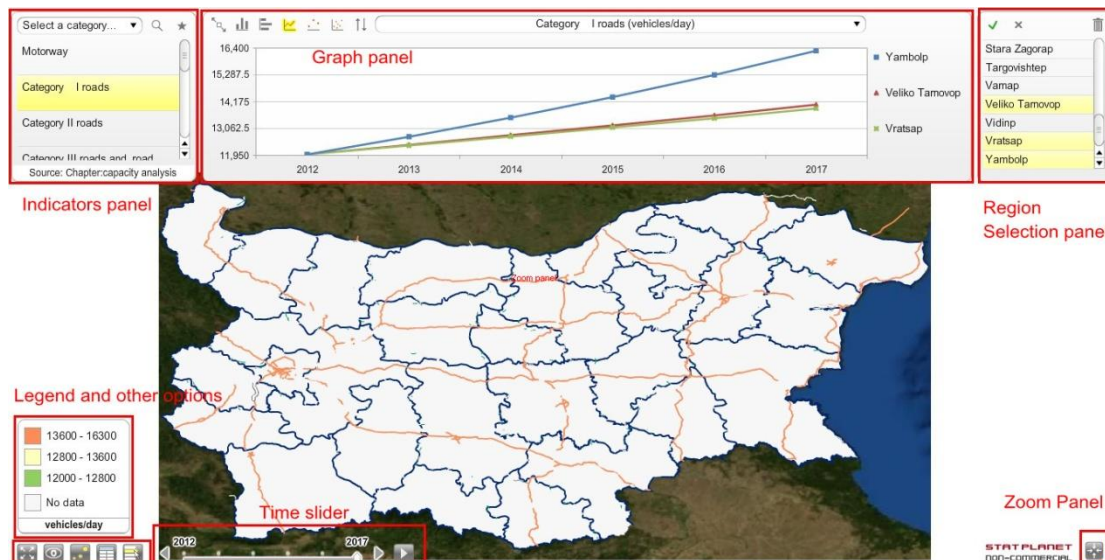


Figure 31. Main interface of StatPlanet

The main components of the project are Indicator panel, Graph panel, Region Selection panel, Zoom panel, Time slider and Legend and other options.

## Indicators panel

Viewers can use the drop-down menu in the right top of the Indicators panel to select a new category. When moving the mouse over one indicator, description of the indicator will be shown (Fig. 32).

The Search function brings up a popup which enables the users to filter the list of indicators to find the one they need (Fig. 33).



Figure 32. Description of the indicators

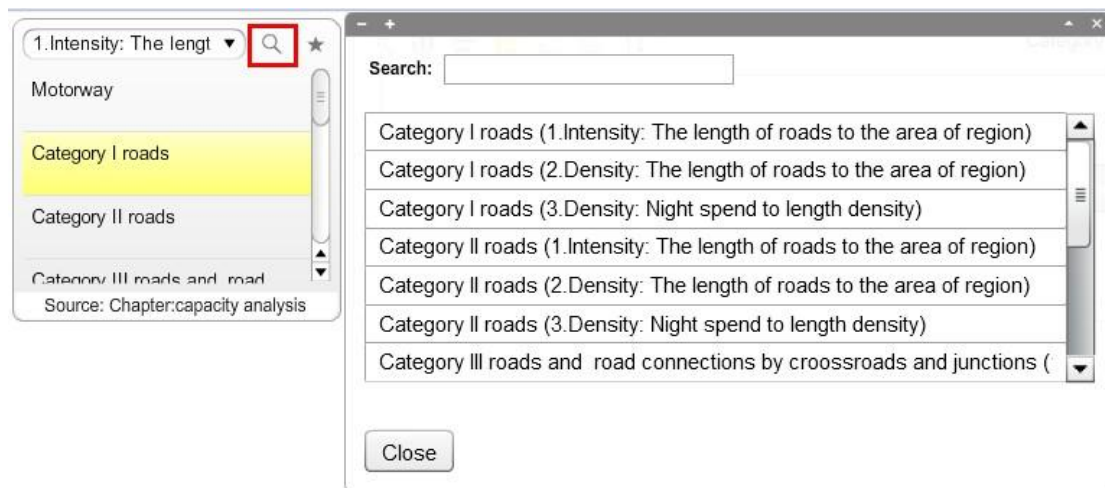


Figure 33. Search function in Indicator panel

## Categories and Indicators

For this project, there are three categories with their own indicators:

1: Intensity: the length of roads to the area of region

1.Intensity: The length of roads to the area of re...	Motorway
2.Density: The length of roads to the area of regi...	Category I roads
3.Density: Night spend to length density	Category II roads
	Category III roads and road connections by crooss...

Figure 34. Screenshot: Category I and indicators in StatPlanet

2. Density: the length of roads to the area of region

1.Intensity: The length of roads to the area of re...	
2.Density: The length of roads to the area of regi...	Total
3.Density: Night spend to length density	Motorway
	Category I roads
	Category II roads
	Category III roads and road connections by crooss...
	comprehensive density

Figure 35. Screenshot: Category II and indicators in StatPlanet

3. Density: night spend to length density

1.Intensity: The length of roads to the area of re...	
2.Density: The length of roads to the area of regi...	
3.Density: Night spend to length density	Motorway
	Category I roads
	Category II roads
	Category III roads and road connections by crooss...

Figure 36. Screenshot: Category III and indicators in StatPlanet

## Graph panel

The graph panel enables bar chart, column chart, time series, vertical bubble chart and scatter plot (Fig. 37).

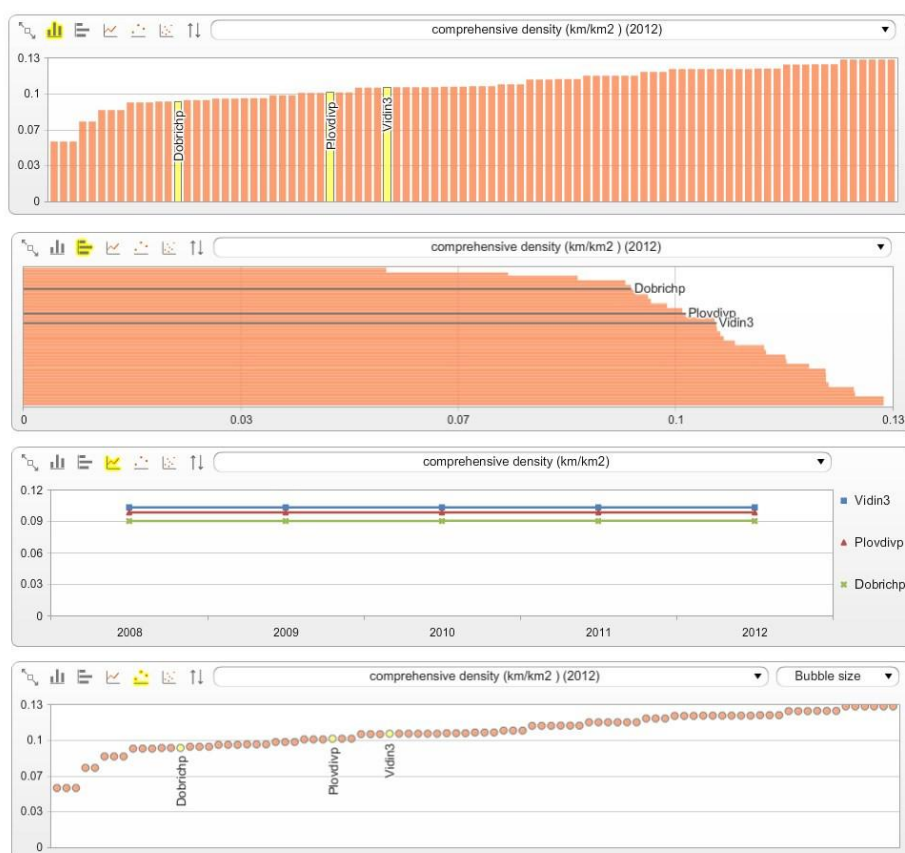


Figure 37. Screenshot of charts in StatPlanet

## Region Selection panel

The Region Selection panel is in the right top corner, multiple regions can be selected, at the same time, the regions selected will be highlighted in charts (Fig. 38).

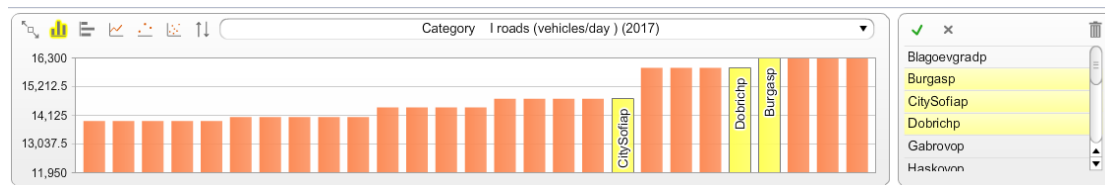


Figure 38. Region Selection panel in StatPlanet

## Legend

Users are allowed to edit and adjust the legend, not only the color, but also the values for each color (Fig. 39).

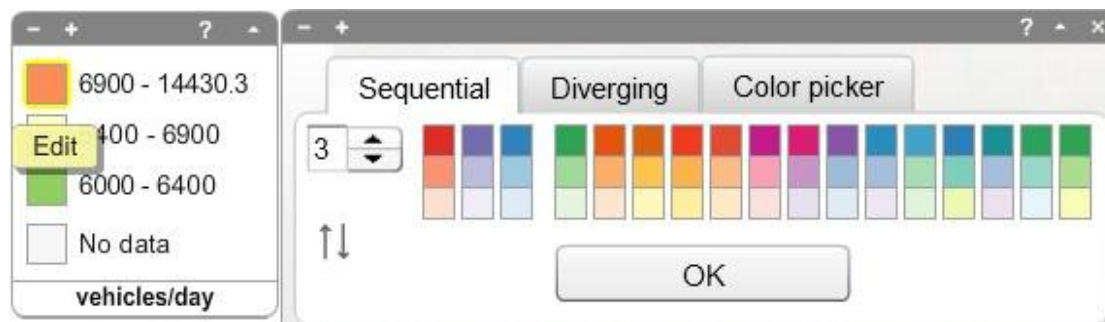


Figure 39. Legend in StatPlanet

## Time Slider

The spatial statistics are time series data, users can click on the arrow buttons to change the year. What's more, the time slider enables animation and shows changes over time. When click the play button, viewers can see the capacity of road networks over time (Fig. 40).



Figure 40. Time slider in StatPlanet

## Other options

Data-table panel: The 'table' button in the bottom-left corner of the screen, users can get a data table of the selected indicator (Fig. 41). The table also have the possibilities to show the mean, standard deviation and range if necessary and the data can be downloaded to the local. Meanwhile, the table has connections to the geographical features and charts.



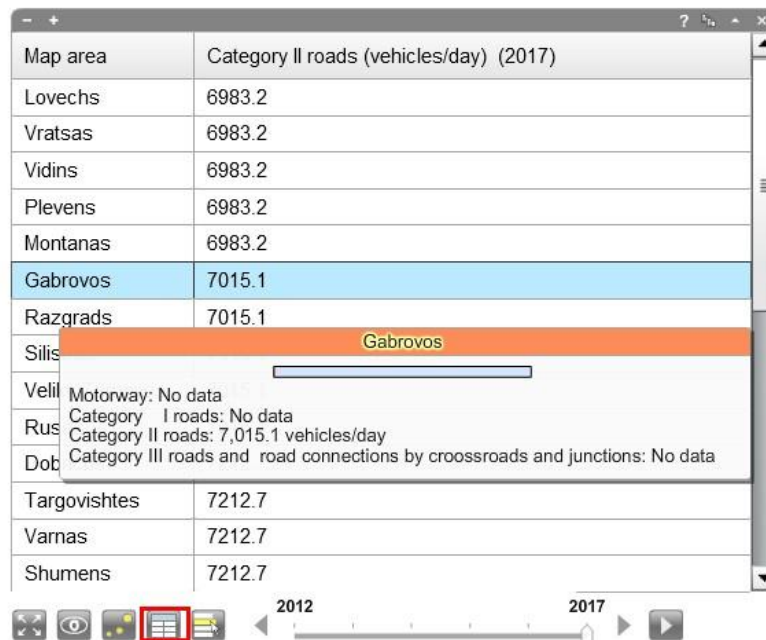


Figure 41. Data-table panel and table in StatPlanet

### Proportional symbol map

A proportional symbol map scales symbols according to the indicator being mapped. In StatPlanet the symbol map is overlaid on top of the choropleth map. This means that two data sets can be shown on the same map—one for the choropleth map and one for the symbol map (Fig. 42).

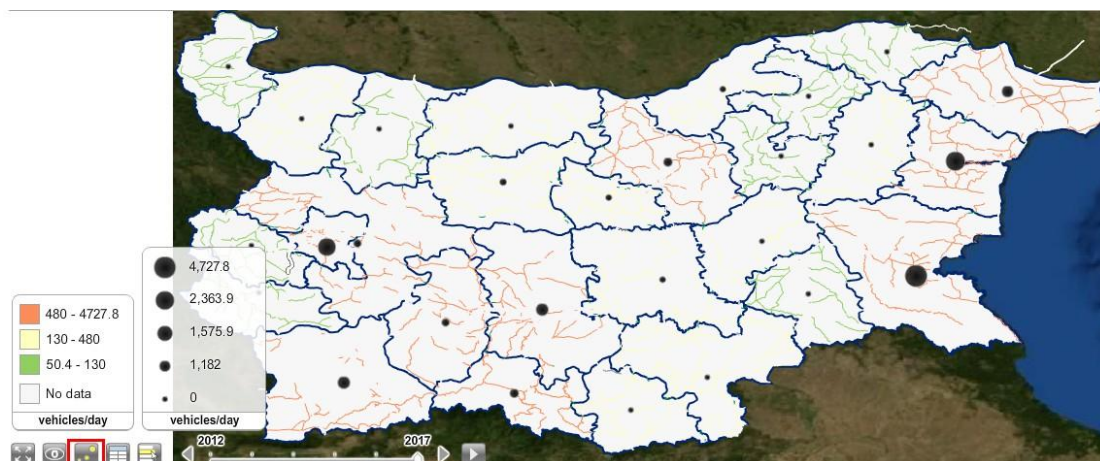
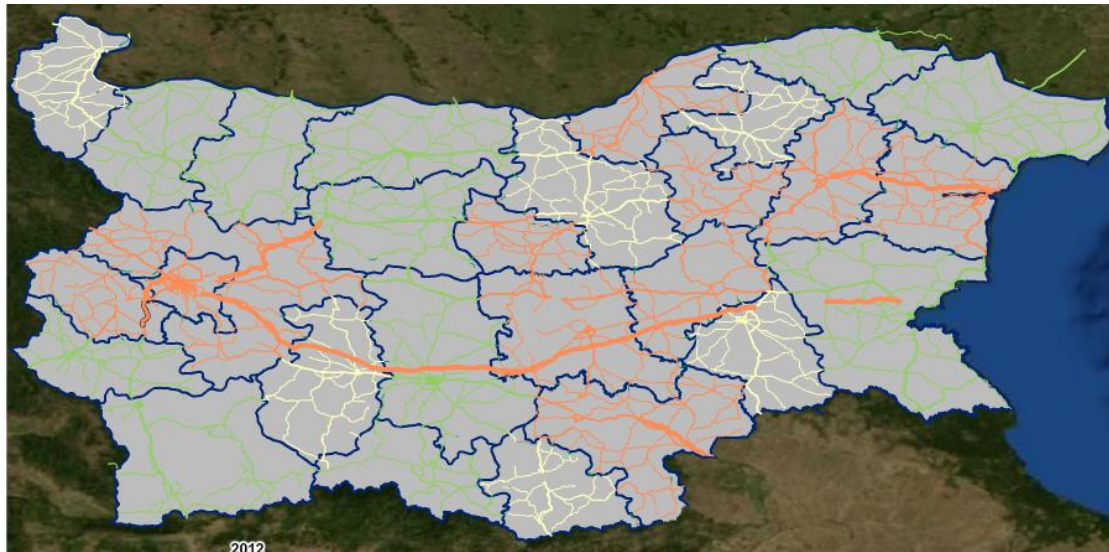


Figure 42. Proportional map in StatPlanet

### Visualization results

Taken the indicator “comprehensive density” as the example, choose category density: the length of roads to the area of region, then click the comprehensive density, the analysis results will be visualized (Fig. 43).



**Figure 43. Screenshot of comprehensive density**

As we can tell, roads with high density are in orange while roads in green are in good condition.

### **Advantages**

- Good performance in interaction between spatial statistics and geographical features, such as interaction among charts, tables and maps
- Various charts available that is an advantage for displaying spatial statistics in a clear way. If the data is just shown by the choropleth map, as we mentioned before, the relations of spatial data might not be direct. By using the linear charts, statistics over time can not be missing
- Time slider is a highlight which enables an animation. The animation indicates the data over time with the visualization shown in map
- StatPlanet does not require special acknowledge compared most mapping application. This advantages is good for the spread and development of cartography to a wide range of people

### **Shortcomings**

- The procedures are more complicated of Flash Version than StatPlanet. Moreover, the shapefiles need to be processed in other software first before importing which add manual work. Meanwhile, the Stat\_Planet\_Editor needs spatial statistics in an organized structure, otherwise the data can't be imported right, manual work is needed
- Though legend can be edited by users, the units of spatial statistics are different, and the meanings of the value are not the same. For intensity analysis, the higher the value is, the more pressure the roads have while for the other two density, the higher value indicates roads in better conditions. Sharing the same legend cause the collide among values. In general the legend need to be fixed and not necessary to be changed by users.

- A problem of my project was it was confusing for viewers to understand the meanings of the numbers and how the statistics come from without reading the paper. However, this problem can be solved by adding description. It is noticed the description is redundant with no specific structure, a good solution is adding a popup function, when clicking the it, a new window with structured description can popup.
- Price is an important factor for users and companies. Nowadays, software supporting interactive thematic map with indicators and statistics are not free, such as StatSilk and CartoVista. The reason is that Cartography is a interdiscipline with many developing branches, the method for displaying statistic data with interactive thematic maps is still under development.



## Chapter 4. Ideal LGIS

Information visualization is the broadest term that could be taken to subsume all the developments described here. At this level, almost anything, if sufficiently organized, is information of a sort. Tables, graphs, maps and even text, whether static or dynamic, provide some means to see what lies within, determine the answer to a question, find relations, and perhaps apprehend things which could not be seen so readily in other forms (Friendly, M et al. 2001).

The history of cartography is also a history of information visualization. The earliest information visualized by cartography is geographical information indicating the place. As the developing of cartography, various information can be implemented in maps, if sufficiently organized. It has been hard to produce and publish maps, diagrams and graphs. Until half a century ago, the invention of human–computer interaction have created tools for visualization of data and computer graphics in a dynamic way.

Most recently, normally visualization method of information are text, tables and diagrams. Maps are more often used for geographical data in the earliest years. However, now additional metadata are added to maps in different ways, such as thematic maps, choropleth maps, graphic maps. Meanwhile, the functions of maps are not limited to navigation and exploration. Cartography has been applied to various disciplines and can be applied to more regions. Nowadays, cartography has been applied to both scientific and social regions. For instance, census maps, pollution maps and noise maps. However, we see the limited advance in commercial aspect.

We are seeking an optimal application which has good performance in both cartographic and statistical aspects. In other words, the application contains not only mapping functions but also spatial data analysis. What's more, the two components should be combined and interactive.

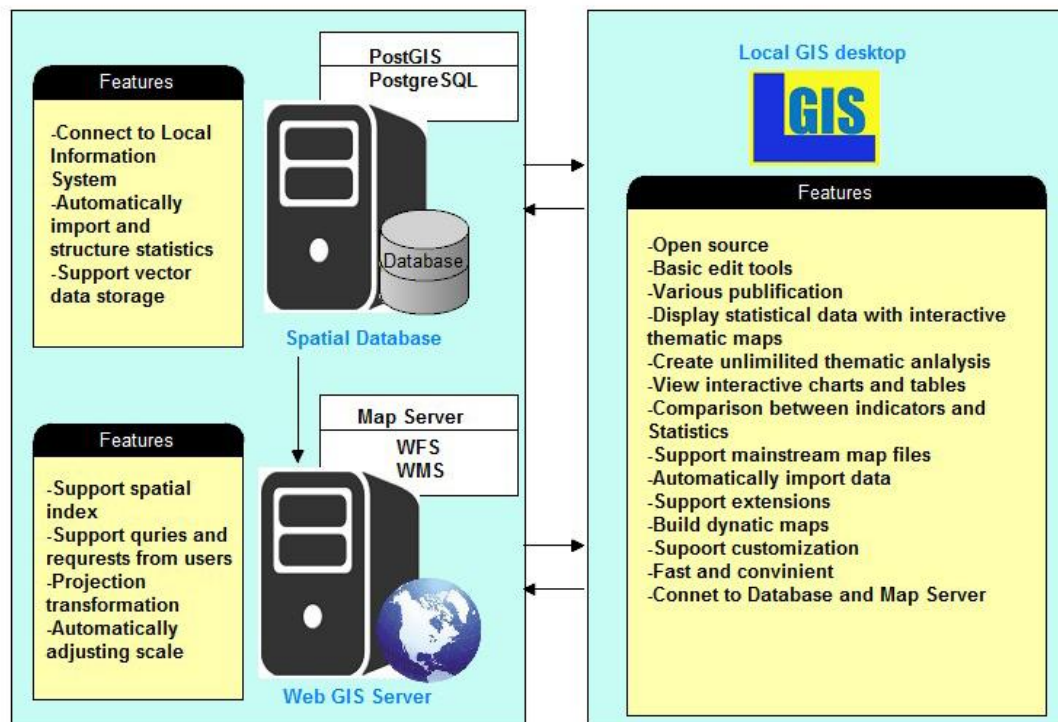
Until now, there is no complete and good performing application. So, what is the ideal application for visualization based on a local spatial analysis?

From the former section, we have evaluated two products of StatSilk, StatPlanet and Flash map of StatPlanet. In the aspect of interaction between maps and statistical data, StatPlanet has a good performance. However, little attention has been devoted to maps and database. In comparison, GeoServer has highlight in the terms of database and users' customization while QGIS put emphasis on editing maps and Geopublish multimedia. Thus, I put forward an ideal LGIS (Local Geographical Information System).

## 4.1 What is LGIS?

LGIS is a combination of LIS and GIS, also tend to offer some common knowledge management functionality for storage and retrieval of unstructured local data such as documents. They deliver functionality to load, store, analyze and present statistical data that has a strong geographic reference.

A LGIS should meet the requirements below in the aspects of service, data acquisition, data observation and user requests



### 4.1.1 Features

**Data import:** The application should support mainstream map files, such as shapefiles, SWG, XML and so on.

**Data edit:** This function don't need to be professional and contain all the editing functions. It provides basic functions like geographical features symbol change, type change, color change and so on.

**Database:** The ideal application shall provide the connection between the product and database. Dynamic update of spatial data due to the real time data. Spatial information can be stored in a database, from which it can be extracted on demands.

**Various indicators:** Nowadays, the information is not limited to only one area, electronic atlas including multiple indicators and multiple layers is the goal of LGIS.

**Interactivity:** The LGIS supports the interactions between users and the maps. The users can send the requests to the server and the map server send the result based on the requests. Also, the interaction between the geographical data and spatial data.

**Visualization:** The two main parts of visualization are geographical data and spatial data. The geographical data, generally, shown in layers, should contains multi layers based on the users. The spatial data shall match the geographical features.

**Extension:** For the implementation of customization, different extensions are necessary for different users' demands. What's more, different types of thematic maps could be manipulated digitally. Moreover functionality such as storage and retrieval of documents should be offered.

#### **4.1.2 Challenges**

Data matching: the combination of geographical features and spatial statistics. In general, during the process of data acquisition, the spatial statistics are not structured according to the geographical features. For instance, in this paper, how to connect the analysis results (spatial statistics) to roads (geographical features)? The capacities are calculated depending on the spatial information grouped in not only administrative districts while the roads are drawn as polyline and not grouped by administrative districts.

Another challenge is the visualization of both spatial data and geographical data. LGIS is LIS overlaps with some capabilities of GIS. The primary function of a LIS is reporting of statistical data rather than the analysis of geospatial data. The emphasis is the visualization of statistical data. It is a challenge to balance the spatial statistics and geographical features, or LIS and GIS. The map should reflect the statistical data accurately and effectively. Meanwhile, the result should avoid redundancy. And do not make the users confused.

#### **4.1.3 Suggestions**

In order to publish a wider range of indicators in a LGIS which matching the geographical data, the spatial attributes can be distributed to the statistical data. More specific, the structure of the spatial data should enable various combination. For example, the roads can be given different attributes, such as regions (postal code, cities and districts) and types (motorway, primary roads and so on), once the users attempt to find the relations between the roads and other indicators (population, tourists.), it is easier if they have a common attributes.

What's more, new technology and tools should be developed in the aspect of visualization, the current visualization method of a LIS is based on existing methods such as charts and figures. We expect more and more visualization method of statistical data that can be implemented and shall have a good connection to geographical features.

## **Chapter 5. Discussion and Conclusion**

First, I would like to point out some limitations of this study, for instance, the technology of visualization of spatial statistics facing many challenges, the spatial analysis based on the sample region Bulgaria and the local information system and the visualization method in this paper have a lot of space for improvement. Besides, the spatial analysis ignored other factors which have significant influence on roads networks.

Former researches put emphasis on the relations and analysis between tourism and roads networks. Certainly, in this paper, a spatial analysis about the tourism and road networks is described. However, there is a demand of the visualization of the spatial statistics in a GIS.

Consequently, four different types of software are evaluated and an ideal LGIS for statistical data is forwarded.

### **5.1 Results**

#### **5.1.1 Bulgaria national roads networks**

In a report from MTITC, the report points out that one of the major problems is the lack of comprehensive, uninterrupted and permanent of transport networks. Another problem is the lack of motorways between the major cities and border checkpoints (MTITC, 2010).

The impact of tourism on the Bulgarian road networks mainly concentrated in the Northeast and Sofia region: Burgas, Varna, Dobrich, Sofia–grad and Sofia. In addition, roads along motorways always have a relatively high intensity or density. Unfortunately, we can not determine the capacity of Bulgaria national road networks from the project exactly. Notwithstanding its limitation, this study does suggest the establishment of roads in a certain regions according to the demands.

From the visualization of the spatial statistics, the impact of tourism on Bulgarian roads is limited. But it is worth noting that the road capacity is affected by numerous indicators. Further spatial analysis considering more factors will be more reasonable.

However, it is obvious if tendencies are persisting as in the assumption, the state of many of national road networks will deteriorate.

According to the capacity analysis of the 4 categories of roads in Bulgaria, we suggest that a motorway connecting Sofia and East Bulgaria should be build. This measure will release not only the pressure of the current motorways but also the pressure of roads which are located along the motorways. As we can see, the national road networks expect motorways have no significant difference all over the country. Thus, the construction of motorways won't cause too much burden on other roads.

### **5.1.2 Software feasibilities**

This paper focuses on the visualization of spatial statistics by the combination of graphs and maps. Therefore, four software have been analyzed. Furthermore, the software StatSilk was evaluated into more details. Based on the former analysis and evaluation, we put forward an ideal LGIS.

LGIS is an outcome when GIS developed to a certain degree which is a refinement of GIS. The key distinction of GIS and LGIS is the "L" which indicates "Local". The information of LGIS is a large dataset which focuses on local information, especially local statistics. The main function of LGIS is to extract spatial statistics from a local information system and visualize the spatial statistics. Besides providing a possible feasibility of the development of cartography in the aspect of visualization of spatial statistic, LGIS is also providing a basis for other region, such as commercial analysis and decision-making.

## **5.2 Further Research**

It should be noted that this study only stay in a theoretical level. Further studies on in a practical aspect will be summarized.

The analysis reported here suggest that an open source Local Geographical System should be developed. Thus we believe it can be implemented in two ways. First, we suggest that StatSilk could combine with SQL and WMS. As far as now, StatSilk is not an open source software and requires a fee for publishing which is a limitation for its development and extension. However, we believe that as the developing of cartography, an open source software which combines maps and spatial statistics will be one significant development tendency of cartography. Another possible research might be based on GeoServer. The biggest advantages is that GeoServer as an open source application has more operability and also is a mainstream software. What's more, current extensions of GeoServer such as Jfreechart provides the basic graph functions. The further practical work can focus on improving the performance of graph in GeoServer provided by Jfreechart. We believe that GeoServer will complete the function of graphs in the near future.

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## Appendix

### Appendix A: Predicted results of night spent, 2013 – 2017

Year	Night spent prediction				
	2013	2014	2015	2016	2017
Total	22,277,242	24,504,966	26,955,463	29,651,009	32,616,110
Blagoevgrad	1,058,274	1,164,101	1,280,511	1,408,562	1,549,419
Burgas	8,117,955	8,929,750	9,822,725	10,804,998	11,885,498
Dobrich	2,133,695	2,347,065	2,581,771	2,839,948	3,123,943
Gabrovo	186,744	205,418	225,960	248,556	273,411
Haskovo	106,831	117,514	129,265	142,192	156,411
Kardzhali	164,256	180,682	198,750	218,625	240,488
Kyustendil	50,024	55,026	60,529	66,581	73,240
Lovech	226,765	249,442	274,386	301,824	332,007
Montana	79,109	87,020	95,722	105,294	115,823
Pazardzhik	439,564	483,521	531,873	585,060	643,566
Pernik	25,951	28,546	31,401	34,541	37,995
Pleven	88,949	97,844	107,629	118,392	130,231
Plovdiv	868,597	955,457	1,051,003	1,156,103	1,271,713
Razgrad	42,818	47,099	51,809	56,990	62,689
Ruse	162,900	179,190	197,109	216,820	238,502
Shumen	70,452	77,497	85,247	93,771	103,148
Silistra	43,271	47,598	52,358	57,593	63,353
Sliven	107,018	117,720	129,492	142,441	156,685
Smolyan	545,982	600,580	660,638	726,702	799,372
Sofia	480,258	528,284	581,112	639,223	703,145
Sofia cap.	1,423,591	1,565,951	1,722,546	1,894,800	2,084,280
Stara Zagora	284,572	313,029	344,332	378,766	416,642
Targovishte	40,972	45,069	49,576	54,533	59,987
Varna	5,035,602	5,539,162	6,093,078	6,702,386	7,372,625
Veliko Tarnovo	302,678	332,946	366,241	402,865	443,151
Vidin	57,474	63,221	69,543	76,498	84,148
Vratsa	79,947	87,942	96,736	106,409	117,050
Yambol	52,994	58,293	64,122	70,534	77,588

## Appendix B: Predicted results of arrivals in accommodation, 2013 – 2017

Year	Arrivals in accommodation prediction				
	2013	2014	2015	2016	2017
Total	5,933,535	6,408,218	6,920,875	7,474,545	8,072,509
Blagoevgrad	403,932	436,246	471,146	508,838	549,545
Burgas	1,268,411	1,369,884	1,479,475	1,597,833	1,725,660
Dobrich	371,647	401,379	433,490	468,169	505,622
Gabrovo	97,371	105,160	113,573	122,659	132,472
Haskovo	61,214	66,112	71,400	77,113	83,282
Kardzhali	84,249	90,989	98,268	106,129	114,619
Kyustendil	31,822	34,368	37,117	40,087	43,294
Lovech	122,467	132,264	142,845	154,273	166,614
Montana	37,863	40,892	44,163	47,696	51,512
Pazardzhik	177,679	191,894	207,245	223,825	241,731
Pernik	13,535	14,617	15,787	17,050	18,414
Pleven	48,068	51,913	56,066	60,551	65,395
Plovdiv	393,805	425,309	459,334	496,081	535,767
Razgrad	23,615	25,505	27,545	29,748	32,128
Ruse	95,044	102,648	110,860	119,728	129,307
Shumen	42,957	46,394	50,105	54,113	58,443
Silistra	27,443	29,638	32,009	34,570	37,336
Sliven	54,700	59,076	63,802	68,906	74,419
Smolyan	206,920	223,474	241,352	260,660	281,513
Sofia	175,740	189,799	204,983	221,381	239,092
Sofia cap.	807,027	871,589	941,316	1,016,621	1,097,951
Stara Zagora	99,414	107,367	115,956	125,233	135,252
Targovishte	23,830	25,737	27,796	30,019	32,421
Varna	987,281	1,066,263	1,151,564	1,243,690	1,343,185
Veliko Tarnovo	192,047	207,410	224,003	241,924	261,277
Vidin	33,456	36,133	39,023	42,145	45,517
Vratsa	33,799	36,502	39,423	42,577	45,983
Yambol	18,200	19,656	21,229	22,927	24,761



**Appendix C:** Motorway night–spend number/length density, 2008 – 2017,  
unit: night spent/length

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>North–West</b>	<b>7,233</b>	<b>7,938</b>	<b>7,074</b>	<b>7,771</b>	<b>8,911</b>	<b>9,980</b>	<b>11,178</b>	<b>12,519</b>	<b>14,022</b>	<b>15,704</b>
Lovech	2,058	1,632	1,513	1,970	1,978	2,215	2,481	2,779	3,112	3,485
<b>North–East</b>	<b>56,765</b>	<b>44,100</b>	<b>47,238</b>	<b>58,504</b>	<b>62,537</b>	<b>70,041</b>	<b>78,446</b>	<b>87,860</b>	<b>98,403</b>	<b>110,212</b>
Varna	65,299	51,615	54,822	62,356	65,338	73,178	81,960	91,795	102,810	115,147
Shumen	486	376	457	577	596	667	748	837	938	1,050
<b>South–West</b>	<b>12,017</b>	<b>9,844</b>	<b>11,102</b>	<b>9,276</b>	<b>10,704</b>	<b>11,989</b>	<b>13,428</b>	<b>15,039</b>	<b>16,844</b>	<b>18,865</b>
Pernik				299	335	375	420	470	527	590
Sofia	2,010	1,520	1,653	1,242	1,300	1,456	1,631	1,827	2,046	2,291
<b>South Central</b>	<b>3,083</b>	<b>2,507</b>	<b>2,069</b>	<b>2,475</b>	<b>2,873</b>	<b>3,218</b>	<b>3,604</b>	<b>4,037</b>	<b>4,521</b>	<b>5,064</b>
Pazardzhik	552	476	485	690	884	990	1,109	1,242	1,392	1,559
Plovdiv	3,826	3,202	3,226	3,668	4,579	5,129	5,744	6,433	7,205	8,070
Haskovo	1,090	1,131	645	617	715	800	897	1,004	1,125	1,260
<b>South–East</b>	<b>58,337</b>	<b>47,650</b>	<b>55,784</b>	<b>65,987</b>	<b>35,763</b>	<b>40,054</b>	<b>44,861</b>	<b>50,244</b>	<b>56,274</b>	<b>63,026</b>
Burgas	142,530	114,267	135,986	162,120	172,600	193,312	216,510	242,491	271,590	304,180
Sliven					424	475	532	596	667	747
Stara Zagora	1,070	1,769	1,354	768	603	676	757	848	949	1,063
Yambol					629	704	789	883	989	1,108

**Appendix D:** Category I roads night–spent number/length density, 2008–2017, unit: night spent/ length

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>North–West</b>	<b>131</b>	<b>144</b>	<b>128</b>	<b>141</b>	<b>161</b>	<b>181</b>	<b>202</b>	<b>226</b>	<b>254</b>	<b>284</b>
Vidin	101	228	187	172	147	165	185	207	232	260
Vratsa	135	155	127	152	176	197	221	247	277	310
Lovech	136	108	100	130	131	146	164	183	206	230
Montana	94	88	87	102	113	127	142	159	178	200
Pleven	166	141	136	142	222	249	279	312	350	392
<b>North Central</b>	<b>246</b>	<b>215</b>	<b>201</b>	<b>245</b>	<b>299</b>	<b>335</b>	<b>375</b>	<b>420</b>	<b>471</b>	<b>527</b>
Veliko Tarnovo	262	193	231	300	391	438	491	550	616	690
Gabrovo	325	306	176	204	203	228	255	286	320	358
Razgrad	99	76	66	91	137	154	172	193	216	242
Ruse	289	282	276	334	390	436	489	547	613	687
Silistra	146	145	143	142	180	202	226	253	283	317
<b>North–East</b>	<b>9,872</b>	<b>7,670</b>	<b>8,215</b>	<b>10,175</b>	<b>10,876</b>	<b>12,181</b>	<b>13,643</b>	<b>15,280</b>	<b>17,114</b>	<b>19,167</b>
Varna	28,054	22,176	23,553	26,790	28,071	31,440	35,212	39,438	44,170	49,471
Dobrich	11,444	8,334	9,294	15,360	17,376	19,461	21,797	24,412	27,342	30,623
Targovishte	239	120	65	102	75	84	94	106	118	133
Shumen	67	52	63	80	82	92	103	116	130	145
<b>South–West</b>	<b>2,306</b>	<b>1,889</b>	<b>2,130</b>	<b>2,096</b>	<b>2,430</b>	<b>2,721</b>	<b>3,048</b>	<b>3,413</b>	<b>3,823</b>	<b>4,282</b>
Blagoevgrad	3,819	3,091	4,233	3,947	5,006	5,607	6,280	7,034	7,878	8,823
Kyustendil	117	97	112	143	228	256	286	321	359	402
Pernik	107	114	88	37	38	42	47	53	59	66
Sofia	653	494	537	441	471	528	591	662	741	830
<b>South Central</b>	<b>873</b>	<b>710</b>	<b>685</b>	<b>819</b>	<b>925</b>	<b>1,036</b>	<b>1,160</b>	<b>1,300</b>	<b>1,455</b>	<b>1,630</b>
Kardzhali	124	76	96	92	111	124	139	156	175	196
Pazardzhik	477	411	419	597	764	856	959	1,074	1,203	1,347
Plovdiv	1,483	1,241	1,251	1,422	1,775	1,988	2,226	2,494	2,793	3,128
Smolyan										
Haskovo	143	148	167	159	184	207	231	259	290	325
<b>South–East</b>	<b>8,501</b>	<b>6,944</b>	<b>8,129</b>	<b>9,616</b>	<b>10,244</b>	<b>11,473</b>	<b>12,850</b>	<b>14,392</b>	<b>16,119</b>	<b>18,053</b>
Burgas	20,034	16,062	19,114	22,788	24,261	27,172	30,433	34,085	38,175	42,756
Sliven	156	141	120	176	224	251	282	315	353	396
Stara Zagora	333	551	422	239	264	295	331	371	415	465
Yambol	186	439	136	122	118	132	148	166	185	208

**Appendix E: Category II roads night–spent number/length density, 2008–2017, unit: night spent/ length**

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>North–West</b>	<b>66</b>	<b>72</b>	<b>65</b>	<b>71</b>	<b>81</b>	<b>91</b>	<b>102</b>	<b>114</b>	<b>128</b>	<b>144</b>
Vidin	82	185	152	140	120	134	150	168	189	211
Vratsa	34	40	33	39	45	50	56	63	71	79
Lovech	185	146	136	177	180	201	226	253	283	317
Montana	30	28	28	33	36	41	46	51	57	64
Pleven	78	66	64	66	104	117	131	146	164	184
<b>North Central</b>	<b>179</b>	<b>157</b>	<b>146</b>	<b>179</b>	<b>218</b>	<b>244</b>	<b>273</b>	<b>306</b>	<b>342</b>	<b>383</b>
Veliko Tarnovo	283	210	250	326	425	475	533	596	668	748
Gabrovo	931	877	505	584	583	653	731	819	917	1,027
Razgrad	34	26	23	32	47	53	59	67	75	84
Ruse	205	200	196	237	277	310	347	389	435	487
Silistra	57	56	55	55	70	78	88	98	110	123
<b>North–East</b>	<b>10,210</b>	<b>7,932</b>	<b>8,497</b>	<b>10,523</b>	<b>11,153</b>	<b>12,491</b>	<b>13,990</b>	<b>15,669</b>	<b>17,550</b>	<b>19,656</b>
Varna	90,175	71,278	75,707	86,110	90,228	101,056	113,182	126,764	141,976	159,013
Dobrich	3,925	2,858	3,188	5,268	5,960	6,675	7,476	8,373	9,378	10,503
Targovishte	174	87	47	74	53	59	66	74	83	93
Shumen	164	127	154	195	201	225	252	283	317	355
<b>South–West</b>	<b>2,291</b>	<b>1,877</b>	<b>2,116</b>	<b>2,086</b>	<b>2,386</b>	<b>2,673</b>	<b>2,994</b>	<b>3,353</b>	<b>3,755</b>	<b>4,206</b>
Blagoevgrad	2,172	1,757	2,407	2,245	2,847	3,188	3,571	3,999	4,479	5,017
Kyustendil	184	152	176	225	359	402	450	504	565	633
Pernik	129	138	106	45	46	51	57	64	72	80
Sofia	686	519	564	464	485	543	608	681	763	854
<b>South Central</b>	<b>487</b>	<b>396</b>	<b>376</b>	<b>450</b>	<b>521</b>	<b>584</b>	<b>654</b>	<b>733</b>	<b>820</b>	<b>919</b>
Kardzhali	139	85	107	103	143	160	179	200	225	251
Pazardzhik	139	120	122	174	223	250	280	314	351	393
Plovdiv	797	667	672	764	954	1,068	1,197	1,340	1,501	1,681
Smolyan	1,122	831	654	892	836	936	1,048	1,174	1,315	1,473
Haskovo	156	162	173	165	189	212	237	266	298	334
<b>South–East</b>	<b>6,617</b>	<b>5,405</b>	<b>6,328</b>	<b>7,485</b>	<b>7,973</b>	<b>8,930</b>	<b>10,002</b>	<b>11,202</b>	<b>12,546</b>	<b>14,052</b>
Burgas	19,113	15,323	18,236	21,740	23,146	25,923	29,034	32,518	36,420	40,790
Sliven	66	59	51	74	94	106	118	133	149	166
Stara Zagora	259	428	328	186	205	229	257	288	322	361
Yambol	201	474	147	132	127	142	160	179	200	224

**Appendix F:** Category III roads night-spent number/length density, 2008–2017,  
unit: night spent/ length

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>North–West</b>	<b>23</b>	<b>25</b>	<b>22</b>	<b>24</b>	<b>28</b>	<b>31</b>	<b>35</b>	<b>39</b>	<b>44</b>	<b>49</b>
Vidin	17	38	31	28	24	27	31	34	38	43
Vratsa	23	27	22	26	30	33	38	42	47	53
Lovech	26	21	19	25	25	28	31	35	39	44
Montana	13	12	12	14	15	17	19	21	24	27
Pleven	32	28	27	28	44	49	55	61	69	77
<b>North Central</b>	<b>61</b>	<b>53</b>	<b>50</b>	<b>61</b>	<b>74</b>	<b>83</b>	<b>93</b>	<b>104</b>	<b>116</b>	<b>130</b>
Veliko Tarnovo	62	46	55	71	93	104	117	131	146	164
Gabrovo	72	68	39	45	45	51	57	63	71	80
Razgrad	20	15	13	18	27	30	33	37	42	47
Ruse	129	126	123	149	174	194	218	244	273	306
Silistra	28	27	27	27	34	38	43	48	53	60
<b>North–East</b>	<b>2,920</b>	<b>2,268</b>	<b>2,428</b>	<b>3,008</b>	<b>3,213</b>	<b>3,598</b>	<b>4,030</b>	<b>4,514</b>	<b>5,056</b>	<b>5,662</b>
Varna	7,940	6,276	6,666	7,582	7,945	8,898	9,966	11,162	12,501	14,001
Dobrich	1,896	1,381	1,537	2,540	2,873	3,218	3,604	4,036	4,521	5,063
Targovishte	54	27	15	23	17	19	21	24	27	30
Shumen	40	31	38	48	49	55	62	69	77	87
<b>South–West</b>	<b>739</b>	<b>605</b>	<b>682</b>	<b>664</b>	<b>761</b>	<b>853</b>	<b>955</b>	<b>1,070</b>	<b>1,198</b>	<b>1,342</b>
Blagoevgrad	780	631	864	806	1,022	1,145	1,283	1,436	1,609	1,802
Kyustendil	23	19	22	28	44	50	56	62	70	78
Pernik	21	23	18	7	7	8	9	10	12	13
Sofia	362	273	297	240	253	283	317	355	397	445
<b>South Central</b>	<b>142</b>	<b>115</b>	<b>110</b>	<b>131</b>	<b>153</b>	<b>171</b>	<b>191</b>	<b>214</b>	<b>240</b>	<b>269</b>
Kardzhali	22	14	17	16	23	26	29	32	36	40
Pazardzhik	66	57	58	82	106	118	132	148	166	186
Plovdiv	317	265	268	304	379	425	476	533	596	668
Smolyan	288	213	168	229	214	240	269	301	337	378
Haskovo	31	32	35	34	39	44	49	55	61	69
<b>South–East</b>	<b>2,958</b>	<b>2,416</b>	<b>2,827</b>	<b>3,332</b>	<b>3,551</b>	<b>3,978</b>	<b>4,455</b>	<b>4,989</b>	<b>5,588</b>	<b>6,259</b>
Burgas	7,994	6,409	7,627	9,093	9,681	10,843	12,144	13,601	15,233	17,061
Sliven	52	47	40	59	75	84	94	106	118	132
Stara Zagora	130	215	165	92	102	114	128	143	160	179
Yambol	44	103	32	29	28	31	35	39	43	49