GEOGRAPHIC INFORMATION SYSTEM AS A SUPPORTIVE TOOL FOR ROAD ACCIDENT INVESTIGATION

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ABSTRACT

The worst problem found in the Road System is, in general terms, the high rate of accidents, which contributes to increase the number of deaths around the world. In Brazil the situation is not different. According to the most important insurance company for personal injury caused by motor vehicles (DPVAT, 2014), 52,226 death benefits were paid for traffic casualties in Brazil. The previous data shows that there should be a call for action in order to solve and reduce this problem.

This paper aims to promote the importance of the Geographic Information System (GIS) for the studies of road accidents. GIS may be an essential tool for accidents investigation. It allows visualization of spatial and georeferenced data, facilitating the analyses. With this system is also possible to undertake researches in order to identify problematic areas, and also point out possible solutions to such problems. For the present study it was used the ArcGIS 10.1 to geocode and map the information for the analysis. The ArcGis 10.1, widely used in the Brazilian market, is a program that has a practical and simple interface. It uses the basic principles of georeferencing, allowing to perform excellent tasks using GIS. The program allows to identify areas where the researches should be extended and intensified in order to bring up benefits to society.

An analysis of accidents on federal highways in the state of Espirito Santo will be presented thus, aiming to show the importance of GIS in locating dangerous and problematic sections which require immediate interventions. Furthermore, will also be shown some effective government measures adopted in some particular areas. In conclusion, GIS is an important support tool that might assist institutions and researchers that investigate road sections with high accident rates. This paper, therefore, is expected to support and help new studies and researchers that are focused on improving Brazilian traffic.

1 INTRODUCTION

According to the *World Health Organization* (WHO) (2013) more than 1.2 million people die a year in the road system. This framework leads us to conclude that some measures should be taken in order to reduce the high rates of deaths. As such, it is very important to know and map the areas where such accidents usually happen. With similar interventions it becomes possible to understand the road dynamics and plan actions to change this perspective.

This article is based on the concepts of the Geographic Information System (GIS), which can be defined as a set of systems of georeferenced data storage; in other words, GIS applications are tools that allow the processing of spatial data usually explicitly strung that can be used to make decisions about any local or global problem (DEMERS, 2000).

These GIS tools help to integrate the collected data in several different functions in governmental entities and companies, providing a more systemic view of reality (HUXHOLD, 1991). In the transport system the GIS is very effective and useful for transport operation, planning, and management as pointed out by Sutton (2004). In addition, it is an efficient helper in road accident studies because it facilitates data visualization, reducing the abstraction of information. The aim of this production is therefore promoting GIS as a support tool for the investigation of road accidents. For this purpose, it is thus intended to raise, map and analyze data of road accidents on Espirito Santo federal highways analyzing them by making use of various parameters. Methodologically, it will be used the ArcMap 10.1 in the production of the maps that will serve as a demonstration for the study. ArcMap 10.1 is a widely used software in the market for the production of charts and maps, and its functioning is based on the use of a georeferenced database. Its interface enables the display of such data in three formats: dots, polylines and polygons.

Throughout this article, it will be possible to learn about some features of GIS, especially about georeferenced database and map production. An analysis of accidents thus was done in three distinct ways, which are going to be exposed further below.

2 THEORETICAL FUNDAMENTS

For a better understanding and analysis of this production, it is fundamentally important to have some knowledge about the covered concepts. In this topic, some fundamental information will be exposed to be used as a guide for the development of the research and results.

2.1 Introduction to GIS

The term geoprocessing refers to the field of knowledge which uses mathematical and computational techniques for the processing of geographic information collected in the field, which increasingly influences the areas of cartography, analysis of natural resources, transportation, communications, energy, Urban and Regional planning, among others (Hall and Davis, 2001).

Geoprocessing uses the computational tools called Geographic Information System (GIS), which were introduced in Brazil in the mid-80s by UFRJ Professor Jorge Xavier da Silva and Dr. Roger Tomlinson, this last one having arrived in Brazil in 1982 and being responsible for creating the first GIS. Ever since then, there has been many groups interested in the development of this area in Brazil..

Nowadays, in the market there are *softwares* that allow performing complex analyzes integrating data of different types to a georeferenced database, such as ArcGis, which was used in this study as a tool in the methodology.

2.2 Geographic Information System

The Geographic Information System (GIS) is a system of *hardware, software*, data, people, organizations and/or businesses that aim at collecting, storing, analysis and dissemination of information on an area of the Earth's surface (Chrisman, 1989). In other words, GIS are computer programs designed to perform a wide range of georeferenced geographic information operations. These programs include features to add, store, visualize, export and analyze such information. Currently, they are able to perform quite every operation related to the information and development of a map that deals with phenomena distributed on the surface of the Earth (Goodchild, 2009).

Using a GIS implies the choice of most appropriate computational representations in capturing the semantics of its domain and application. Developing it means offering the widest set of data tools and algorithms as possible, in order to be able to represent the great diversity of space conceptions (Câmara e Monteiro, 2001).

2.3 GIS and the Transportation System

Currently, in the road system, GIS programs are used to solve everyday problems, such as traffic problems and accidents. According to Dantas, Taco and Yamashita (1996) In the 80's and 90's the use of GIS in transportation throughout Brazil was intensified. The use of these systems has been increasing with the XXI century, which brought advances in computer and information technology

Analysts of transport are using GIS tools in infrastructure planning, design, management, public transport planning and operation, traffic analysis and control, transport safety analysis, environmental impact assessment, and also to configure and manage complex logistics systems. (Miller and Shaw, 2001).

The Iowa Department of Transportation, USA, supported by the Center for Transportation Research and Education of the Iowa State University, has developed a local Geographic Information System of accidents. The system includes the location of all accidents in all state highways in the last 10 years, which reaches about 700 thousand accidents. It provides spatial information of accidents and allows the database to be consulted and analyzed, providing information about the high rate accident areas. Each accident has up to three files (accident, driver, and injury) that provide information about the occurred accidents. The database contains the severity of the injury and time/day information. Information about the roadway, including the average daily traffic, rode width, length of each segment, and speed limit are also available. (Estochen, Souleyrette and Strauss, 1998).

Since 1996, the big Brazilian cities also use GIS in their transport systems, as in the city of Belo Horizonte – state of Minas Gerais. The town uses the tool to improve traffic organization and services to the citizens. Many lines of action were adopted in this project, and one of them was offering the public, by telephone, information about the location of bus stops and previously set routes between two specific places; another area is focused on the maintenance of signaling and monitoring of accidents as pointed out by Zuppo, Davis and Meirelles (1996).

3 METHODOLOGY

To develop this study it was used the ArcMap 10.1, which is an ArcGIS application for drawing and investigation of maps, as well as their analysis in order to solve geographical issues. It can also produce maps that express this analysis, in a simple and functional interface.

In order to demonstrate the importance of GIS, sections of federal highways that cross Espírito Santo with highest rate of accidents were mapped, and some possibilities of studies that can be performed with this tool were demonstrated.

To that end, some data provided by the Management Information System of the Federal Highway Police (SIGER / PRF, 2015) were used, as well as shapefiles of federal highways in Espirito Santo, provided by the National Department of Transportation Infrastructure (DNIT, 2014) and the municipal boundaries available at the Geospatial Integrated Bases System of the State of Espirito Santo - GeoBases (2014). As data standardization factor, it were used Vehicle Daily Average data provided by DNIT (2015).

Accident data was georeferenced based on mileage provided by DNIT, getting a 100m georeferencing accuracy. Three analyzes of these data were done. These analyzes, shown in the form of maps, were used to demonstrate different possible analyzes that can be performed. In the first map were used the absolute numbers of accidents that occurred in 2014, raising the number of accidents per section, making possible to identify the most dangerous areas referring to the number of accidents. The second one used the average daily number of vehicles as a normalization parameter for accident data, making the comparison between the highroads and its sections more plausible. Finally, the third map came up with an overview of the evolution of road accidents, thereby making possible to analyze the efficiency of the adopted measures.

4 RESULTS AND DISCUSSIONS

The spatial distribution of traffic accidents can present relevant information about the most likely areas of occurrence. In order to contribute to decrease the number of accidents on federal highways in Espirito Santo, GIS showed itself as a technological tool that makes the database processing of the road system variables. The flexibility in manipulation georeferenced data, altogether with the capabilities to perform on low cost plataforms and the operating speed/agility makes the GIS a very accessible feature. It possibilitates the access and processing of several data simultaneously in an adequate time frame, allowing the development of several studies. It were thus produced three maps with different themes that demonstrate some of the various analyzes that can be performed using this tool.

4.1 Determine the most dangerous segments of the roads in 2014

Using ArcGIS 10.1 is possible to graphically perform a study of the most problematic sections of the road; with the program it becomes easy to determine sections that require immediate intervention. On Image 1, it is illustrated an analysis of accidents on federal highways of Espirito Santo, showing sections with high accident rates. This one was made taking into account the absolute number of road accidents in the year of 2014 making it possible to determine the most dangerous sections of the road.

4.2 Analyze accidents with standardized data

With GIS it becomes simpler to simultaneously study several highways of various types and sizes, as can be seen on Image 2. For standardization purposes it was used the average daily number of vehicles

as a comparison parameter. It becomes viable thus a more reasonable comparison among several highways and sections.

4.3 Analyze accident rates over the years

Using GIS is also possible to analyze the evolution of the accident frameworks over the years, making it possible to undertake studies to investigate the effectiveness of the measures previously taken. On Image 3, the results of a study that aimed to obtain analysis of the data evolution can be seen; to produce that, data of the period from 2009 to 2014 were raised. On the map sections that were or have been problematic, and that have suffered or not successful interventions are highlighted. Thus, it becomes easy to check the efficiency of the adopted solutions on the road to determine the best measures for certain circumstances.

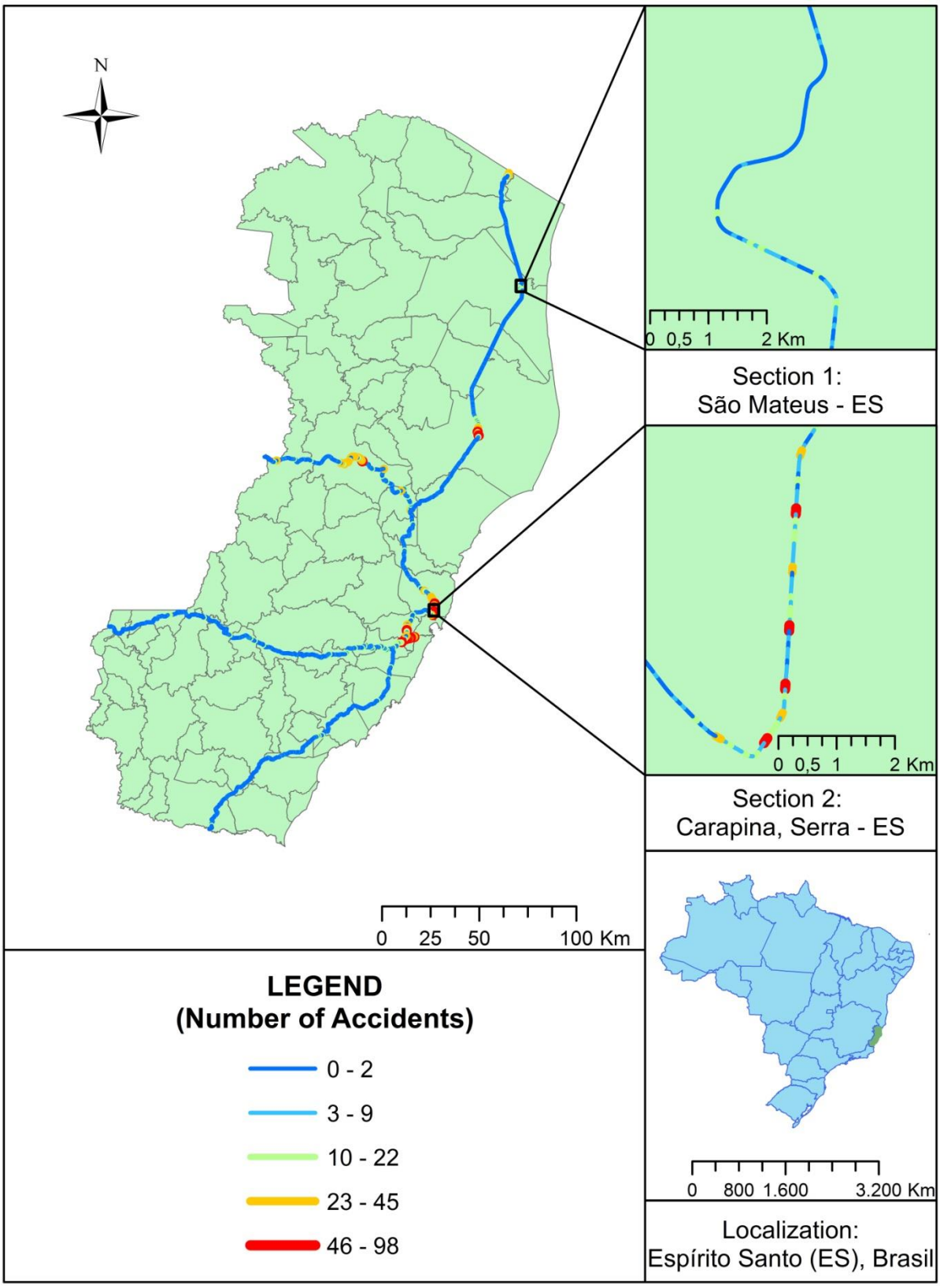


Image 1- Number of accidents on federal highways of Espírito Santo

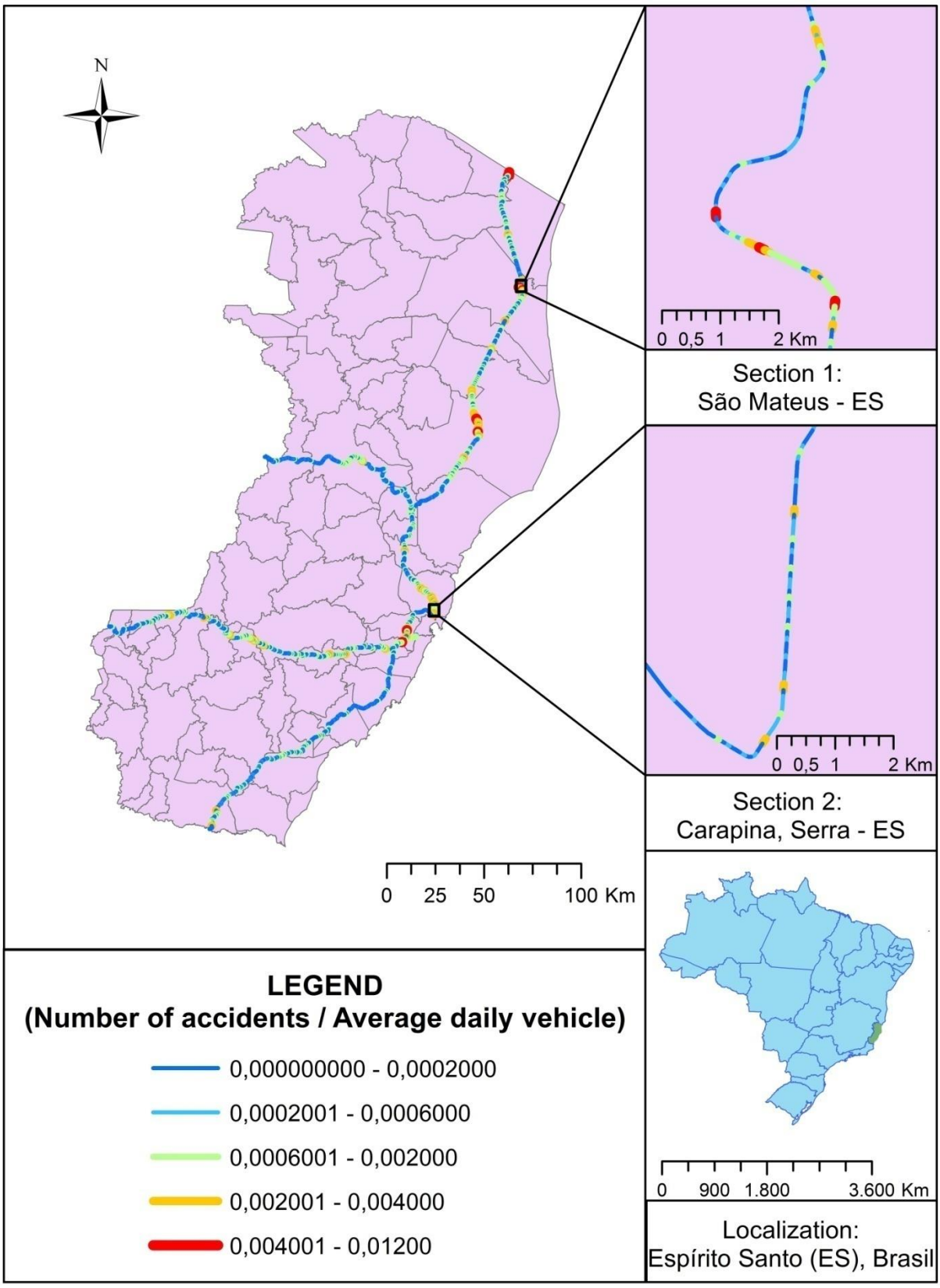


Image 2 - Accidents in 2014 standardized with ADV

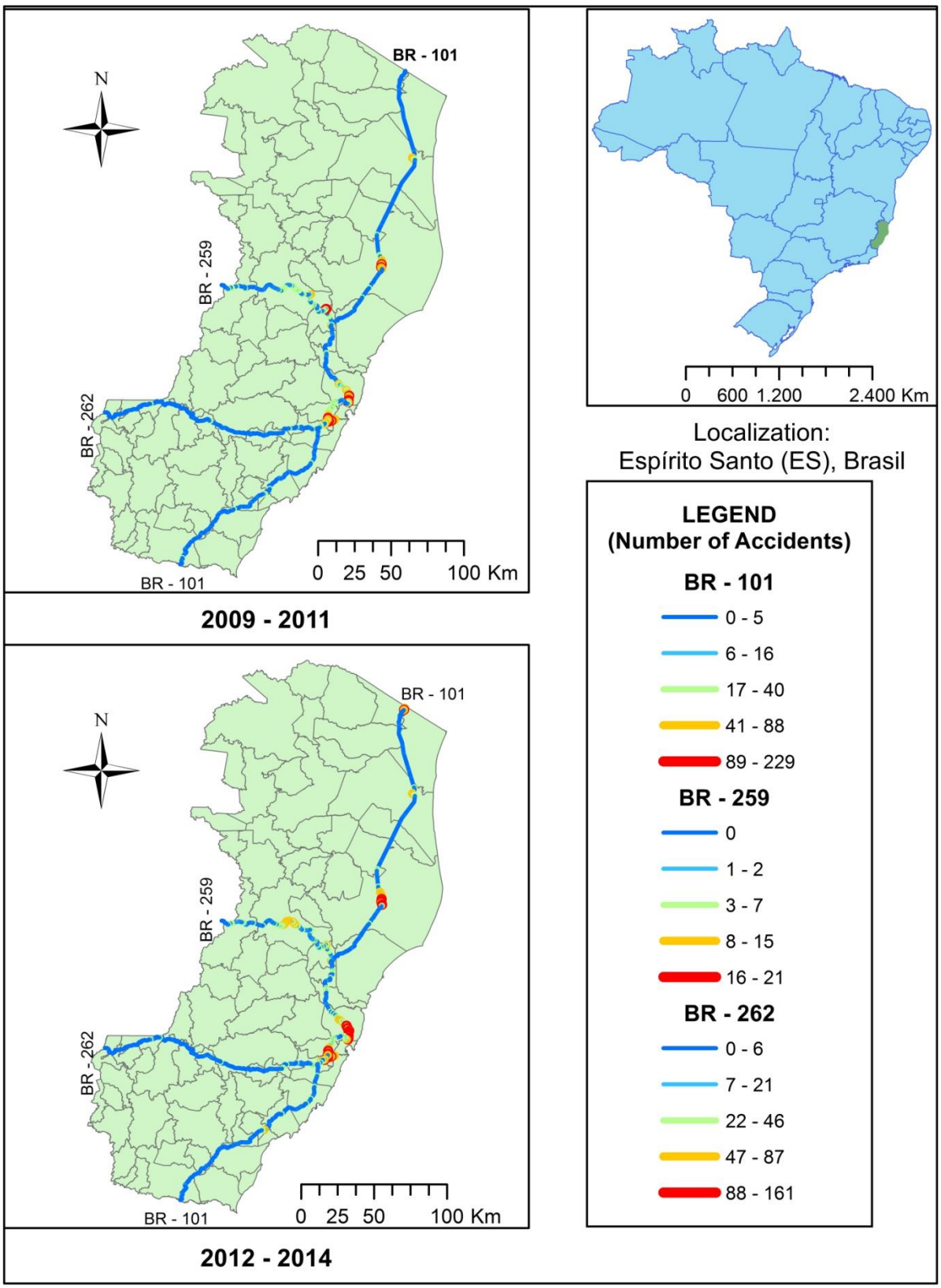


Image 3 – The evolution of accidents over the years

4.4 Considerations

The study through SIG enables a wide range of analyzes about certain information. On map 1 and 2 there are sections where many road accidents occur. However, there is a great difference between analyzes with absolute numbers and analysis with the rates of accidents standardized by ADV. In these maps, two sections where such differences can occur are observed, the first one being in São Mateus-ES where there is a very high rate of accidents per vehicle and the second one being in Carapina's region, in the city of Serra-ES which is characterized by high absolute numbers of accidents.

Map number 3, allows visualizing the evolution of accidents on the roads, making clear the sections where there were improvements. Therefore it is possible to investigate the results of measures carried out in places that were successful, and optimize the public budget by investing in really effective measures.

5 CONCLUSION

It is concluded that the SIG has proved to be an effective tool for the investigation of road accidents; it was possible to analyze the accidents in different ways, pointing out problematic sections. It can be noted that with the GIS, sections may receive more or less prominence, according to the purpose and the methodology adopted.

It also enriches the study by reducing the abstraction of information and facilitating the obtaining of more reliable results. Finally, it can be stated that the objective of this study was achieved by demonstrating the efficiency of GIS for the study of road accidents, proposing thus possible discussions about its use for the improvement of the transport system.

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