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A REVIEW OF THE MANAGEMENT OF ROAD CORRIDORS BY USING GIS OVER THE WORLD AND IN VIETNAM

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Abstract

The aims of the management of road corridors are to ensure safety traffic; Protecting the integrity of the land for the road and existing buildings within road corridors; Ensuring the land for transportation in the future; ... Therefore, road corridors are protected and managed. In addition, in fact, they are changed easily because of the natural disasters (earthquakes, landslides, floods, ...) or the human activities (encroaching,...), so, it shows that need to use a strong manage tool as GIS (Geographic Information System) in analysis, store data, update, query information, report,... in the management of road corridors. In Vietnam, the management of road corridors has conducted mainly in paper maps or digital maps - stored as *.dxf format of Autocad software, meanwhile, the statistics data have often stored as *.doc or *.xls – as format of Microsoft word, Microsoft excel. These causes several problems, the first, can be seen immediately because of the asynchronous stored so test, control data when the report has required, very time-consuming; the second, there is volatility on the road (subsidence, earthquakes, landslides ...), the updating of this information into the system has been very difficult, not to mention the need to immediately look up information by a certain route it is very difficult to implement; ... Nowadays, many countries have researched and successful applied GIS in the management of road corridors over the world. This paper presents a review of the researches of the application of GIS in the management of road corridors over the world and in Vietnam. On that basis, to propose the GIS application model in the management of road corridors in Vietnam.

Keywords: review; GIS; road corridors; world; Vietnam.

Introduction

Road corridors (or road safety corridors in Vietnam) are required part of road, they include roads and the land along two sides of roads.

The content of the road corridor management includes three main branches, as:

- Investment in construction, upgrading and rehabilitation of road traffic.
- Management and maintenance of road.
- Management of the road quality.

Nowadays, in Vietnam, the management of the quality of road corridors has conducted mainly in paper maps or digital maps - stored as *.dxf format of Autocad software, meanwhile, the statistics data have often stored as *.doc or *.xls – as format of Microsoft word, Microsoft excel. These causes several problems, the first, can be seen immediately because of the asynchronous stored so test, control data when the report has required, very time-consuming; the second, there is volatility on the road (subsidence, earthquakes, landslides ...), the updating of this information into the system has been very difficult, not to mention the need to immediately look up information by a certain route it is very difficult to implement; ... In fact, they are changed easily because of the natural disasters (earthquakes, landslides, floods, ...) or the human activities (encroaching,...), so, it shows that need to use a strong manage tool as GIS (Geographic Information System) in analysis, store data, update, query information, report,... in the management of road corridors. While many countries have researched and successful applied GIS in the management of road corridors over the world.

The following section presents a review of the researches of the application of GIS in the management of road corridors over the world and in Vietnam, mainly refers to the management of the road quality.

1. Over the world

The application of GIS in road traffic management isn't been a new problem by integrating the related parameters into the topographic analysis technical to create the system of land-cover maps on the world. Benn and Grabau (1968), Grabau (1968) explained the process of combining the data for this system. They provided an example of the specific application of this procedure in the assessment of the construction effort for military airlines. Construction effort was defined as the number of workdays required by a standard workforce in preparing a runway of standard specifications. Here, they used a mathematical model which was developed empirically with data derived from current design and construction by the Department of the Army. McHarg (1969) provided an other example about the use of land-cover technique with attribute parameters (environmental, social,...) to create a synthetic map to choose the route which had the lowest construction cost. This synthetic map contained each parameter map (environmental, social,...) overlap, therefore, determined the cost of opening a route was relative. Wilson and Stone House (1983) used the weight and land-cover technique by using a computer in a quantitative approach in the integration of the attribute information about the environment, society,...for the same purpose. Therefore, a system of generalized route selection based GCARS computer program (A generalized computer-aided route selection system) was developed to solve the need of planning the routes (Turner and Miles, 1971). This system was not only strong in calculation but also storage effectively, as: the model of earthwork cost, building sidewalks, roadway, the way to go, the way to back,... Here, the researchers used the analytical technique of land cover with the same input parameters, including environmental, social, ... to determine the cost of opening a new route, planned a new route ... Although these factors had various weights but the final product of this process was quite similar. The different factors (the slope of terrain, geomorphology, soil maps, ...) which had a big effect on the construction effort, the cost of opening a new road corridor,..., were less cared.

Turner and Hausmanis (1973) used GCARS to select road corridors Guelph-Dundas, Ontario State, USA. These elements were concerned here: the technical design parameters, social life and wild animals. Therefore, the different parameters (topographic maps, geological maps of the area,...) weren't considered although they had a great influence to cost of building a new road corridor. To overcome this, Morofsky (1977) provided a good example of the GIS application in the rank in locating and assessing the routes and road corridors. The ranking was based mainly on the sensitivity of the road surface, the geological structure and geomorphological mapping. At the regional scale, the assessment was based mainly on the effects of distinctive regional climate which had an important influence on the vegetation and the soil development. An automatic system was developed allowing flexibility in generating alternative routings. Juffer et al (1983) introduced an innovative technique in selecting a preliminary route by using a computer program to analyze the geography and evaluate alternative route. The factors considered in the evaluation were derived from environmental impact statements and assessments. Here, the researchers ignored the social factor that focus on the environment. In general, the ranking or the road corridor assessment should be based on many factors: topography, geology, social life, environment, ... and not simply rely on the influence of climate or assessment of environmental impact, ...

In recent years, many GIS software packages have made on the basis of available data and the analysis can be carried out quickly and efficiently. The GRASS (Geographic Resource Analysis Support System) is one of the form design, it has provided many useful tools in the development, storage and analysis database, including analysis, image processing (Westervelt and Shapiro, 1988; Goran, 1990). Vieux and Kalayanapuram (1992) used GRASS 3.1 in choosing a safety route for the transportation of hazardous materials. The optimum route was selected after considering factors which can cause unsafe along the route. A "buffer" safety was created along the route on the basis of test different maps, such as: the map of population distribution, topographic maps, land use maps, the soil map, hydrology, vegetation, ... The relative importance of each attribute maps and materials (were transported) were considered a key in determining the intensity of influence. Impact index on each route was calculated by the regression analysis exposed the intensity of the properties in the "buffer" along the route. Routes had the smallest impact index would be selected as the best path for transporting hazardous materials.

As there were too many parameters need to put into the transportation network, such as: time, movement speed, types of streets, intersections, current status of land use, replacing sidewalks, ... then only GIS could solve efficiently, quickly and accurately. Isah O.Anavberokhai (2008), Tran Van Anh et al (2013) used GIS and multi-criteria analysis (MCA) to create a road planning map in Lokoja, the capital of Kogi State, Nigeria - based on Landsat satellite image of the study area, at the same time, many factors were interested here, as: the slope of the road, current status of land use, population density, the interests of the government, ... R.A.Ganorkar et al (2013) used the ArcGIS software of ERSI in determining an optimum route in order to reduce travel time, here the most interested factors were the intersections, types of streets, movement speed on each road, ... based on a background map which contained the spatial information related to road traffic network.

The same problem of determining the optimum route of transportation of hazardous materials or shorten the travel time, ... the scientists used the multi-criteria analytical technique with a lot of the different input parameters in GIS. If Vieux and Kalayanapuram (1992) concerned the map of the population distribution, topographic maps, land use maps, vegetation, ... and ignored the slope of road, the status of land use, Isah

O.Anavberokhai (2008) concered these factors. Meanwhile, R. A. Ganorkar et al (2013) were mainly interested in the intersections, types of streets, movement speed on each road, ... This created a difference in each study, but also there is a need to complete each other to solve the optimum route selection is thoroughly recommended, although the purpose of meeting is different.

Today, the concept of online GIS data (GIS online) aren't new, especially in the information explosion period. Collecting, aggregating and analyzing large amounts of information to use as a foundation for decision making, policy makers serve to the management of transportation network has a great significance. Therefore, Timothy J. Gates et al (2013) used online GIS data in modeling usability evaluation of land use on road corridor I-94, experiment on 20 miles of Kalamazoo and Calhoun county, State of Michigan (USA). This road corridor was suitable for modeling because there were both urban and rural, natural objects, ... in addition, Kalamazoo River also intersected this corridor. The database which was collected from MDOT (Michigan Department of Transportation), MGD (Michigan Geographic Data Library), MNFI (Michigan Natural Features Inventory), NLCD (National Land Cover Database), related to this study corridor. Besides, the researchers also used topographic maps, map of soil, map of hydrology, land use planning map, ... to enter the GIS software - ArcGIS Desktop Version 10.1. In the process of mapping the road corridor planning, each database was stored in shapefile format which would be treated as a separate layer in the GIS and overridden on the background map of Michigan. The results of the researchers included land use maps (current and in the future) and RSI index (Roadside Suitability Index) which used to evaluate compatibility relative of each object with the development the ROW (Right Of Way) next to the corridor. Online GIS data is considered a public information channel between the State, the manager and the people because of the internet. With the creation of the two-way flow of information in each channel of dialogue, online GIS data can minimize problems in the management process. Here, Timothy J. Gates et al (2013) used most of the parameters which are directly related to land use, such as: topographic maps, map of soil, map of hydrology, land use planning map, ... However, an ignored factor is the coordinates of the control point in locating the input data layer to ensure the last research results are complete and accurate.

In the developing countries, the traffic congestion is unavoidable. Therefore, Ernest Agyemang (2013) applied GIS-T model (Geographical Information System for Transportation) instead of the traditional technique of time determine to zoned areas of traffic congestion before. GIS-T could be understood simply as the combination of GIS and system of transport information (Vonderohe et al., 1993; Thill, 2000). So, GIS-T was the connection between hardware, software, data, people, organizations and political institutions to collect, store, analyze and connect information about traffic transport (Miller and Shaw, 2001). Here, Ernest Agyemang used a GPS handheld receiver, a table of digital data format, a stopwatch to determine the travel time of the vehicle on the road corridor Kimbu-Adenta (Nigeria), all parameters would be integrated into a base map stored in ArcMap in order to analyze and predict the trend of traffic jams on the road corridor Kimbu-Adenta.

Adebayo. H. Oluwasegun (2015) used GIS software in the analysis of the traffic situation in the Lagos Metropolis road corridor, Nigeria. The data were taken from the regional transportation agency Lagos Metropolis, topographic maps, street maps, ... in addition, the author also used geographic coordinates of points which were determined by a GPS handheld receiver on the road corridor and used data from the stopwatch and determined the density of vehicles in traffic. All data was integrated and spatial analysis in ArcGIS 10.0. The result of this study was a digital map on which displayed different levels of congestion and density of vehicles in traffic.

In general, the researchs have had the GIS application, from GCARS, GRASS, ArcGIS, ... to solve the various problems related to road corridors and they are under the category of road quality management. Previously, the studies have mainly noticed that the optimum route to meet the following criteria: reducing travel time, the lowest construction cost, the less dangerous route,... Now, the researches are mainly focused on analysis and prediction the trend of traffic jams or determinatinon the density of vehicles in traffic,... based on the integrated parameters used mostly topographic maps, map of land use, soil maps, street maps, map of population distribution ... and in addition, the geographic coordinates of the control points are determined by a GPS handheld receiver.

2. In Vietnam

In Vietnam, the management of road corridors is concerned by the government and the ministries, and the most interested problems are efficient management and exploitation of road works.

In recent years, Vietnam Road Administration has developed and implemented some international research programmes in order to build a system of necessary information for road corridor management with the support of the World Bank (WB), in which, to mention two programs which have used by many countries in the world (World Bank, 1997; Jianhua Li et al, 2004; Pasquale Colonna et al, 2005; Ig Schutte, 2008):

- HDM-4 (Highway Development and Management Model).
- iRAP (International Road Assessment Programme).

These programs are essentially a system of standard criterias, containing components of different attributes, toward certain types of road and follow the methods of different investigation, of different collection (Kerali H. R. et al, 1998). For example, HDM-4 program of the World Bank, Vietnam Road Administration had to establish 159 standard criterias and very detailed, such as: number segment, highway, climate, annual average daily of

traffic vehicles AADT, year of counting vehicles, the maximum speed allowed on the road (km / h), road surface materials, surface thickness, shrinkage coefficient of concrete, steel content average (%), the average depth of subsidence streak wheel (mm), the standard number of potholes, ... (table 1).

Table 1. Some information for the road management and road safety corridors under HDM-4 program of the World Bank in Vietnam (Kerali H. R. et al, 1998; Rodrigo Archondo-Callao, 2008).

Length (km)	Length (km)
Carriageway width (m)	Carriageway width (m)
Motorized traffic (AADT)	Motorized traffic (AADT)
Traffic composition per vehicle type (%)	Traffic composition per vehicle type (%)
Last surfacing year (calendar year)	Last surfacing year (calendar year)
Pavement type	Pavement type
Climate zone type	Climate zone type
Speed flow type	Speed flow type
Traffic flow pattern type	Traffic flow pattern type
Geometry type	Rise + Fall (m/km)
	Horizontal Curvature (deg/km)
Structural adequacy type	Benkelman beam (mm) or FWD deflection (mm) or structural number (#)
	Most recent surfacing thickness (mm)
	Previous/old surfacing thickness (mm)
Ride quality type	Roughness (IRI, m/km)
Surface condition type	All structural cracking area (%)
	Ravelled area (%)
	Number of potholes (No./km)
	Mean rut depth (mm)
	All transverse thermal cracking area (%)
	Wide structural cracking area (%)
	Edge break area (m ² /km)
Surface texture type	Texture depth (mm)
	Skid resistance (SCRIM 50km/hour)
Road Works History	Last rehabilitation (calendar year)
	Last construction (calendar year)
	Last preventive treatment (calendar year)
Drain type	Drain type
Drain condition type	Drain condition type
Construction quality type	Construction quality type

The information in the table above were examined, investigated from a variety of sources, such as: records of management, surveyed directly on the ground, ... For some indicators, such as : international roughness IRI (m/km), the material plasticity index (%), ... they had to use specialized equipments to measure. Therefore, they had to measure a lot and quite expensive. Besides, according to the data format of the HDM-4 program, this information system was presented, stored in Microsoft Excel so updated such information not continuous. On the other hand, when implementing the HDM-4 Project of the World Bank in Vietnam, because the content management towards the road quality maintenance, it didn't cover all the general requirements the management of the exploitation of road quality, road safety corridors and this was a reason make the program stopped many years ago (Ha Thi Hang, 2016).

Similarly, the iRAP program in Vietnam was stopped after a period of implemetation. Although the iRAP program has had many advantages, such as: used GIS to create a database of road transport networks so search easily, updated information on road movements; used iRAP online software to create a two-way of information between managers and users, ... However, the aim of iRAP program is to minimize the number of road traffic accident through the inspection of road infrastructure (by the driver or by video), so, the first requirement of this program has been to invest the cars which were attached the specialized equipment, constantly moving, survey on the roads, and the cost has been relatively big, the measuring time has been relatively long. In addition, the cost for inviting foreign experts to Vietnam to train, using specialized software, ... (Figure 1).



Figure 1. The test equipment of road infrastructure through the video (left in Vietnam, right in Serbia) follow the iRAP program (World Health Organisation, 2009)

In general, the application of GIS in the management of road network in Vietnam is still quite limited, just at the level of research and implementation mainly in small and fragmented region, can be applicable to local areas (Nguyen Van Vinh 2010, Dinh Quang Trung 2011, Dinh Thi Phuong 2012) or the application of GIS in the management of transport (Pham Xuan Mai va cs 2005, Le Van Trung 2012) or for urban planning , tourism (Tran Hung 2011, Le Anh 2012), ... So, if on the world, many countries have researched and succeeded in applying GIS in road management, road corridors management, ..., such as the US, China, India, ... then in Vietnam, the GIS application in the management of road corridors is still researched and is able to implement in the whole country in general and Hanoi in particular need to have time.

Summary and conclusion

In Vietnam, road safety corridors have often been changed by natural disasters (earthquakes, floods, etc.) or human activities (such as: urbanization along the route; the frequent encroachment of road safety corridors, even illegal construction of civil works; many roads upgraded or incorrect connection unregulated, etc.). All impacts to traffic operations and traffic quality. While the management of road corridors has conducted mainly in paper maps or digital maps - stored as *.dxf format of Autocad software, meanwhile, the statistics data have often stored as *.doc or *.xls – as format of Microsoft word, Microsoft excel. It takes a lot of time for the inspection and classification of objects or total, analysis,... This becomes more difficult when the urbanization rate is increasing, the road safety corridors constantly fluctuating due to many different reasons ... The application of GIS technology can solve the difficulties in the management of road safety corridors today. The first, GIS technology helps to create a database in a heterogeneous system, it is very important in query, extract, update, analyze, store,... data. This model can be seen easily (Figure 2).

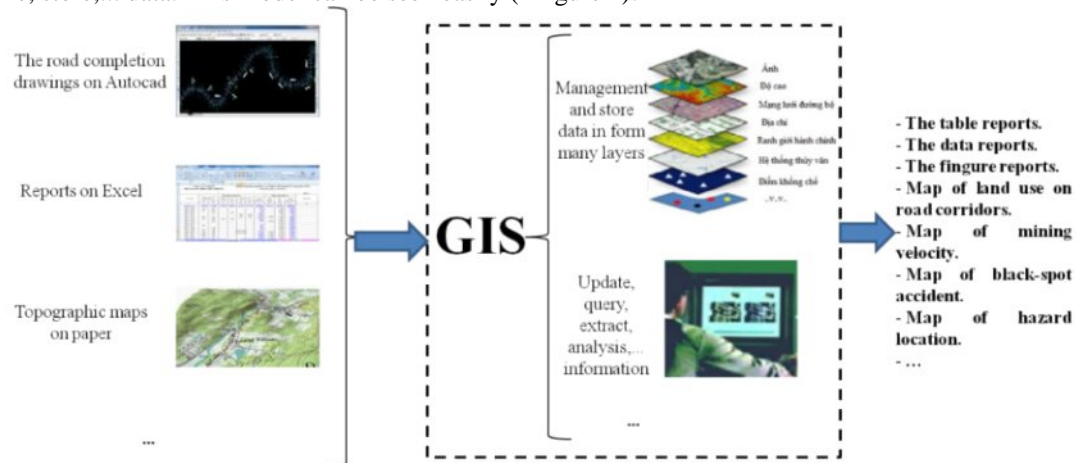


Figure 2. The proposal of GIS application model in the management of road safety corridor in Vietnam
(Ha Thi Hang, 2016)

According to our research, in Vietnam so far, no research of applying GIS in the management of road corridors has been done (according to the Department of Road Management 1, 2 - Directorate for Roads of Vietnam). So, to achieve high efficiency, the application of GIS in the management of road safety corridors should cover all content of road quality management. For greater clarity, the contents of the next research should focus on the following issues:

- Experimental model of GIS application in the management of road corridors in Vietnam (experiment on Highway 6).
- Building a model of remote sensing and GIS application in the management of road corridors in Vietnam.

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