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The development of road databases and analysis of traffic accident-prone section (blacksite) based on Geographic Information System (GIS)

M E Bolla and B S Djahi

Nusa Cendana University, NTT, Indonesia

E-mail: margiebolla@staf.undana.ac.id

Abstract. Historical data on traffic accidents can provide information on blacksite areas. This can aid in the approach for reducing the number of traffic accidents. Therefore, this research aims to develop database of traffic accidents by the implementation of Quantum Geographic Information System (QGIS) and its interface uses ArcView GIS. We found that there are 69 roads which are identified as the location of traffic accidents. Of these, there are 15 roads as blacksite. The most vulnerable road is the Timor Raya road which has an accident rate (APW) of 813.2 and a UCL value of 71.55. This database provides comprehensive information on geometric conditions of the road, accident data and blacksite, and also features road photographs and cross-sectional road drawings.

1. Introduction

East Nusa Tenggara with the city of Kupang as the provincial capital is one of the provinces in Indonesia which has the highest traffic accident rate in Indonesia. Based on data from the Police Traffic Directorate, the level of traffic accidents in the province is the third largest in Indonesia. The number of traffic accidents in Kupang City has increased from 2011-2015 where there were 940 traffic accidents with 1558 victims[1]. The cost for the traffic accidents is around 14,365,572,490 Indonesian Rupiahs[2].

Therefore, Determination of traffic accident prone locations requires systematic historical data, but until now it has not been available in Kupang City. The traffic accident data at the Kupang Kota Resort Police is still in written form that are easily damaged, so it is necessary to create a database to facilitate the management and search of accident data. Database based on Geographic Information System (GIS) has been widely used in facilitating the performance of policy holders, where the GIS-based database is capable of performing data processing as well as advanced spatial analysis. Geographical Information Systems (GIS) stand out for their ability to perform complex spatial analysis. However, sometimes the GIS, has been used only as a geographical database to store and represent data about accidents and road characteristics[3].

There are 2 different GIS software became a star in compiling Gis-based database that are ArcGIS and Quantum GIS (QGIS). Many studies have been developed regarding the use of both software in mapping of traffic accident prone sites such as Reference [4] creates a website page using Quantum GIS 1.8.0 Lisboa as software for make digital maps, and a study conducted by [5] that used arcGis in analyzing sight distance for road safety. QGIS software is also used by [6] to geocode five years (2009-2013) road accidents locations over the digitized map of Varanasi. The both software have their own

advantages and disadvantages, but the main advantage of QGIS is that there are no license levels in QGIS. Open source QGIS software does not limit which tools can be used.

Based on the conditions as described above then it is critically important to have comprehensive database in order to develop and find better strategies for better traffic safety. Therefore, this research aims to develop a GIS-based database using Quantum GIS program, analyze road network that are accidents prone, and arrange the interface of accident data with ArcView program. This will provide information in particular for public policy makers and help them to finding better strategies to reduce the number of traffic accidents.

2. Literature Review

It is stated in Reference [7] that traffic accident is an unexpected and unintentional highway event which involve vehicles and other road users. This results in human casualties and/or property losses. Blacksite identification is done by investigating historical data.

2.1. Weighting the accident data

Weighting is a value used to calculate the accident rate. This calculation is based on the death, severe and minor injuries. The weighting of traffic accidents (APW) is performed using accident-equivalent as given by [8], following this ratio shown in equation (1).

$$MD : LB : LR : K = 12 : 3 : 3 : 1 \quad (1)$$

where:

MD = death
LB = severe injuries
LR = minor injuries
K = material loss due to accidents

2.2. Rank method of accident-prone road

According to [8], the determination of accident prone-roads may use quality-control statistics using UCL (Upper Control Limit) Chart, with the following formula:

$$UCL = \lambda + \Psi \, x \sqrt{\frac{\lambda}{m} + \frac{0{,}829}{m} + \left(\frac{1}{2} \times m\right)} \quad (2)$$

where:

λ = average accident rate for all road
Ψ = probability factor = 2.576 (for probability 99%)
m = accident rate on each road

Roads with accident rates above UCL are defined as accident-prone roads (blacksite).

2.3. Quantum GIS (QGIS)

GIS software that will be used in this research is Quantum GIS Chugiak, which is a tool used to manage (input, management, process and output) spatial data or geographically referenced data. The use of QGIS in the world of spatial information systems has reasons:

a. It is free software.
b. It is frequently updated by enhancing and added new tools.
c. Users can also create their own tool functions.

2.4. ArcView GIS

The development of GIS application requires an effective and efficient interface since this is a bridge between system and users. In this research, user interface is created using ArcView, a popular GIS software for spatial data management. This has been developed by ESRI (Environmental Systems Research Institute, Inc) by the use of Avenue programming language.

3. Methods

3.1. Development of GIS-based spatial data

GIS-based spatial data is used to analyze and sketch road network. Map data is arranged in the form of shapefile (.shp) which consist of vector data maps of points, lines, and areas (polygons). The shapefile format maps come from various sources, such as the Quantum GIS forum, the Open Street Map forum and from the BAKOSURTANAL website. The map sketching begins by the recapitulation of GPS survey results data, geometric survey of roads and recapitulation of road name and road function data.

3.2. Analysis of traffic accident data

The field calculator feature is used to analyze traffic accident data from 2011-2015. The analysis is carried out by multiplication between the attribute fields, where the field is filled with accident data recording, accident weighting (formula 1) and data required to calculate UCL (formula 2), so that the formulas included in field calculator can be executed. The result can also be presented in the form of the attribute field.

3.3. Arrangement of GIS-based database

The data that has been collected and analyzed is then arranged in the database. They are displayed in the form of interface, which is formed by the use of *ArcView* GIS software.

4. Analysis

The following steps are conducted in the analysis and database compilation.

a. The first step is to collect primary and secondary data, which is then arranged in the form of GIS-based spatial data using QGIS software. Data consists of city road network, polygon, and coordinate points of GPS survey. This needs to be re-sketching for the interface arrangement. We then input the coordinate points of GPS survey using GPS tools.
b. We then use Map Composer to create map in the form of JPEG, which aims to depict the entire Kupang city road network. The data used in the depiction is the result of the shapefile image map (point a).
c. Blacksite analysis; Accident weighting and UCL calculations is performed using field calculator features. The obtained results are arranged by adding an attribute column.
d. Results showed that there are 69 road segments in Kupang City classified as traffic accident location. Of these, 15 road segments are classified as blacksite. The most vulnerable road segment is the Timor Raya road that has an accident weight of 813.2 and the UCL value of 71.55.
e. Arrangement of interface; the interface is named ‘Database dan Analisis Lokasi Rawan Kecelakaan di Kota Kupang berbasis SIG (Road Database and GIS based Blacksite Analysis’. At the beginning of the interface there are two options: 'Menu Utama (Main Menu)' option and 'Keluar (Exit)' option to end interface usage.

   The entire process of compiling this database is presented in Figure 1.

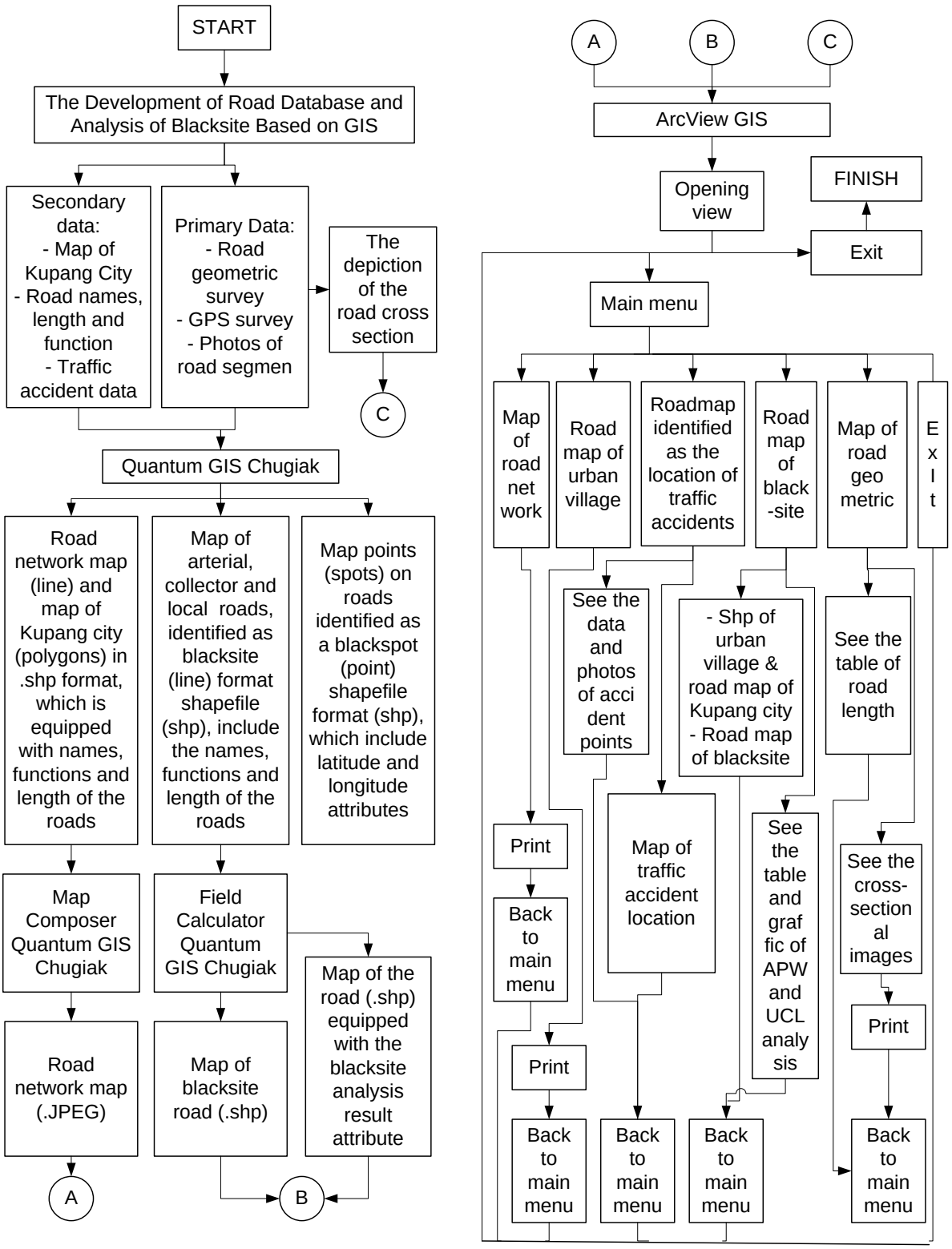

Figure 1 Flowchart of Database Compilation

5. Conclusion and recommendation

5.1. Conclusion

Based on the analysis above, it showed that the road network maps, blacksite map, geometric data and cross-sectional maps of road segments, as well as photographs of roads which are identified in traffic accident data can be arranged into GIS-based databases by using QGIS software and being depicted using ArcView GIS interface. The blacksite analysis can be done in the database which is compiled, where the result of the accident data analysis using QGIS showed that there are 69 roads identified as traffic accident locations, where fifteen of them are classified as blacksite. The top blacksite road is Timor Raya where the accident point weightage (APW) and UCL are is 813.2 and 71.55 respectively.Traffic accident data in the databases are in line with the other information: maps, results of blacksite analysis, road photographs and cross-sectional road drawings where data can be printed as needed. GIS-based data that are neat and informative will be able to accommodate the needs of stakeholders to make quicker and more accurate decisions in minimizing the number of accidents that occur, as well as in preparing the program of handling the location of traffic accident prone (blacksite).

5.2. Recommendation

a. An analysis needs to be conducted often as data always changes overtime due to the changes in the blacksite locations overtime.
b. The database has to be updated to accommodate the other aspects that are required for road safety analysis such as traffic accident modelling and road safety audit.

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