

FORECASTING THE CASE OF TRAFFIC ACCIDENTS THROUGH THE GEOGRAPHIC INFORMATION SYSTEM (GIS) APPLICATION METHOD WITH DOUBLE EXPONENTIAL SMOOTHING AND ANALYTICAL HIERARCHY PROCESS (AHP) IN CITY OF JAYAPURA-PAPUA

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ABSTRACT

Traffic accidents is a problem that needs great attention from all parties, both government and society. Traffic accidents has high cases in Indonesia can caused by various factors, namely: environmental factors (nature), the driver and the road. The aim of this study is to provide constructive advice to Traffic Officer of Jayapura to facilitate the countermeasures of cases Traffic Accident in the City of Jayapura with the presentation of accurate data information so that, it can be set the right solution to fight and prevent cases of Traffic Accident in the City of Jayapura. Double Exponential Smoothing methods used to forecast the vulnerable data to Traffic Accident and AHP is used to determine the dominant criteria. The results of AHP in visualized in the form of GIS. Through the application of WebGIS Traffic Officer can present the accurate data to support the process of countermeasures and prevention the cases of Traffic Accident in the City of Jayapura, so as to provide good performance for Traffic Officer in Jayapura.

Keywords: *Traffic Accidents, Double Exponential Smoothing, Analytical Hierarchy Process, Geographic Information System.*

1. INTRODUCTION

Traffic accident is a problem that needs great attention from all parties, both government and society. This is because of the number of Traffic Accident case is very high in Indonesia. This case is the third number killer, after heart disease and stroke in Indonesia. The high of Traffic Accident number in the Indonesia can be caused by various factors, such as: environmental factors (nature), the driver and the road [2]. Environmental factors (nature) such as a bad weather conditions which can affect the rider has a short viewing distance that can cause an accident. The driver's elements that can be carelessness, lack of awareness of individuals and / or lack of knowledge about the efforts to obey the traffic that include the violations of traffic signs [1]. While the factors associated with speed, road planning, road geometric, safety fence in a mountainous area, whether there is a road median, visibility and road surface conditions. Roads are damaged or perforated endanger road users [2].

Those three factors are the cause of traffic accidents in the area under investigation. To prevent the occurrence of traffic accidents that increasing, then the researchers use a double exponential smoothing method and AHP to get the right solution to prevent cases of lacquer in the City of Jayapura in order to reduce the accident rate of Traffic Accident for the following year.

The causes of the accident can be detected through statistical data Traffic Accident issued by Traffic Officer in Jayapura as the manager of a highway in the City of Jayapura. It contains primary data on the causes of accidents and the written description of the occurrence of the accident. the Traffic Accident data was collected in this study in the period of 2008-2013. The accident data is used in this study includes several categories which have been selected by investigators Based on the three factors that cause Traffic Accident (see Table 1).

Table 1: Factors and Category of Traffic Accident in City of Jayapura, Papua.

Factor	Category
The cause of Traffic Accident based on the environment	Flood
	Land slide
	Fog
	Rain
	Earthquake
	Tsunami
	Storm
	The Fallen tree
The cause of Traffic Accident based on the road condition	Broke
	Hole
	The view limited
	Slippery
	No Lamp
	No road markers
	No signs
	The road markers is broken
The cause of Traffic Accident based on the driver condition	Hairpin bend
	Careless
	Tired
	Sleepy
	Sick
	Disorderly
	Psychology pressure
	Drug's control
Drunk	
Speed limit	

The Traffic Accident case prevention efforts must be done properly. Therefore, through the development of mapping technology and computer technology or informatics is a Geographic Information System (GIS), the researchers want to provide a mean capable of supporting the prevention efforts of Traffic Accident cases effectively and efficiently. GIS in this research are used to provide a more accurate information to the government (including the attendant Traffic Officer) and the wider community, which can support countermeasures of Traffic Accident cases in the City of Jayapura.

The presentation of data using GIS is needed because of the data presentation that carried by Traffic Officer in City of Jayapura considered ineffective and inefficient, which is still in the form of a textbook report (manual data) are likely to be only known by the Traffic Officer. This is recognized by the Traffic Police officers on duty at the Jayapura police station in the interview process conducted by researchers on January 5th, 2014. The lack of information about the case of Traffic Accident may affect the response to cases of Traffic Accident (Example: The efforts to raise awareness people to obey the traffic rules through online media

(eg WebGIS) that can save time, energy and cost). Information provided by GIS in this research is a point-prone location Traffic Accident along with the factors that trigger the cause of Traffic Accident.

The solutions of countermeasures and prevention of Traffic Accident cases performed with the aid of WebGIS applications through the application of methods of forecasting Double Exponential Smoothing and Analytical Hierarchy Process (AHP). Application of this method is useful as a media communication that serves to distribute, publish, integrate, provide information in the form of digital maps (showing visually the area of Traffic Accident according to the results of forecasting the data on the factors that cause Traffic Accident through Google maps), as well as perform the functions of analysis and queries related to the process of forecasting the data of Traffic Accident for the next period in each region in the City of Jayapura (through the method of Double Exponential Smoothing) and determining the dominant factor triggers that cause Traffic Accident (through AHP) so as to set the right solution for tackling and prevent cases Traffic Accident in the City of Jayapura.

The research questions in this research are (1) How to overcome and prevent the cases of Traffic Accident that faced by Traffic Officer in Jayapura by using WebGIS program with the application of double exponential smoothing method and AHP? (2) What form of presentation of data through WebGIS applications are assessed to support the process of countermeasures and prevention of cases Traffic Accident in the City of Jayapura? The purpose of this study, are: (1) Provide constructive suggestions and ease in handling and preventing Traffic Accident that faced by Traffic Officer in Jayapura through WebGIS program with the application of double exponential smoothing method and AHP; (2) Presenting more accurate data that can support the countermeasures and prevention of Traffic Accident cases in City of Jayapura (through the application of WebGIS).

2. LITERATURE

2.1 Geographical Information Systems (GIS)

GIS or Geographic Information System is a computer system which has the ability to merge data, organize the data and perform the data analysis that would eventually produce the output that can be used as a reference in making decisions on issues relating to geography [4], in this research, the location is the geography of Traffic Accident area cases.

The main objective of using GIS is to get the information that has been processed and stored as an attribute of a location or object easier. The main characteristic of data that can be used in GIS is the data that has been tied to the location and the basic data are not yet specified. Not only that, GIS technology can be used also for scientific investigations, resource management, development planning, cartography and route planning [4].

Here is some research evidence regarding the use of GIS in various fields: (5) GIS for the determination of the direction of the function of land use in Merauke Regency, Papua Province [11]; (6) GIS as a tool to determine the location of grants Banjarbaru primary school South Kalimantan [12].

Similarly, in this study, GIS is used to provide more accurate information to the government (including the attendant Traffic Officer) and the wider community, which can support the countermeasures and prevention of Traffic Accident cases in the City of Jayapura. The information provided by GIS in this research is a point-prone locations Traffic Accident along with the factors that trigger the cause of Traffic Accident. The information obtained through the process of forecasting the data and data analysis (which aims to support decision-making within the right solution set). Data is presented visually or through a digital map.

2.2 WebGIS

WebGIS becomes particularly important given the current GIS application development leads to the Web-based applications. The development of applications in a network environment has shown great potential in relation to geo information. Excess use of WebGIS is a centralized data, lower costs for hardware and software, by the web based makes it more convenient to be used and allows greater access to GIS data. WebGIS has become a trend in which the spatial data management of Indonesian government has issued a program of 'one map' (the policy of the map) which is an initiative of the construction of an integrated spatial data between all sectors so that there is a spatial data reference for each theme map [16].

WebGIS goal is to develop a digital map-based WebGIS for easy retrieval of data and information on the road network, transport facilities, drainage channel and infrastructure firefighters, updating data and draw up a workable mechanism [16].

The benefits of WebGIS is the availability of maps or information based WebGIS well-structured, accurate, easy to read and understand by

a layman, either data or map schematic, supporting the macro planning of the road network, transport, drainage systems, facilities and infrastructure extinguisher fire in the city of Surabaya, either directly or indirectly [16].

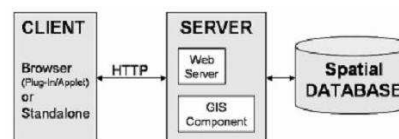


Figure 1. Architecture System WebGIS

The picture above shows the architecture of a minimum of a Web GIS system. The applications are client side that communicates with the server as a data provider via web protocols such as HTTP (Hyper Text Transfer Protocol). Such this applications can be developed with a web browser (Mozilla Firefox, Opera, Internet Explorer, etc.) [16].

2.3 Method of Forecasting

Forecasting is an essential tool in an efficient and effective planning [15]. The forecasting techniques are divided into two parts, namely: (1) subjective forecasting method and (2) the objective forecasting methods. Subjective forecasting methods have qualitative models. While the objective forecasting method has two models, namely: (a) the causal model and (b) the time series model. The forecasting method that used in this research study is objective forecasting method with time series model, in which the methods used to predict the exponential smoothing method is the Double Exponential Smoothing. The Double Exponential Smoothing method is best used for data with trend pattern [5]. The method is used to predict the Traffic Accident data in the next period in each region in the City of Jayapura. This is because Traffic Accident data in 2008-2013 in City of Jayapura are data with a pattern trend.

Here are some studies that prove that the Double Exponential Smoothing considered effective in forecasting: (1) Double Exponential Smoothing considered more effective than the moving average method, which is used to predict the use of a telephone in PT. Telkomsel DIVRE3 Surabaya [13]; (2) Implementation of forecasting production of meat-based geographic information systems through the application of Double Exponential Smoothing in Gorontalo province is considered effective to predict the meat production in the coming years according to the regions in the Gorontalo province and animal

species that exist [14]; Double Exponential Smoothing formula is as follows:

$$\begin{aligned} St &= \alpha * Y_t + (1 - \alpha) * (St - 1 + bt - 1) \\ Bt &= \gamma * (St - St - 1) + (1 - \gamma) * bt - 1 \\ Ft + m &= St + bt m \end{aligned}$$

Note:

- St = Forecasting for the t period
- Yt + (1-α) = Actual value *time series*
- bt = Trend in the t-period
- α = The first smoothing parameter between zero and 1
- 1 = Smoothing observed values
- γ = The second parameter for smoothing the trend
- Ft+m = The result of forecasting to m
- m = Number of period to face that would be predicted

To facilitate understanding of the types of forecasting above, there is the following chart on the types of forecasting methods (see Figure 1).

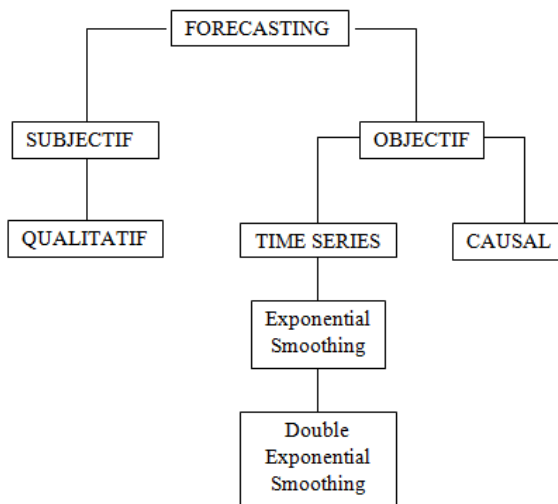


Figure 2. Types of Forecasting Method.

As a benchmark to determine how far the Double Exponential Smoothing forecasting model able to predict the data that has been preceded well, then use calculation Mean Absolute Percentage Error (MAPE) to measure it. This method is calculating the difference between the original data and data forecasting results. The differences are absolute, and then calculated into a percentage of the original data. This percentage results obtained its mean value [5].

MAPE has the advantage of an error stating the results of forecasting of the actual demand during certain periods that will provide information

on the percentage of errors is too high or too low, so it would be more accurate. In contrast, the weakness is owned by MAPE, MAPE is a measure of the relative error [6]. MAPE forecasting error calculation method has been proven to be able to measure the performance of the model in forecasting on a study of the exponential smoothing method for forecasting the use of a telephone in PT. Telkomsel DIVRE3 Surabaya [13], in which the relatively more accurate calculation results. The formula to calculate using MAPE is as follows [7]:

$$MAPE = \frac{1}{n} \sum_{t=1}^n \frac{|Y_t - \hat{Y}_t|}{Y_t}$$

Note:

- Yt = value to the period of data-t.
- Ŷt = Value -t forecast period.
- N = A lot of data.

2.4 Analytical Hierarchy Process (AHP)

AHP is a method to help arrange a priority of the various options using multiple criteria (multi-criteria). Because of its multi-criteria, AHP is quite widely used in the preparation of priorities or decisions. As well as being multi-criteria, the selection or prioritization in AHP is done with a logical procedure, structured, transparent and participatory [8]. With the increasingly high demands with regard to transparency and participation, AHP will be very suitable for the arrangement of public policy priorities, which demands transparency and participation [8].

Based on the strength of AHP, this AHP research is used to determine the dominant factors that trigger the cause of Traffic Accident.

It is intended to set the right solution to overcome and prevent cases of Traffic Accident in the City of Jayapura.

Here is some evidence of the use of AHP for decision-making in several studies: (1) OPEC using AHP to choose strategies in an effort to realize its objectives [11]; (2) The use of AHP to prioritize research topics that will be proposed by UNCAPSA, a research institute run by UN-ESCAP [8].

In broad outline, there are three stages in the preparation AHP priorities, namely: (1) Decomposition of the problem; (2) Valuation to compare the elements of decomposition; and (3) Synthesis of priority [10].

2.5 Google Maps

Google Maps is a web service-based mapping service provided by Google and is free of

charge, which has the ability for a lot of web-based mapping service. Google Maps also has properties *server side*, the maps that are stored on Google's servers can be utilized by the user. Google Maps API is a *library* in the form of *javascript* to modify existing maps on Google Maps as needed. To build applications that utilize the *Google Maps* on the desktop and mobile devices will be used *Google Maps Javascript API v3* which has the advantage of a faster than previous versions [9].

Google Maps in this study is used to present data effectively and efficiently which can support the process of countermeasures and prevention of cases Traffic Accident in the City of Jayapura. Google Maps is able to demonstrate visually the exact area of Traffic Accident according to the results of forecasting the data on the factors triggering cause of Traffic Accident in which the visual representations required to provide an understanding more clearly against conditions related attributes, which can complement the non-spatial data that is already owned by Traffic Officer in Jayapura. For example: Providing updates to data on the location Traffic Accident more quickly and with a digital display that is interesting, rather than using a conventional map.

3. Methodology

3.1 Flowchart Forecasting and AHP

Figure 2 is a process flow diagram *Double exponential* smoothing forecasting and AHP. Prior to forecast, Traffic Officer in Jayapura collected data in this study is that in the period 2008-2013.

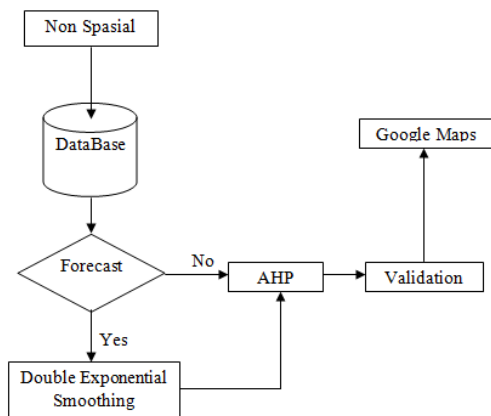


Figure 3. Forecasting Process Flow Diagram and AHP

So, doing the forecasting process takes existing data or previous data (previous year (2013.2012)), the process to look forward to forecast for 1 year ahead. After collecting the value of

forecasting of the data prior to the future, the data collected from the forecasting process are passed to the process AHP, where the results of AHP determine the dominant factors that trigger the cause of Traffic Accident as to set the right solution to overcome and prevent cases Traffic Accident in the City of Jayapura. Then the data is visualized.

4. RESULTS AND DISCUSSION

The need for constructive suggestions and to make easier in handling and preventing Traffic Accident faced by Traffic Officer station for the next long-term period (one year ahead). Additionally Traffic Officer City of Jayapura considered ineffective and inefficient, which is still in the form of a report textbook (manual data) are likely to only be known by the traffic officer. Then most of traffic officer in Jayapura do not yet have a media information that can provide information of the region through online media by using WebGIS program.

Hence need a system that can provide information about the data prone to accidents in the form of program webGIS and can predict the results of the data are prone to accidents for the period of long-term (one year ahead) and then determine the dominant factor triggers cause Traffic Accident to set the solution precise and present data that can effectively and efficiently support the process of countermeasures and prevention of cases Traffic Accident in City of Jayapura (through the application of WebGIS).

4.1 Application of WebGIS and forecasting results with AHP

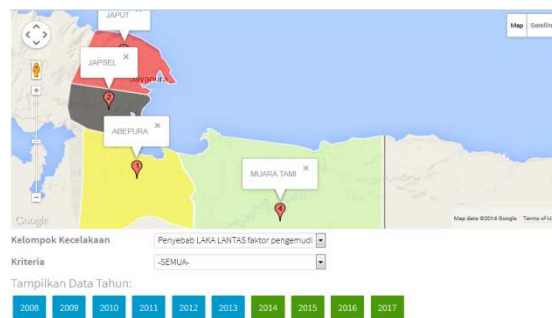


Figure 4. Initial Display Selection webGIS and Group Accident

Figure 4 is a display WebGIS. In view of this WebGIS, the user selects a category or group accident (one of the causes of accidents) the causes of Traffic Accident is driver factors, then at this

stage the user selects the year 2013, where in 2013 there has been no forecasting process.

Table 2. The Data of Accident Prone rating in 2013

Criteria	Abepura	South Jayapura	North Jayapura	Muara Tami
Unawares	0.32	0.32	0.32	0.04
Fatigued	0.25	0.25	0.25	0.25
Sleepy	0.25	0.25	0.25	0.25
Pain	0.25	0.25	0.25	0.25
Disrderly	0.25	0.25	0.25	0.25
Psychological Stress	0.1	0.4	0.4	0.1
The Medicine	0.25	0.25	0.25	0.25
The Influence of alcohol	0.29	0.36	0.29	0.07
The Speed Limit	0.11	0.67	0.11	0.11
Total	2.07	3	2.37	1.57

North Jayapura	49 cases. The cause of traffic unit factor the driver	0 cases. The cause of traffic unit based on natural factors	0 cases. The cause of traffic unit based on factors road
Muara Tami	29 cases. The cause of traffic unit factor the driver	0 cases. The cause of traffic unit based on natural factors	0 cases. The cause of traffic unit based on factors road

Table 2 shows the results of the accident-prone rankings in 2013. In the category of driver factors, the first rank is the accident-prone areas of South Jayapura with a value of 3, second in North Jayapura 2.37, Abepura third rank of 2.07, fourth ranked Muara Tami with a value of 1, 57.

In this case, the user can also know the main factors causing the accident in 2013. From the results show in Table 3, the researchers made application traffic officer webGIS to assist in dealing with the main factors causing the accident in order to reduce the accident rate in the next year.

Table 3 shows the main factors causing the accidents in 2013. From the three cases, the highest factor is the factor of the driver. Abepura 46 cases, 67 cases of South Jayapura, North Jayapura Muara Tami 49 cases and 29 cases. From the four areas that have the highest accident case is South Jayapura with 67 cases the driver causes an accident factor. This shows that in 2013 the driver factor in South Jayapura highest with 67 cases.

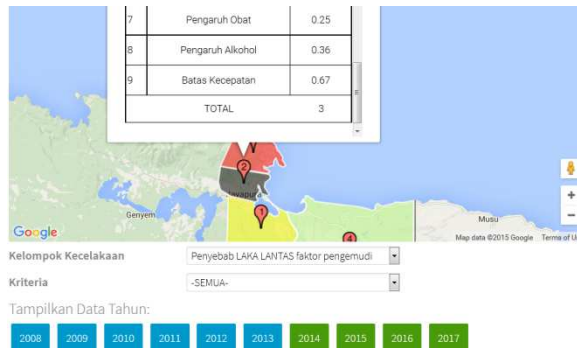


Figure 5. Map Display Digital 2015

Table 3. Main Factors Cause Accidents in 2013

Region	Driver	Natural	Road
Abepura	46 cases. The cause of traffic unit factor the driver	0 cases. The cause of traffic unit based on natural factors	0 cases. The cause of traffic unit based on factors road
South Jayapura	67 cases. The cause of traffic unit factor the driver	0 cases. The cause of traffic unit based on natural factors	0 cases. The cause of traffic unit based on factors road

Figure 5 is a display webGIS or digital map display. In this display, the user selects the same category or group accident (one of the causes of accidents) the causes of Traffic Accident is driver factors, then at this stage the user selects 2015, where in 2015 the process of forecasting.

Table 4. Results of Prediction Accident Prone rating 2015

Criteria	Abepura	South Jayapura	North Jayapura	Muara Tami
Unawares	0.36	0.27	0.27	0.09
fatigued	0.21	0.43	0.29	0.07
Sleepy	0.12	0.47	0.35	0.06
Pain	0.24	0.41	0.29	0.06
Disrderly	0.11	0.67	0.11	0.11



Psychological Stress	0.23	0.38	0.31	0.08
The Medicine	0.25	0.25	0.25	0.25
The Influence of alcohol	0.33	0.33	0.27	0.07
The Speed Limit	0.09	0.55	0.27	0.09
TOTAL	1.94	3.76	2.41	0.88

Table 4 shows the results of the accident-prone rankings in 2015. In the category of driver factors, the first rank is the accident-prone areas of South Jayapura with values of 3.76, 2.41 second in North Jayapura, Abepura third rank of 1.94, ranking fourth in Muara Tami value of 0.88.

Table 5. Key Factors Cause of Accident 2015

Region	Driver	Natural	Factors
Abepura	110 cases.	0 cases.	0 cases.
	The cause of traffic unit factor the driver	The cause of traffic unit based on natural factors	The cause of traffic unit based on factors road
South Jayapura	158 cases.	0 cases.	0 cases.
	The cause of traffic unit factor the driver	The cause of traffic unit based on natural factors	The cause of traffic unit based on factors road
North Jayapura	127 cases.	0 cases.	0 cases.
	The cause of traffic unit factor the driver	The cause of traffic unit based on natural factors	The cause of traffic unit based on factors road
Muara Tami	63 cases.	0 cases.	0 cases.
	The cause of traffic unit factor the driver	The cause of traffic unit based on natural factors	The cause of traffic unit based on factors road

Table 5 shows the main factors causing the accidents in 2015. From the three factors or cases, the highest factor is the factor of the driver. Abepura 110 cases, 158 cases of South Jayapura, North Jayapura Muara Tami 127 cases and 63 cases. From the four areas that have the highest accident case is South Jayapura with 158 cases the driver causes an accident factor. This shows that in 2015 the driver factor in South Jayapura with 158 cases of the highest accident.

Based on interviews conducted with the 30 officers who have studied Traffic Officer WebGIS applications to monitor and predict traffic accidents in the City of Jayapura, all expressed satisfaction with the performance of the program and all of them stated that the program can be used for the next Traffic Officer.

5. CONCLUSION

Double Exponential Smoothing Method is used to calculate data of traffic accident prone and AHP is used to determine the dominant criteria. The result of AHP is visualized in form of GIS.

Through WebGIS application, Traffic Officer will be able to present accurate information in order to provide right solution to support the process of tackling/reduction and prevention of traffic accident cases in Jayapura, thus could improve the performance of Traffic Officer in Jayapura.

Scoring result acquired, effective calculation method, and WebGIS application is highly beneficial if used by traffic accident officers to predict the cause of traffic accidents, to reduce the traffic accident rate in next year. This application can be accounted by WebGIS for Traffic Officer in City of Jayapura.

Based on the result of the study and discussion conducted, it is suggested that there is a need for specific record-keeping because the more specific the data, the more accurate the prediction will be. Factors causing accidents should be multiplied or expanded to know more data about traffic accident prone.

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