Spatial Distribution of Dengue Haemorrhagic Fever (DHF) Vulnerability Level Based on Population Density, Rainfall, Drainage Condition, Natural Water Body, and Vector Control Program in Tanjung Redeb Sub-District, District of Berau, East Kalimantan

Risva[1*], Siswanto[*], Subirman[*]
[1]*Department of Public Health, Mulawarman University, Samarinda, 75119,Indonesia*

[*)]Corresponding author: risvaskm@gmail.com

Abstract. Dengue hemorrhagic fever (DHF) has still become a major health concern in the world particularly in the tropical and sub-tropical area such as South-east Asia including Indonesia. In 2010, about 1.317 mortality due to dengue out of 150.000 cases has made Indonesia become the highest case of DHF country in South-east Asia. The province of East Kalimantan represents the endemic region of DHF and contributes the highest cases in Indonesia especially in the sub-district of Tanjung Redeb, district of Berau. This study investigated the level of vulnerability of DHF at sub-district scale based on population density, rainfall, drainage condition, natural water body and vector control program. A geographical information system (GIS) software were used for mapping the spatial distribution of vulnerability area of DHF in sub-district of Tanjung Redeb for every three months period of 2014. The level of DHF vulnerability in Tanjung Redeb was fluctuate. At the first three months was medium, and continues to become high level at the second and third three months, then become medium level at the last three months during 2014-time period. This result indicates that the spatial distribution based on climate, landscape, and human factors might be used to predict the vulnerability area of DHF at the fine scale such as sub-district level. This information will in turn may help government to conduct a better strategy for controlling the transmission of DHF in each area.

Keywords: Level of Vulnerability, DHF, GIS, Tanjung Redeb-Berau

Introduction

Dengue has still become a major health concern in the world particularly in the tropical and sub-tropical areas such as South-East Asia including Indonesia. Dengue Hemorrhagic Fever has impactson theenvironmentand economic in this region [1]. It is estimated over 50 million people were infected annually with dengue and up to 500.000 people develop a potentially lethal complication called dengue hemorrhagic fever/dengue short system [2]. Mosquito vector, Aedesaegypti are endemic to most of thetropical and sub-tropical region over the world. Prevention and control program are the main methods of reducing the prevalence of the diseases (DHF). Hence, goodstrategy for the prevention and control system is needed. Several studies have been conducted in various regions over the world to studythe link of environmental factors and the prevalence of dengue fever by using spatial analysis.There were approximately fifty million dengue haemorrhagic fever (DHF) infection and about 2,5 million people live in the dengue endemic regions [3]. Dengue fever (DF) associated dengue haemorrhagic fever / dengue shock syndrome has emerged as an important public health problem in the countries of the South East-Asia and Western Pacific region.

Fig. 1. Study area, with principal cities and town

Indonesia is a highest country of list of the dengue fever case in South East-Asia, with the number of mortality is 1317 people from 150.000 cases in 2010. Indonesia is a tropical island, and East Kalimantan Province is endemic area od Dengue Hemorrhagic Fever (DHF), particularly in district of Berau. Spread of DHF in Beraumight be caused by environmental (weather, rainfall), mobility (accessibility), population density, and natural water body. In order to accelerate the healthy problem, delivering about healthinformation is essential. Geographical Information System (GIS) and SPSS are utilized to deliver more information to prevent DHF disease. The objective of this study was to investigate the DHF vulnerability level based on the population density, rainfall, drainage condition, natural water body, vector control using GIS.

Dengue fever (DF) and dengue hemorrhagic fever (DHF) are caused by the dengue virus. Virus of dengue is a mosquito-borne infection which in recent years has become a mayor international public health concern. Several studies have been applied in term of Applying geographical information system (GIS) corresponding to the dengue hemorrhagic fever such as mosquito habitat and dengue risk potential in Hawaii; a conceptual framework and GIS application [4]. There are few studies have analyzed spatial distribution vulnerability level based on population density, rainfall, drainage condition, natural water body, and vector control. In this context, application of GIS modeling for dengue fever to the prone area based on socio-cultural and environmental factors [5]. Application of GIS in modeling of dengue risk based on sociocultural data, found that any steps taken to improve any of the social and cultural practices would have favorable effects on reducing dengue case[6]. The use of GIS in Ovitrap monitoring for dengue control Singapore, found that GIS was used to plan vector surveillance and control operations [7]. Modeling dengue fever risk based on socioeconomic parameters, nationality and age group; GIS and remote sensing based case study,found that there was a strong positive association between dengue fever cases and socio-economic factors[8].Numerous reviews have broadly addressed the used of geographical information systems (GIS), mapping and spatial and space-time modeling approaches in operational control program [9][10][11].The weather variability such as monthly maximum, minimum temperature, rainfall, and relative humidity identified as meaningful and significant indicators for the increasing occurrence of dengue fever [12]. Incorporating GIS mapping and google earth technologies in a dengue surveillance system for developing countries might be used to prioritize control strategies and to target interventions to highest risk areas in order to eliminate the likely origin of the mosquito vector [13]. Geographical information systems is also utilized to assessing the spreading patterns of dengue infection and chikungunya fever outbreaks [14].

This study aims to investigate the level of vulnerability of DHF at sub-district scale based on population density, rainfall, drainage condition, natural water body and vector control program. A geographical information system (GIS) software were used for mapping the spatial distribution of vulnerability area of DHF in sub-district of Tanjung Redeb for every three months period of 2014. To know the level of vulnerability of dengue hemorrhagic fever, this study analyzes the data using an SPSS approach and then the result would be converted to the Geographical Information System (GIS). With those facts in mind, there are few studies have been published using GIS methods to model the spatial relationship between dengue fever cases, population, population density, to create a predictable mapping of level of vulnerability based on environmental, climate, and human factors. This study hypothesizes that the spatial distribution based on climate, landscape, and human factors might be used to predict the vulnerability level of dengue haemorrhagic fever (DHF) at fine scale and could help thegovernment to conduct a better strategy for controlling the transmission of DHF in each area.

Materials and Methods

A. Study Area

This research was conducted in Tanjung Redeb, District of Berau since of the major dengue epidemic that occurred in East Kalimantan, Indonesia. Tanjung Redeb is the capital city of Berau on the island of East Kalimantan. Around 83.942 inhabitants, consist of 45.127 men and 38.856 women distributed over an area of 23,76 km2, with a population density of around 2.848,36 inhabitants/ km2 and a number of 235,178 household. In every year, wide range spread of dengue hemorrhagic fever (DHF) occurs in East-Kalimantan and caused high mortality. Actually, prevention of DHF has been conducted but the diseases still exist in the area. DHF is significantly increasing during 2010-2011 in Tanjung Redeb where there were 144 cases in 2012. Distribution of thepopulation of sub-district of Tanjung Redeb shown in Table 1.

Table 1. Distribution of population based on sub-distribution in Berau Districts

No	Sub-District	Men	Women	Total
	Sungai Bedungun	4.553	3.867	8.380
1	Tanjung Redeb	12.741	10.865	23.606
2	Bugis	8.053	6.886	14.919
3	GunungPanjang	5.311	4.550	9.861
4	KarangAmbun	7.203	6.242	13.445
5	Gayam	7.266	6.466	13.732
Total		45.127	38.856	83.942

B. Data Collection and Analysis

Data have been collected consist of primary and secondary data. Primary data were collected through a filed survey. The questionnaire covered about gender, occupational pattern, awareness, and knowledge about dengue, mosquito protection practice. Secondary data were obtained from three government office including health office, city office and statistic office. The collecting data was conducted on March 2015 to September 2015. The data were collected in Tanjung Redeb such as population density, rainfall, drainage condition, natural water body and vector control used in the building of GIS layer to create the dengue potential map. Geographical Information System (GIS) is an automated computer-based system with the ability to capture, retrieve, manage, display and analyze large quantities of spatial and temporal data in a geographical context. In this study, GIS is utilized to demonstrate the spatial distribution of dengue hemorrhagic fever (DHF) vulnerability level based on population density, rainfall, drainage condition, natural water body and vector control program.This research used analysis epidemiology with ArcGIS 10.

Results and Discussion

The questionnaireswere administered during the survey to the randomly selected respondents for data collection. SPSS software was employed for the parameter estimation and GIS then used to create the dengue potential map. We divided three-part sub-sections to describe the main result.

A. Spread of DHF

DHF data in District of Berau is provided by Abdul Rival Hospital, it is an official hospital of Berau. The data were reported in weekly and monthly. The DHF was significantly increasein TanjungRedeb during 2013 and it might become aserious problem if not addressed properly. The following is amapping of DHF based on the data during 2013 in Tanjung Redeb. As can be seen in Fig. 2 that the red color is anareaof DHF case, the number of DHF case in thedistrict of Berau is 169 cases in 2013, and there were 111 cases in Tanjungredeb. It means 65.68 % of DHF in District of Berau exist in Tanjung Redeb.

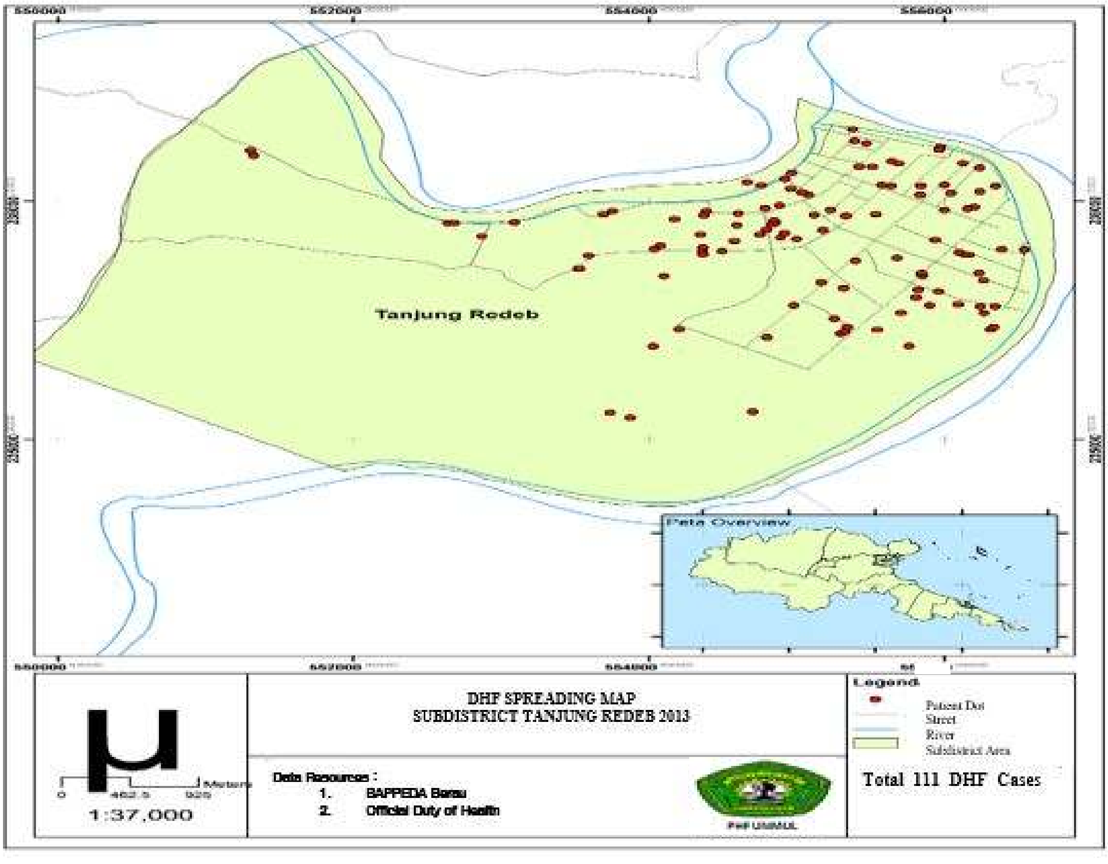

Fig. 2 Spread of DHF in Tanjung Redeb at 2013

B. The Level of Vulnerability

The level of Vulnerability was obtained by analyzing the determinant variable such as population density, landscape, rainfall and larva free index. The variables which have been given value (signed) and weighting according to the magnitude of the effect of vulnerability of time and area toward DHF and then over layer. Its result then divided within three class categories/level namely low risk, medium risk, and high risk of DHF. This prediction would be areference point for future research since the population density, landscape, rainfall, and larva free index would not be significantly changing in shortly time, therefore this research is assumed relevant for preventing based on time and area, and risk each other. The following is amapping of thevulnerability of DHF during 2014 and divided into four quarters. Fig. 3 is amapping of vulnerability level of DHF for thefirst quarter.

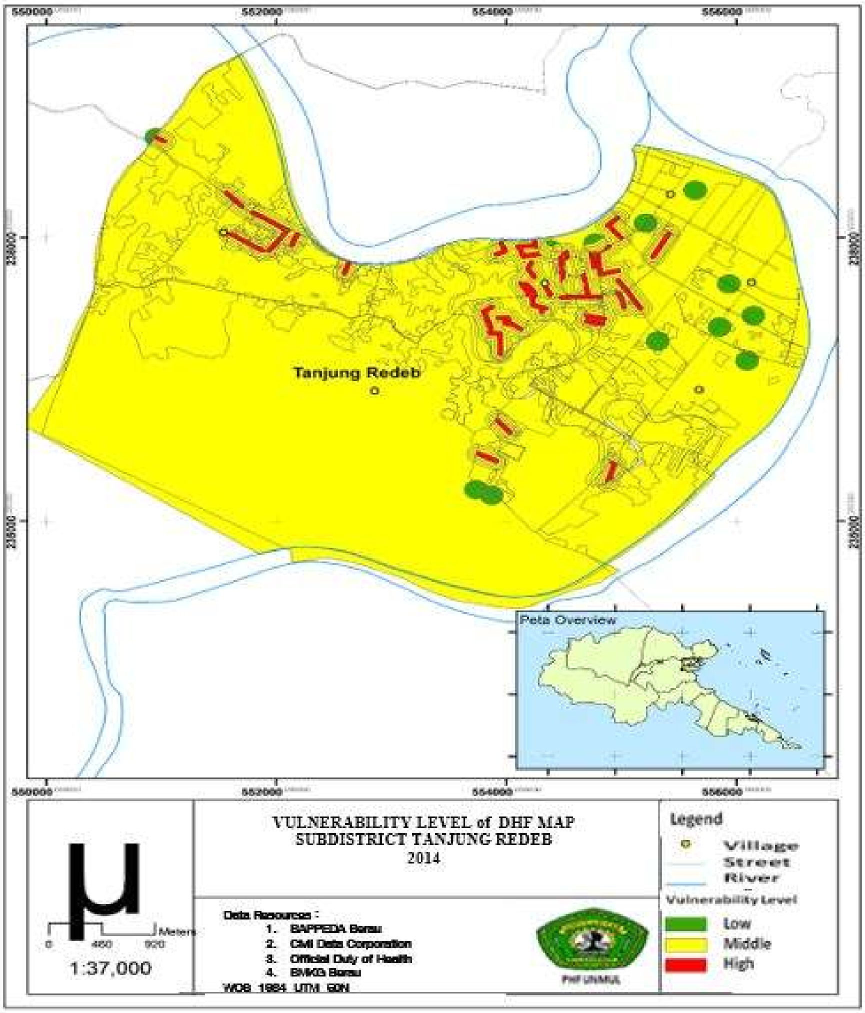

Fig. 3 Vulnerability level of DHF for First quarter

Fig. 3 shows that there are some areas with vulnerability level medium and some areas exist in high vulnerability level as well as a few areas exist in low level. The vulnerability level of DHF for 2nd quarter is presented in Figure 4.

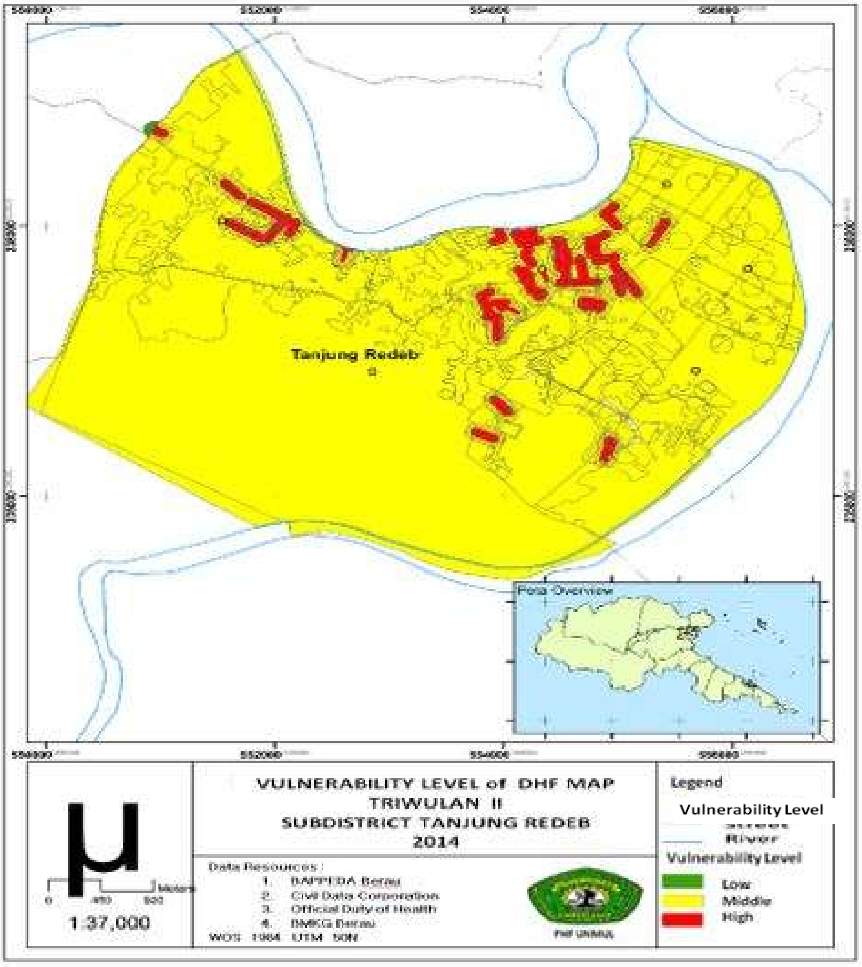

Fig. 4 Vulnerability level of DHF for 2nd quarter

As can be seen in figure 4, there are several areas exist in high vulnerability level and there were some areas exist in medium vulnerability level. The vulnerability level of DHF for 3rd quarter is shown in figure 5.

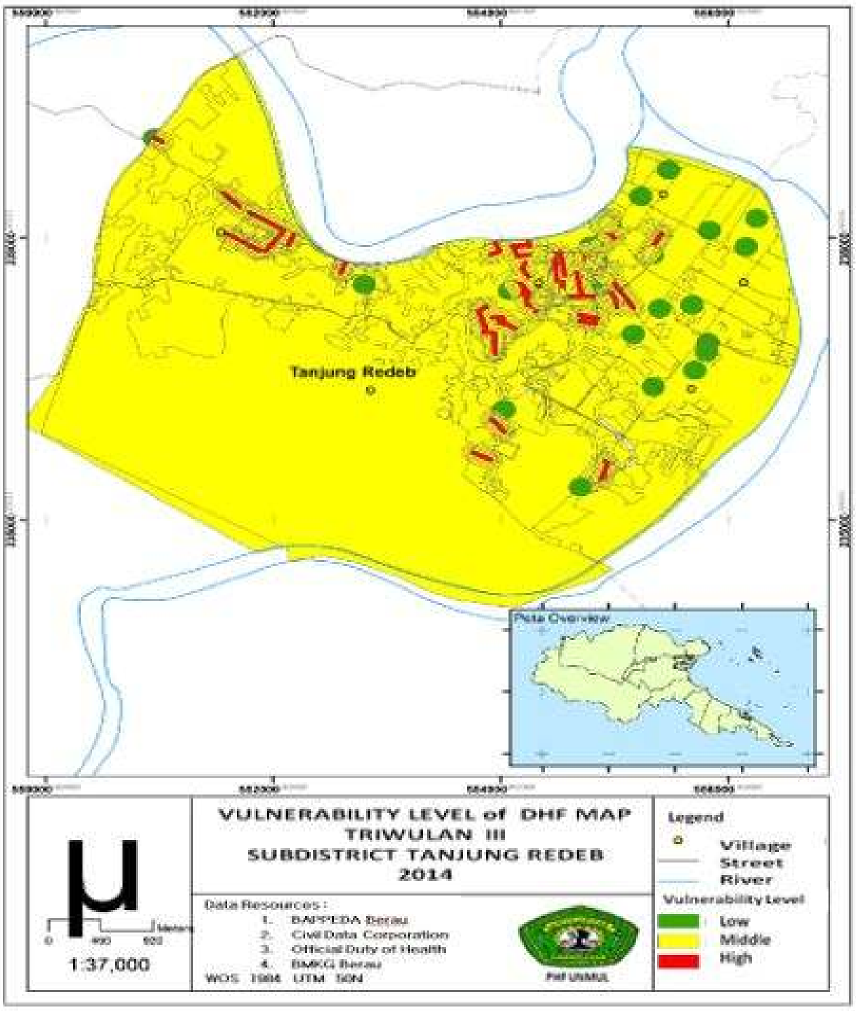

Fig. 5 Vulnerability level of DHF for third quarter

Figure 5 shows that the vulnerability level of DHF almost same between high, moderate, and low level. The vulnerability level of DHF for 4th quarter is depicted in figure 6.

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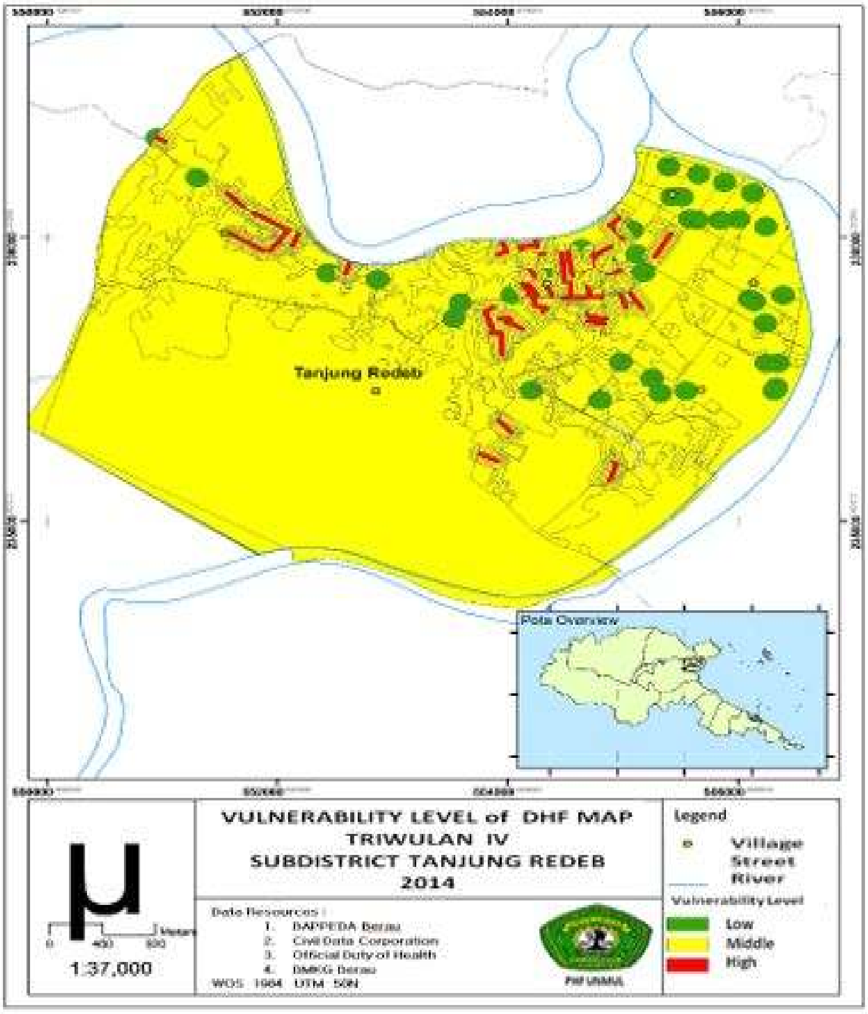

Fig. 6 Vulnerability level of DHF for fourth quarter

In figure 6, it shows that the low vulnerability level of DHF is higher than moderate and high level.

The main objective of the study is to investigate the spatial distribution dengue haemorrhagic fever (DHF) vulnerability level based on population density, rainfall, drainage condition, natural water body, vector control program. Analysis of the survey data revealed that the level of DHF vulnerability in Tanjung Redeb was fluctuate as described in a map by GIS. Applying of geographical information system analysis has improved corresponding between socioeconomic factors and dengue haemorrhagic fever (DHF) prevalence. In line with previous study (AlphanaBohra et. Al, Korine N. Kolires, Krishna Prasad et.al), the application of GIS in modeling of dengue risk based on sociocultural data; case of Jalore, Rajasthan, India has found that the sociocultural factors such as the housing patterns, limited use of mosquito protection measures, irregular water supplies, poor management of waste disposal, storage of water on the premises due to inadequate water supplies in summer months, and prolonged storage of water for domestic and other purposes significantly affected the incidence of dengue [4]. This result to be relevant with the recent study. Mosquito habitat and dengue risk potential in Hawaii: A conceptual framework and GIS application argued that by modifying inputs through a variable weighting process, decision regarding mosquito and disease control can be adjusted based on specific temporal and local spatial variation [2]. Application of GIS modeling for thedengue fever prone area based on socio-cultural and environmental factors – A case study of Delhi City Zone. It was found that GIS modeling was done to generate risk map of dengue incidence [3]. This result revealed that there is relevant between previous and recent study. Advances in mapping, geographical information systems technologies, and progress in spatial as well as space-time modeling could be harnessed to prevent and control the diseases [9]. Hence, this study showed that the spatial distribution of vulnerability level of Dengue Haemorrhagic Fever DHF based on population density, rainfall, drainage condition, natural water body, and vector control program could be predicted. Even though the examined models were supported and the results were generally in line with previous studies, there are limitations associated with thepresent study.

Conclusion
Dengue fever or dengue haemorrhagic fever is one of the most important emerging tropical disease at the beginning of the 21st century. [15]. In 2010, it is about 1.317 mortality due to dengue out of 150.000 cases has made Indonesia become the highest case of DHF country in South-east Asia. Geographical Information system (GIS) modeling was done to create map the potential of vulnerability level of dengue haemorrhagic fever, with three levels such as high, medium, and low-level risk. This study also revealed that dengue haemorrhagic fever generally occurred in areas with high density population. The data analysis and modeling show that the population density, rainfall (climate change), drainage condition (landscape), natural water body, and vector control have higher influence on dengue haemorrhagic fever incidences. A geographical information system (GIS) software was used for mapping the spatial distribution of vulnerability area of DHF in sub-district of Tanjung Redeb for every three months period of 2014. The level of DHF vulnerability in Tanjung Redeb was fluctuate. At the first three months was medium, and continues to become high level at the second and third three months, then become medium level at the last three months during 2014-time period. This result indicates that the spatial distribution based on climate, landscape, and human factors might be used to predict the vulnerability area of DHF at the fine scale such as sub-district level. Therefore, this result will in turn may help thegovernment to conduct a better strategy for controlling the transmission of DHF in each area. Given the importance of the information of vulnerability level of dengue haemorrhagic fever, the development of geographical information system in prevention of public health area still need to be explored further.

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