QuickBird image for the preparation of the ecological spatial model dengue hemorrhagic fever disease

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ABSTRACT- This study aimed at (1) determining the environmental parameters of QuickBird imagery as a basis for determining the level or potential information associated with dengue disease, and (2) conducting spatial ecological modeling to determine areas at vulnerability of dengue disease based on the results of the analysis of the spatial relationship between the incidence of dengue disease with environmental conditions parameters settlement QuickBird image interpretation. QuickBird image analysis consists of: image interpretation, test the accuracy and presentation of spatial data related environmental parameters suspected dengue disease include: (1) the density of settlement, (2) settlement patterns, (3) the distance the settlements on the river, (4) the distance the settlements to landfills (depot transporter), (5) population density, and (6) weather and climatic conditions (rainfall, temperature, and humidity). The results show the ability and contribution of Quickbird imagery in spatial modeling dengue disease incidence, by generating spatial data related environmental parameters suspected dengue disease events with reasonable accuracy, which subsequently became the basis of spatial data in a geographic information system for spatial ecology modeling, and determine areas vulnerable and at risk of dengue and dengue cases prediction.

1. Introduction
Indonesia as a tropical country is an endemic area of various infectious diseases, such as malaria, dengue, tuberculosis, filariasis, diarrhea, and etc. Based on the occurrence of the process, the infectious diseases can be categorized into: (1) endemic infectious diseases which influence the Human Development Index, namely tuberculosis, diarrhea, malaria, filariasis, and hepatitis; (2) infectious diseases that have the potential to become an outbreak. This kind of disease is periodically predictable, able to be anticipated and able to be prevented. They are dengue hemorrhagic fever, cholera, and diarrhea; and (3) new infectious diseases [1].

According to the World Health Organization (WHO), dengue hemorrhagic fever (DHF) has become one of the diseases classified as epidemic and endemic, and the drug has not found [2]. The cause of DHF is arbovirus that enters the human body through *Aedes aegypti* or *Aedes albopictus* mosquitoes which nest and breed in clean water storage, stagnant water in secondhand goods, and leaves [3]. *Aedes aegypti* and *Aedes albopictus* mosquitoes attack densely populated urban areas and have high mobility. Various ways have been done to prevent the proliferation of mosquitoes that cause dengue disease, but the results are not optimal. Every year, there is an increase in people with dengue disease and has a lot of casualties ranging from children to adults [4][5].

Yogyakarta as one of the cities in Indonesia is also a dengue endemic area. Some cases of dengue fever occur and increase from year to year, and even had an outbreak in 1972. From year to year, the number of patients found was never zero. Since 1980, the number of patients has continued to increase significantly until 1998 and has reached the highest peak. The decline occurred only once in 1992.
1998, sharp declines happened several times. In 2010, it rained all year around. This kind of weather is very influential on the increasing number of patients [6].

The breeding of *Aedes aegypti* and *Aedes albopictus* mosquitoes as a vector of dengue highly depends on altitude, relief, rainfall, temperature, drainage systems, hydrology, settlement density, population density, and environmental quality of settlements. Therefore, the geography as a study of various phenomena of the earth's surface emphasizes on the human interaction with the environment. It has a role in solving the health problems which are closely associated with the environment [7]. In addition, the development of science and technology in general also affects the development of geography analysis. The development of remote sensing technology enables the collection of geographical data to be more time-saving, cost-effective and labor-intensive than using terrestrial methods [8].

Spatial data of environmental conditions are needed to be able to perform spatial analysis of dengue disease. The inventories of environmental conditions are land use, building density, residential density, settlement pattern, settlement distance to the river, landfills, and the population density. These conditions are the initial information to determine the spread of dengue disease which related to the environmental factors.

The inventory of environmental conditions can be obtained from terrestrial survey or by remote sensing. The use of remote sensing as a way of collecting data especially spatial data. It has several advantages, namely: (1) time, costs and energy saving with high accuracy, (2) provide a synoptic picture so it is easy to observe in large areas simultaneously, (3) have a high temporal resolution so as to follow the development of a highly dynamic environment [9].

QuickBird satellite was launched on October 18, 2001. It is a remote sensing satellite that produces very high-resolution image namely 0.61 m for panchromatic and 2.24 m for multispectral channels. This satellite can replace the use of aerial photography for resource management studies such as the study of land use and urban planning, business studies, including environmental studies.

Based on the above problem formulation, compiled the following research questions: (1) How is the QuickBird imagery capability for extracting spatial data parameters associated environmental conditions incidence of DHF and ecological contribution in spatial modeling incidence of dengue disease; (2) What is the relationship between the spatial or spatial correlation with the incidence of dengue disease parameters neighborhoods conditions QuickBird imagery interpretation, and the parameters in the terrestrial environment, using spatial statistical analysis and geographic information systems, (3) What can be spatially structured ecological models to determine areas prone to dengue disease based on the results of spatial statistical analysis between the incidence of DHF with parameters of environmental conditions settlements QuickBird imagery interpretation, and the parameters in the terrestrial environment.

2. Methods

This research is applied remote sensing and geographic information systems for health study. This study will utilize QuickBird remote sensing image as the data provider of spatial urban environmental conditions and geographic information systems as methods and techniques of spatial data analysis. In this study using the ecological approach.

The incidence of dengue fever required three elements, namely: environment, cause (agent) and the host. In this study, these elements function as an independent variable or referred to as a predictor factor. As the dependent variable is the level of vulnerability to DHF.

The first predictor factors, namely the environment variable will be extracted through remote sensing image is map parameters of environmental conditions, including: the density of settlement, settlement patterns, and the distance to the river settlements. The second predictor variable is the data from direct observation and secondary data, population density, landfills while climate data includes the data of rainfall, temperature, and humidity.
Population is the whole object of research. The population in this study was all units of residential land in the city of Yogyakarta which is recorded in the QuickBird image. The number of known populations after image interpretation. The sample is in part of the population studied. Sampling of land units used to test the precision of the interpretation of the parameters of settlement density, settlement patterns, and determine the location of landfills while. The sampling technique used in this study is proportional sampling technique. Proportional sampling technique is used to find the balance between the number of samples in each category according to the degree of difficulty of interpretation, whereas, systematic random sampling was used to determine the object that will be sampled in each category.

Analysis of the data in this research analysis is divided into three according to the research objectives, namely: first, analysis of QuickBird imagery capabilities for spatial data extraction parameters of urban environmental conditions; second, the analysis of the spatial correlation parameter environmental conditions with the incidence of dengue disease; and third, spatial modeling for the determination of regional ecological risk to DHF and estimates for dengue outbreaks.

3. Results and discussion

3.1. As QuickBird Imagery Ability Analysis of Spatial Data Source Parameters Environmental Conditions Urban Settlement against Dengue fever

QuickBird imagery capabilities as a spatial data source parameters of urban environmental conditions will be analyzed using several indicators, namely: ease of interpretability, accurateness and precision, and practicability. The results of the analysis of QuickBird imagery capabilities for spatial data extraction parameters environmental conditions are presented in Table.1.

| No | Aspect                      | Indicator                                      | Result |
|----|-----------------------------|------------------------------------------------|--------|
| 1  | (Interpretability)          | Spatial Resolution                             | ✓      |
|    |                             | Spectral Resolution                            | ✓      |
|    |                             | Radiometric Resolution                         | ✓      |
|    |                             | Recognizability                                | ✓      |
|    |                             | Completing Information                         | ✓      |
| 2  | (Accurateness and precision)| Land use Interpretation Level II               | ✓      |
|    |                             | Land use Interpretation Level III              | ✓      |
|    |                             | Building Interpretation                        | ✓      |
| 3  | (Practicability)            | Image availability                             | ✓      |
|    |                             | Temporal Resolution                            | ✓      |
|    |                             | Price                                          | ✓      |
|    |                             | Time Frame                                     | ✓      |

A : Very good (100-76), B : Good (75-51), C : Moderate (50-26), D : Not Good (25-0)

Advantages of QuickBird imagery compared to aerial photography are at a relatively large central distortion in aerial photographs, while the QuickBird imagery will be further reduced because the height of the vehicle QuickBird. QuikcBird vehicle that reaches a height of 450 km from the Earth's surface, allowing the acquisition of data with better quality metrics from aerial photographs. Temporal resolution QuickBird imagery is also better than aerial photography. In aerial photographs possible existence of differences in hue/color between each sheet of photos, but the QuickBird image color/hue of each scene is the same.
Test the accuracy of the interpretation of land use is done by using 140 sample points, for the interpretation of land use second level is equal to the level of 94.28 percent and 93.57 percent amounting 3.2. Modeling Spatial Ecology

3.2.1. Model Index

Principles of assessment of vulnerability to DHF disease using index model is the multiplication of the weights (w) and value (r) of each parameter, which further aggregated all these parameters. Through the cross test nearest neighbor distance and local bivariate moran-I index parameters will be obtained environmental conditions associated incidence of DHF disease, as well as the strength of the relationship will determine the weight of selected environmental parameters.

Through the map overlay results obtained using the vulnerability index level of vulnerability to the spread of dengue disease. According to the context, vulnerability maps generated an environment description that is susceptible to dengue based overlay environmental factors that have been chosen. Grading susceptibility to dengue disease events tailored to the vulnerability index value range, where the minimum value that can be generated is 9 and the maximum value is 45. Based on these values were divided into four classes.

| Table 2. Vulnerability Class Classification of DHF |
|-----------------------------------------------|
| No   | Vulnerability Index | Vulnerability Class       |
|------|---------------------|---------------------------|
| 1    | 9–18                | Not Vulnerable            |
| 2    | 19–28               | Susceptible               |
| 3    | 29–38               | Quite Vulnerable          |
| 4    | 39–48               | Highly Vulnerable         |

Source: Data Analysis

Based on the modeling, produced a map of susceptibility to incidence of DHF. Through vulnerability maps, presented susceptibility to the disease class distribution of dengue in the city of Yogyakarta. To be able to determine the level of vulnerability of each village conducted extensive recapitulation of each vulnerability class wards. Overall, in the city of Yogyakarta are highly vulnerable areas which is an area of 3,074,978.96 m² (10 percent), the region with the quite vulnerable, covering 6,985,137.391 m² (20 percent), susceptible areas, covering of 14,478,975 m² (42 percent), and that are not vulnerable area 9,627,341.53 m² (28 percent).

3.2.2. Model Regression

OLS statistical procedures or Ordinary Least Square used in this study to conduct regression modeling. In this test, dengue cases in 2010 is used as the dependent variable, and the independent variable is the density of settlements, settlement patterns, distance to the river settlements, settlement distances to polling stations, and population density. In the regression model, the mapping unit used is the administrative borders the village, while the independent variables have a raster format. To get the value of each independent variable in each village were calculated using zonal statistics tools. The result of calculation using zonal statistics produced data on the value of the minimum, maximum, range of values, mean, standard deviation, and number value. The data used in the regression modeling is the average value of each parameter in each village.

OLS application generates information about the predicted value and the residue, the matrix coefficients of variance, and the value of z moran I. predictive value generated through OLS is a uniform distribution, so there will be no data to deviate much from the average as the actual dengue cases. OLS procedure generates predictive value of dengue cases in each village, the highest score was 47 and the
lowest score is 21. The predictive value is further classified by quintile techniques are divided into 4 classes. Map prediction incidence of dengue in the city of Yogyakarta as a model of spatial ecology, because some environmental parameters, such as density of settlements, settlement patterns, distance settlements on the river, the distance to the landfill (depot transporter) temporary settlements, and population density are used as independent variables.

3.3. Analysis of Spatial Modeling Dengue fever

Average accuracy for the model index amounted to 86.55 percent and for the accuracy of the regression model is equal to 88.46 percent. For the accuracy of each village, there is a very low accuracy for the village Baciro, Pakuncen, Suryatmajan, and Terban. According to the results of spatial modeling, vilages are included in the class of high vulnerable, but the data of dengue cases in 2011 and 2012 are included in the not vulnerable

The fact is that the city of Yogyakarta has a considerable number of cases, an average of dengue patients each year can reach up to 500 people, and even in 2010 the number of cases reached 1,517 people. Data Yogyakarta City Health Department said that in the period 2010 to 2014, there are 20 people died of dengue disease, as shown in Table 4.4. Follows.

| Year | Cases  | Died | Villages                                      |
|------|--------|------|----------------------------------------------|
| 2010 | 1,517  | 6    | Giwangan, Surosutan, Brontokusuman, Ngupasan, Gedongkiwo, Pringgokusuman |
| 2011 | 460    | 2    | Tegalrejo, Surosutan                        |
| 2012 | 374    | 2    | Suryatmajan, Pringgokusuman                 |
| 2013 | 908    | 7    | Kricak, Bener, Sosromenduran, Patangpuluhan, Warungboto, Giwangan, Semaki |
| 2014 | 418    | 3    | Warungboto, Semaki, Patangpuluhan           |

Source: Department of Health Yogyakarta City, 2014

In the city of Yogyakarta, there are several villages that every year there are cases of dengue fever or events, such as the Tahunan Village, Surosutan, and Suryodiningratan. Relating to land use, in some villages the land is exploited to the cemetery, and the cemetery is suspected habitat *Aedes aegypti* and *Aedes albopictus* vectors of dengue fever. Because the cemetery is often less attention in cleanliness. Observations in the field pointed out that most of the area of the cemetery do not have water channels so that rainwater is often pooled at a lower place. In the cemetery area has always found a reservoir of water such as flower pots from the ground and from above the cemetery ceramics, cast concrete gravestones that had basin into, stem leaves, plants that can hold water, waste plastic/cans discarded by so that potential visitors become mosquito breeding sites. Around the cemetery into settlements with a distance of less than 50 meters, so that people around the cemetery also has a high level of susceptibility to suffer from DHF.

Several efforts to control and prevention have been made to reduce dengue cases in the city of Yogyakarta, among others, by increasing mosquito nets eradication program through 3M (closing, drain, bury), plus the provision abate, and control the development of mosquito larvae with community involvement.

3.4. Modeling Spatial Ecology of Early Warning System Dengue fever outbreak

Incidence of disease in a society is basically a result of the interaction between the local populations with a variety of components in the environment. Interactive relationship between man and his behavior with environmental components that have the potential dangers of the disease known as the incidence of the disease. Incidence of a disease process is referred to as the pathogenesis of the disease. Thus, the incidence of the disease is essentially only influenced by demographic variables and
environment variables. In other words, the resultant health problems of the interactive relationship between environmental and demographic variables.

In the perspective of ecosystems, communities or groups of people living in a particular time and space is a component or an integral part of an ecosystem. Ecosystem is an order that describes the reciprocal relationship with the atmosphere of partnership and a relationship of mutual dependence between the various components of objects, both inanimate and living things in a room. Ecosystems will be stable if there is no interference, even though the relationship between components in a dynamic ecosystem can occur sacra, but the ecosystem with a variety of natural mechanisms that there will continue to maintain a balance. Outbreaks of the disease in a region called Extraordinary Events or outbreaks in essence are a disruption of ecosystems.

Early Alert System or an early warning system for outbreaks of dengue include several nodes, namely (1) the source node disease, (2) the transmission medium, (3) population, and (4) the incidence of disease. (5) Macro environmental factors (weather and climate) influence on all the nodes. **Node 1:** source of disease

DHF is a source of dengue virus and the mosquito vector *Aedes aegypti* and *Aedes albopictus*

**Node 2:** media transmission of disease

Media transmitting diseases such as dengue fever mosquito rides include: bionomics mosquito, vector density, and density of larvae. Other transmission media related to the breeding grounds of mosquitoes (breeding place), among others, the condition and quality of the housing, including housing density, settlement patterns, distance to the river settlements, and settlement distances to landfills. Settlement environmental conditions can be observed from remote sensing imagery, among other QuickBird images were then conducted spatial analysis and modeling of spatial geographic information systems. With the acquisition of data quickly and accurately can help determine the spread of dengue disease so that early warning for outbreaks of dengue can be immediately carried out. **Node 3:** exposure behavior

On the occurrence of DHF, some demographic factors have an important role for the spread and expansion of dengue disease events, namely overcrowding, the state of sociodemographic, mobility, as well as the behavior of the population. Agent disease, with or without a ride other environmental components, enters the body through a process known as the interactive relationship. Interactive relationship between the components of the environment with the following behavior can be measured in a concept known as exposure behavior. Exposure behavior is the amount of contact between humans and the environment component containing the potential dangers of the disease. **Node 4:** disease

Disease is the outcome interactive relationship between the population and the environment that has the potential hazards and health problems. Someone said if one pain or joint abnormalities compared to the average population.

3.5. **Macro Environmental Factors**

On the occurrence of dengue fever, a certain temperature-humidity environment will affect the bionomics mosquitoes, such as biting behavior, mating behavior, long hatching of mosquito eggs, and others. Temperature and specific humidity will stimulate the mosquitoes do copulation or marriage, make mosquitoes become more aggressive in search of prey and cause the frequency of mosquito bites is increasing, which in turn would increase the probability of contracting the disease.

Important climate factors that can be used as an early warning or early warning and control of DHF, is rainfall. The influence of rainfall on the incidence of dengue disease, with regard to the following matters.

3.5.1. **Breeding place or places.**

The influence of rainfall with the breeding place or breeding sites for *Aedes aegypti* and *Aedes albopictus* very closely. High rainfall allowing many emerging breeding place, however, heavy rainfall can also sweep breeding place there, both natural and artificial. Alternate rain and hot conditions at the
turn of the season more positive effect on mosquito populations because rainwater does not flow and pooled in some places.

3.5.2. Waste

Waste management is an important influence on the incidence of dengue if associated with rainfall. This is because if the waste is not managed properly, will increase the number of breeding place in the neighborhood.

3.5.3. Adaptation mosquitos

Differences in the rainy season and the dry season as well as differences in the amount of rain and the dry season causes an influence on changes bionomics *Aedes aegypti* and *Aedes albopictus*. Adaptability of *Aedes aegypti* and *Aedes albopictus* is very high to changes in climate and weather patterns, even the eggs of *Aedes aegypti* and *Aedes albopictus* can survive in the dry and hot conditions without water for up to four months.

3.5.4. Humidity and temperature

The rainy season and the dry season have an influence on the level of ambient temperature. This influence tends to be local to a specific time period; this is because the temperature and humidity levels are more complex and are affected by the phenomenon of global, regional, topography, and vegetation. The turn of the rainy season to dry season air temperature ranges between 23°- 31° C; this is an optimum temperature range for mosquito breeding.

Remote sensing technology and geographic information systems with spatial analysis can be utilized in preparing the Early Alert System for the dengue outbreak. Parameter settlement environmental conditions, such as the density of settlements, settlement patterns, and the distance to the river settlements, a parameter that can be tapped from remote sensing image, and parameters that cannot be tapped from remote sensing imagery, i.e. the distance parameter of the waste temporary housing and overcrowding, also the weather/climate; with the help of geographic information systems and spatial analysis, can be input in determining early warning against outbreaks of dengue. If the environmental conditions of settlements is good, with good quality, then the incidence of dengue are expected to decline or decrease the number of events. Conversely, if the environmental conditions of poor housing quality, the incidence of dengue is expected to rise or increase the number of events.

Macro environment conditions that are influenced by weather/climate can affect mosquito bionomics. Rainfall, humidity, and temperature can be used as a determining factor increased incidence of dengue, so the dynamics of the macro environment can be used as an early warning for outbreaks of dengue fever, for example, when the rainy season with high rainfall intensity, an indication of the increasing incidence of dengue in a place/area, so it can be decided whether these places will experience an outbreak of dengue or not.

A bad environment is a risk factor for the onset of the disease. Density settlements, settlement patterns, distance to the river settlements, within landfills, a transmission medium for the occurrence of dengue disease. Similarly, demographic factors, such as population density is a risk for the occurrence of the disease. So environmental factors and population are both a risk factor for disease incidence.

Thus, the dynamics of the environment, good macro environment (weather and climate) and neighborhoods and population factors can be used as a determinant of early warning system for the occurrence of dengue disease, and become part of the surveillance or management of DHF of environmental factors or referred to as the Surveillance Epidemiology, for the prevention of the occurrence of Extraordinary Events or outbreak dengue.

4. Conclusion

4.1. The image of QuickBird has excellent capabilities for spatial data extraction parameters and environmental conditions contribute to the high incidence in the modeling of spatial ecology dengue
disease. Based on three indicators, namely ease of interpretability, accurateness and precision, and practicability, QuickBird imagery has good ability for spatial data extraction parameters of the environmental conditions of settlements, i.e. density of settlements, settlement patterns, and the distance settlement of the river. Parameter environmental conditions such settlements can be tapped from QuickBird imagery and can be correlated with the incidence of DHF.

4.2. Spatial statistics analysis has the ability to description spread of dengue fever incidence and testing spatial correlation with the parameters of environmental conditions, so that the determination of environmental parameters related to the distribution of dengue cases can be done through a real picture with strong evidence. Statistical analysis showed that the spatial distribution of dengue fever cases in the residential areas of Yogyakarta is a non-random distribution so that the possible existence of factors that affect the distribution.

4.3. Two spatial model used in this study, namely (a) The model index is used to determine the level of vulnerability of the region to the incidence of dengue with high accuracy, as many as 73.2 percent of dengue cases are in areas that have a class of vulnerability "quite vulnerable" and "not vulnerable". The model produces an accuracy index is based on actual agreement amounted to 86.55 percent. 0.34 Kappa coefficient values are included in the category of fair agreement. (b) Regression models with Ordinary Least Square method generates predictions of dengue cases with accuracy rate of 88.46 percent.

4.4. From the model of spatial ecology can be arranged Early Warning System Outbreak dengue with four vertices, and the environmental factors, namely (1) node source of the disease, (2) node transmission medium, (3) node population (sosiodemographic) and (4) node disease events, and (5) the macro environmental factors (weather and climate) that affect all of the nodes.

5. Recommendations for further research

5.1. Remote sensing technology and geographic information systems can be utilized in the field of health, especially for environment-related disease control. Therefore, studies using remote sensing data type of the other needs to be done, tailored to the scale, the area of research, and the characteristics of the disease.

5.2. Integration of remote sensing, spatial statistics analysis and geographic information systems conducted in this study could be a framework in the study of health, good for dengue disease and other infectious diseases, even in the study of non-communicable diseases.

5.3. Modeling of spatial ecology as this research needs to be done in other endemic areas in Indonesia that have similar geographic characteristics, demographic and climatology.

5.4. The parameters used in this study are limited to the environmental parameters which can be intercepted or interpreted from remote sensing data, plus weather and climate parameters. Meanwhile, the other parameters such as sociodemographic parameters, the behavior of the population, population mobility, and parameter vector density, density of larvae, not studied. Therefore, further research needs to be done by taking into account these parameters.

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