Geographic Information System Mapping Risk Factors Stunting Using Methods Geographically Weighted Regression

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Abstract

Technological developments in this era of globalization are very rapid. This requires humans to enter life together with information and technology. *Stunting* as a chronic nutritional problem in children, continues to be a global challenge. Geographic Information Systems (GIS) have proven to be effective tools in spatial analysis and distribution mapping *stunting*. In this context, method *Geographically Weighted Regression* (GWR) has been used to model the spatial relationship between factors that contribute to stunting. This research will produce a Geographic Information System using the method *Geographically Weighted Regression.* With this Geographic Information System, it can display location points and affected information *stunting.* Because of this system, the Padang Lawas Utara District Health Office does not need to store location data *stunting* in archive form again but digitally. This study underscores the importance of using GIS with the GWR method in mapping patient locations *stunting.* Through the integration of geographic data and spatial analysis, we can generate a better understanding of the influencing factors *stunting* at the local level, which in turn can support prevention and response efforts *stunting* which is more effective.

Keywords: Geographic information system, mapping, stunted sufferers, Geographically Weighted Regression, stunting

1. Introduction

Technological developments in this era of globalization are very rapid. This requires humans to enter life together with information and technology. Geographic Information Systems (GIS) are computer systems used for topographic and cartographic research that can include a set of programs related to the process of storing, organizing, and displaying data (Vennithasari & Papilaya, 2020)(Liu *et al.,* 2017). Graphic or spatial data is used to visualize the state of the earth's surface, and this data is used as a reference such as coordinates on maps, aerial photos and satellite images. At the same time, identification data can be obtained from statistical data, survey records and other information related to geographic information systems (Febrian & Nasir, 2021)(Fadliana & Darajat, 2021)(Riswandi *et al.,* 2023)(Halimah & Suntin, 2020)(A. Kurniawan *et al.,* 2019).

Stunting is where a child or toddler (baby under five years) has a terminal illness because the condition is shorter in age. Factors causing stunting are poor parenting, lack of health services for pregnant women, lack of good family knowledge about nutritious food, and difficulties in accessing clean water and sanitation (Ade Saputra *et al.,* 2020)(Muna *et al.,* 2022)(Fathurrahman *et al.,* 2022).

Indonesian is one of the countries with prevalence stunting quite high compared to other middle-income countries. The results of the 2022 Indonesian Nutritional Status Study (SSGI) show a stunting prevalence of 21.6% (RI, 2022). Problem Stunting cannot be underestimated. Toddlers who experience stunting will have a suboptimal level of intelligence, making children more vulnerable to disease and in the future could be at risk of decreasing levels of productivity. Ultimately broadly stunting will hamper economic growth, increase poverty and widen inequality (Rahayu *et al.,* 2018)(Putra & Suariyani, 2021).

The North Padang Lawas District Health Service is one of the agencies that supervises and controls health program planning, including suppressing the spread of disease in particular stunting. Currently the North Padang Lawas District Health Service has a

number of sufferers stunting which can be said to be quite vulnerable. Currently, the North Padang Lawas District Health Service does not yet have a system or tools to visually display the geography of sub-district and village areas. And there is no information presented showing the route to the patient's location stunting. During this time to obtain information on the whereabouts of the patient's location stunting This is only limited to discussions by local residents so it seems slow in taking action. To carry out the mapping, a Geographic Information System (GIS) was chosen to assist the North Padang Lawas District Health Service in searching for all information about stunting, especially within the scope of North Padang Lawas District.

To analyze risk factors stunting In this research, a model approach was used*Geographically Weighted Regression* (GWR)*,* where the modeling results are then visualized in the form of regional mapping using a Geographic Information System (GIS). Model*Geographically Weighted Regression* (GWR) is a spatial analysis technique that is commonly applied to identify areas and populations at high risk of disease and analyze disease in space and time(X. Chen *et al.,* 2023). By including geographic weighting elements in the parameter estimates, the GWR model is able to produce parameters at each observation location(Amarrohman *et al.,* 2023) *(Firmansyah et al.,* 2023)(Amelia *et al.,* 2020)(L. Chen *et al.,* 2023). The most important thing in the GWR model is weighting because the weight is a value for each location. Near locations have a strong influence on estimates from distant locations (Lutfiani *et al.,* 2019)(Kartika & Kholijah, 2020).

In previous research by (Fadliana & Darajat, 2021) said that Geographically Weighted Regression (GWR) is a development of the global linear regression model which is used to overcome the problem of spatial heterogeneity caused by conditions or differences in characteristics between one location and another. According to research(Diastina *et al.,* 2019), if the regression parameter values are the same for all observation locations, it means there is no difference between the GWR model and the global regression model. According to (Kartika & Kholijah, 2020) it is estimated that the GWR method can be used, because there are several factors that are considered as causes of poor people which are related to the geographical aspects of the region.

The problem of stunting needs serious attention. Prevention and treatment of stunting can be done, among other things, by analyzing risk factors that are thought to influence the occurrence of stunting. The aim of this research is to determine the most dominant factors influencing stunting in North Padang Lawas Regency using the GWR method.

2. Method

This research was conducted at the North Padang Lawas District Health Service located at road. Gunungtua – Hajoran Km.3 Batu Tambun. The research area covers 12 sub-districts, 2 sub-districts and 386 villages in North Padang Lawas Regency.

The R&D (Research and Development) method is a development design that has the aim of developing and validating the product or application that will be designed and developed (Andarsyah & Fadilla, 2020)(Samosir & Purwandri, 2020). In Geographic Information Systems (GIS) risk factor mapping stunting by using the method *Geographically Weighted Regression* (GWR) is an approach that combines elements of research and development to produce appropriate and relevant solutions in overcoming problems stunting based on geographic data.

The following are general steps of the R&D method that can be applied in the context of using GWR for risk factor mapping stunting :

a. Problem Identification Stage

The first step is to identify the public health problem that you want to solve, in this case it is stunting. *Stunting* is a condition of failure to thrive in children caused by malnutrition and has an impact on poor physical and cognitive growth.

b. Study Literature

Conduct literature studies to understand related theories stunting and factors that influence its spread. Also review previous research that has been conducted on stunting and use of the GWR method for geographic data analysis.

c. Data collection

Collect the data needed for GIS analysis to map patient locations stunting. This data can include data on levels of malnutrition, child growth, demographic data, environmental data, accessibility of health services, etc. Make sure the data has a spatial component (location information) to be integrated with GIS.

d. System Creation

Build a Geographic Information System (GIS) that can display and manipulate spatial data related to stunting. GIS will help in visualizing and understanding spatial patterns of distribution stunting and the factors that influence it.

e. Evaluation and Implementation

Evaluate the results of the interventions that have been carried out. Review whether the intervention has been successful in reducing levels stunting in a particular region and whether any adjustments need to be made. Implement interventions by involving various related parties to achieve significant impacts.

2.1 Modeling*Geographically Weighted Regression* (GWR)

The following are general steps in applying the GWR method in mapping stunting risk factors:
a. Data Preparation: Collect relevant data for analysis, including data on the location of stunting sufferers and variables that influence stunting. Make sure the data has a spatial component related to geographic coordinates (for example, latitude and longitude).
b. GWR Implementation: Use GIS software that supports GWR analysis. In the software, determine the dependent variable (y) and independent variable (x) that will be used in the analysis. Next, run a GWR analysis to obtain local regression coefficients for each point or location in the spatial data.

c. Interpretation of Results: After the GWR analysis is complete, interpret the results to understand the spatial relationship between research variables and the location of stunting sufferers. Spatially significant factors can be identified through different local regression coefficients for each location. The results of GWR analysis can be visualized in the form of a map or graph to describe the spatial pattern of this relationship.

2.2 System Development Methods

Waterfall is a classic model that has a sequential nature in design software (H. Kurniawan *et al.,* 2021). Waterfall in Geographic Information Systems (GIS) risk factor mapping stunting using method*Geographically Weighted Regression* (GWR) is a software development approach that is linear and sequential.

This method consists of a series of stages that must be passed sequentially, starting from *Requirement* (Needs Analysis), *Design* (System Design), *Implementations* (Program Development), *Verification* (Testing), and stage *Maintenance*. The following are the system development steps *Waterfall* for GIS risk factor mapping stunting with GWR:
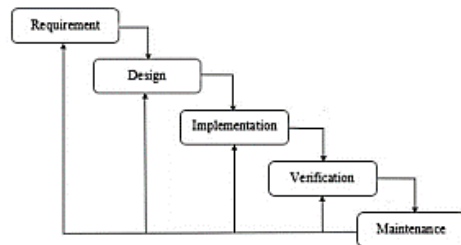

Figure 1. Waterfall method

3. Results and Discussion

3.1 Research variable

The variables used in this research consist of one response variable (Y) and 8 predictor variables (X). The details of the research variables are as shown in Table 1.

Table 1. Research Variables

Variable	Unit
stunted toddlers (Y)	29,2 %
Pregnant Women Who Receive Health Assistance (X_1)	99 %
Pregnant women get Blood Addition Tablets (TTD) 90 tablets (X_2)	45 %
Chronic Energy Deficiency (CED) who receive additional nutritional intake (X_3)	100 %
Child's weight at birth <2.5kg (X_4)	2,7 %
Toddlers 0-59 months with BB & TB according to standards (X_5)	86 %
Children aged 0-6 months who receive complementary foods with breast milk (MP-ASI) (X_6)	100 %
Toddlers receive complete basic immunization (X_7)	37 %
Households with access to adequate toilets (X_8)	44 %

3.1 Modeling GWR (*Geographically Weighted Regression*)

In accordance with the aim of this research, it will implement stunting data in a spatial regression model, namely by using analytical methods *Geographically Weighted Regression* (GWR).

a. The following are the estimated values for the regression model parameters:

Table 2. Regression Model Parameter Estimation

Variable	Estimate	Std. Error
Intercept	0,073076	637,250979
X1	0,000000	20,095025
X2	0,000000	396,129037
X3	0,000000	5008,156683
X4	1,074074	14,698012
X5	0,545455	210,440016
X6	0,000000	4502,843887
X7	0,000000	7,994697
X8	0,000000	0,000000

Based on Table 2 above, it is known that the child's weight variable at birth is <2.5kg (X4), Newborn babies receive Early Initiation of Breastfeeding (IMD) (X5). Thus the resulting linear regression estimation model is

$$\hat{y} = 0,073076 + 1,074074\beta_4 + 0,545455\beta_5$$

b. Model Goodness Testing

Testing the goodness of this model can be done by looking at the value of AIC (*Akaike Information Criteria*), R-Square and BIC/MDL as follows:

Table 3. Model Goodness Criteria

Variable	GWR
AIC	-617,250979
R-Square	1,000000
BIC/MDL	-612,401912

3.2 Implementation of Results

A web-based Geographic Information System is one of the mapping media, one of the objectives of this research is to utilize a web-based Geographic Information System as a medium for information regarding factors that influence events. *Stunting* in North Padang Lawas Regency.

Based on the objectives achieved in this research, the following is the process and results of creating a web data-based Geographic Information

System *Stunting* in North Padang Lawas Regency as follows :

a.   District Data Page

Figure 2. above is a display of the District Data page, where in this menu there are 12 Districts in North Padang Lawas Regency.

b.   Patient Notes Page

Figure 3. above is a display of the Patient Notes page, which contains the patient's identity *Stunting*. And on this page there is also an add, edit and delete menu.
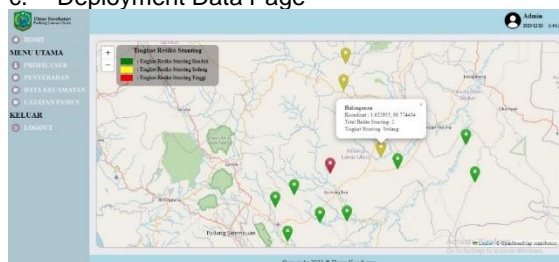
c.   Deployment Data Page

Figure 4. is the result of implementing the GWR or location-based regression modeling interface design. Where in it there is a point where the patient is located *Stunting,* Amount *Stunting* and also level *Stunting*.

Conclusion

This research will later produce a Geographic Information System using this method *Geographically Weighted Regression*. With this Geographic Information System, it can display location points and affected information stunting.

Based on the results and discussion, it can be concluded that the results of risk factor mapping stunting in North Padang Lawas Regency using the GWR model with a weighting function shows that the variables: Child birth weight <2.5kg and Newborns receiving Early Breastfeeding Initiation have a significant effect on the prevalence of toddlers stunting in all sub-districts in North Padang Lawas Regency. And in certain sub-districts it is also influenced by the variables of pregnant women receiving health assistance, toddlers receiving complete basic immunization, and pregnant women receiving 90 blood supplement tablets.

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