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Research Article

Food security and vulnerability modeling of East Java Province based on Geographically Weighted Ordinal Logistic Regression Semiparametric (GWOLRS) model

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Abstract. Modeling of food security based on the characteristics of the area will be affected by the geographical location which means that geographical location will affect the region's potential. Therefore, we need a method of statistical modeling that takes into account the geographical location or the location factor observations. In this case, the research variables could be global means that the location affects the response variables significantly; when some of the predictor variables are global and the other variables are local, then Geographically Weighted Ordinal Logistic Regression Semiparametric (GWOLRS) could be used to analyze the data. The data used is the resilience and food insecurity data in 2011 in East Java Province. The result showed that three predictor variables that influenced by the location are the percentage of poor (%), rice production per district (tons) and life expectancy (%). Those three predictor variables are local because they have significant influence in some districts/cities but had no significant effect in other districts/cities, while other two variables that are clean water and good quality road length (km) are assumed global because it is not a significant factor for the whole districts/towns in East Java .

Keywords *: East Java , food security, GWOLRS*

Introduction

The need for food is a basic human need is most essential and must be met by the state and society. Law No. 7 of 1996 on Food, defines food security as food for the fulfillment of the condition of each household, which is reflected in the availability of sufficient food, both quantity and quality, safe, equitable, and affordable. Understanding of the food security include macro aspects, namely the availability of sufficient food and at the same micro aspects, namely the requirement for food every household to live a healthy and active life. At the national level, food security is defined as the ability of a nation to ensure that all its inhabitants obtain sufficient food, decent quality, safe, and based on the utilization and optimization based on the diversity of local resources.

The problem of food security is an issue that is not being resolved. Multidimensional problem that is faced by the sub-systems of production, distribution sub-systems, sub-system of consumption. Under the identification map Food Security and Vulnerability Assessment 2009 (Food Security and Vulnerability Atlas / FSVA 2009) conducted by the Food Security Council (DKP) looks 100 districts identified food insecurity, the 94 districts of which are outside of Java. Only six districts on Java identified food insecurity which consists of one county located in Banten, and five districts in the province of East Java regency of Sampang Sumenep, Pamekasan, Bangkalan and Probolinggo. It is interesting to recall studied East Java is one of the provinces with the second highest GDP after Jakarta and is one of the national granaries because it has the second largest rice production in West Java, but there are still food insecure areas. Modeling on food security is built based on the characteristics of the area that would be affected by the geographical location among regions. This is due to differences in geographic location that would affect the potential possessed by a local. Therefore, a method of statistical modeling is needed that take into account to the geographical

location or the location factor observations. Such a statistical method that is developed to explain the relationship between the response variable and predictor variables that depend on the geographic area is Geographically Weighted Regression (GWR) (Fotheringham, Brundson and Charlton, 2002). When the response variable is categorical in ordinal scale, the method used is Geographically Weighted Ordinal Logistic Regression (GWOLR). In reality, not all of predictor variables in the model have the effect of spatially GWR. Several influential predictor variables are globally, while others can maintain the spatial effect. Then the model developed is Geographically Weighted Ordinal Logistic Regression Semiparametric (GWOLRS)

Nakaya et al. (2005) explained that GWOLRS is one of the model that consider the geographical factors as predictor variables in ordinal variable and there are parameters that are influenced by location (varying coefficient) and other parameters that are not affected by location (fixed coefficient). In GWOLRS models, the response variable Y is predicted by calculating the odds of each category *a* where the calculation involves the regression coefficients $\beta_a(u_i, v_i)$ that depend on the location and γ_m regression coefficients that is constant. GWOLRS models for the i-th location is as follows

$$logit\left[P(Y_i \leq a|x_i)\right] = \alpha_a(u_i, v_i) + x_i^{*T}\beta^*(u_i, v_i) + x_i^{**T}\gamma$$

where $a = 1, 2, \ldots, A-1$, and u_i, v_i is *latitude* and *longitude* for the i-th location.

Based on equation above, the cumulative odds for a category *a* is:

$$P(Y_i \leq a|x_i) = \frac{\exp\left[\alpha_a(u_i, v_i) + x_i^{*T}\beta^*(u_i, v_i) + x_i^{**T}\gamma\right]}{1 + \exp\left[\alpha_a(u_i, v_i) + x_i^{*T}\beta^*(u_i, v_i) + x_i^{**T}\gamma\right]}$$

Based on ordinal logistic regression parameter estimation, the estimation of parameters of GWOLR can also be performed using Weighted Maximum Likelihood Estimator (MLE) (Hosmer and Lemeshow, 2000).

The function of the weighting is to give the results of estimation of different parameters at different locations. Euclidean distance (d_{ij}) between the location of the i-th and j-th location be calculated by using following equation (Leung, et al., 2000):

$$d_{ij} = \sqrt{(u_i - u_j)^2 + (v_i - v_j)^2}$$

Fixed Bisquare Kernel weighting function can be expressed as follows (Chasco, et al., 2007):

$$W_j(u_i, v_i) = \left[1 - \left(\frac{d_{ij}}{h}\right)^2\right]^2 \text{ for } d_{ij} \leq h$$
$$W_j(u_i, v_i) = 0 \text{ for } d_{ij} \leq h$$

Food security has nothing to do with food insecurity. Food insecurity means food insufficiency in a condition experienced by a region, community or household at a specific time to meet the physiological needs for growth and public health (Ariningsih and Rahman, 2008). Hence, discussing food security and food insecurity is discussing anything that causes food needs that are fulfilled or not.

Bogale and Shimelis (2009) have analyzed and did mitigation of food insecurity in Indonesia. Food insecurity is not just a question of food availability; this is shown from the amount of energy and protein availability nationally that has exceeded the recommended levels, but there are still problems arising with malnutrition and starvation. Access to food is as important as the availability of food itself. One of the elements in the distribution of food access is the visibility of the transportation infrastructure, warehousing, market, and most importantly, people's purchasing power. It should also be encouraged about food diversification, as there is stagnation in rice production and decreasing of farmland.

Material and Methods

The data used in this study is secondary collected in Susenas (National Socioeconomic Survey) module three annually consumption in 2011 and other secondary data collected by BPS (Central Bureau of Statistics). The area is the province of East Java that includes 38 counties and cities. Food security indicators used are the percentage of poor (X1) , the production of rice (X2), life expectancy (X3), clean water (X4), the long road of good quality and moderate (X5) with variable Y (0 = hold, 1 = prone, 2 = less, 3 = vulnerable).

Steps GWORLS modeling

1. Determine predictor variables that are global and local variables
2. Calculate the weighting matrix $W(u_i, v_i)$ using weighting function Fixed Bisquare Kernel ,which is the euclidean distance between the insert Regency/City and optimum bandwidth for the whole District/City obtained from the method of Cross Validation (CV) .

3. Perform parameter estimation using Maximum Likelihood Estimation (MLE) and the weighted significance testing GWOLRS model parameters $(\beta^*(u_i, v_i)$ and $\gamma)$ stimulant and partial.
4. Form the model for the case GWOLRS Food Security in East Java in 2011 and interpretation of the model formed .
5. Do the assumption of non multicollinearity and spatial heterogeneity.

Results and Discussion

There was no multicolinearity among the predictor variables as VIF statistic that was more than 10, so it could be continued to build such a logistic regression model. Besides, there was spatial heterogeneity in the data so that GWOLRS should be used. The next step, based on the testing parameters simultaneously that obtained the test statistic greater than the critical value (19.152 > 12.01), it can be concluded that food security indicators that are local (influenced by the location) and global (not influenced by location factors) jointly affect food insecurity in East Java in 2011. Among 37 regions, let us see the analysis result of parameter estimation and the test statistic of Batu as a sample in Table 1.

Table 1. Analysis result of GWOLRS for Batu City

Para-meters	Estima-tion	*Standard Error*	Wald test
α_1	-22.6417	14.5169	-1.5597
α_2	-18.1568	14.0062	-1.2963
β_1	-0.1726	0.1009	-1.7101*
β_2	0.4218	0.1032	2.6487*
β_3	0.3818	0.1821	2.0966*
γ_1	-0.0473	0.0530	-0.8918
γ_2	0.0010	0.0006	1.5754

GWOLRS model for food insecurity in Batu were:

$$logit\left[P(Y_i \le 1|x_i)\right] = -22.6417 - 0.1726X_1 + 0.4218X_2 + 0.3818X_3$$
$$logit\left[P(Y_i \le 2|x_i)\right] = -18.1568 - 0.1726X_1 + 0.4218X_2 + 0.3818X_3$$

The three-predictor variables that were local or influenced by the location, i.e. the percentage of poor in East Java Province (%), rice production per district (tons) and life expectancy (%). The third predictor variable was local because it had a significant influence in some districts/cities but had no significant effect to the another districts / cities to, while the other two predictor variables, those are clean water and good quality road length (km) are assumed to be global or not affected by location because it is not a significant factor for the whole district/town in East Java.

Table 2 Odd Ratio GWOLRS Model for Batu City

Parameter	Prediction Value	*Odd Ratio*
β_1	-0.1726	0.8415
β_2	0.4218	1
β_3	0.3818	1.4649

Value of the odd ratio that was less than 1 for a variable percentage of the poverty level (%) indicated that the lower the percentage of the poverty level (%) in Batu then classified categories tendency Batu City, District / City resistant food would be lower. The odd ratio value of more than 1 for rice production variables and life expectancy indicated that higher rice production and life expectancy then the tendency Batu City, Batu City classified food secure higher category.

Food security indicators that significantly based models in Batu GWOLRS not necessarily have a significant effect in the District / City another. Based on the results of testing the model parameters partially GWOLRS then produced two groups of districts / cities in East Java is based on similarity of predictor variables or indicators of food security is a significant effect on food insecurity in 2011. Table 3 is a grouping table regency / city in East Java by significant predictor variables in each region.

Table 3. Grouping regencies based on Variables significant predictor's variables

Regency	Significant Variables
Ponorogo,Trenggalek, Tulungagung, Blitar, Kediri, Malang, Lumajang, Jember, Banyuwangi, Bondowoso, Situbondo, Probolinggo,Pasuruan, Sidoarjo,Mojokerto, Jombang, Nganjuk, Madiun, Ngawi, Bojonegoro, Tuban, Lamongan, Gresik, Bangkalan,Sampang, Pamekasan,Sumenep, Kediri City,Blitar City, Malang City, Pasuruan City, Mojokerto City, Madiun City, Surabaya City, Batu City,	X_1, X_2 , X_3
Pacitan, Magetan	X_2 , X_3

Based on the map of resilience and vulnerability in East Java province in 2011, the analysis results of model predictions by GWOLRS in East Java in 2011 showed that there were 19 districts should

be grouped as experiencing food susceptibility. Those districts were Ponorogo, Trenggalek, Tulungagung, Blitar, Malang, Jember, Banyuwangi, Pasuruan, Sidoarjo, Mojokerto, Jombang, Nganjuk, Magetan, Ngawi, Bojonegoro, Lamongan, Gresik, Blitar, and Mojokerto. For the 18 counties that grouped as less food are Pacitan, Kediri, Lumajang, Bondowoso, Situbondo, Probolinggo, Madison, Tuban, Bangkalan, Pamekasan, Sumenep Kediri City, Malang City, Probolinggo City, Pasuruan City, Madiun City, Surabaya City, and Batu City. Only Sampang area that could be defined as a region in food insecurity.

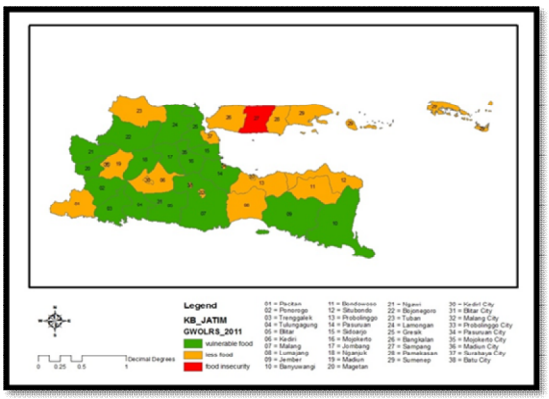

Figure 1. The map of food insufficiency

Predictions for each category of food insecurity regencies / cities in East Java based methods GWOLRS obtained by calculating the odds of each category of food insecurity in each district / city and define the category with the greatest opportunities. The food insecurity classification based GWOLRS models is presented in Table 4.

Table 4. The classification of Food Insecurity in East Java

Actual	Prediction			Classification accuracy
	1	**2**	**3**	
1	12	5	0	70.58%
2	7	11	0	61.11%
3	0	2	1	33.33%
Total				**63.16%**

APER values were obtained based on the classification table is equal to 34.84%. This value indicates that the percentage of samples incorrectly classified by the model is equal to 34.84% GWOLRS or in other words the exact percentage of samples classified by the model GWOLRS amounted to 63.16%. Testing the assumption of non-multicollinearity yielded the decision that there was no multicollinearity in the data because the VIF value for each predictor variable-value was below 10. Therefore, that data can be modeled using logistic regression models. Testing spatial heterogeneity resulted to the decision that there is diversity in each spatial data, so the data can be modeled using the model GWOLRS.

Conclusion

In 2011, there were three predictor variables that were influenced by the location: the percentage of poor in East Java Province (%), rice production per district (tons) and life expectancy (%). The other two predictor variables, e.i. clean water and good quality road length (km) were assumed to be global or not affected by location because it was not a significant factor for the whole District / town in East Java. The GWORLS model yielded high accuracy (63.16%) in the classification on food insecurity. It is still needed a further research to determine other indicators of food insecurity classification and food insecurity map in East Java province.

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