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Modeling The Nutritional Status of Underweight and Stunting Toddler in East Java Using Multivariate Geographically Weighted Regression Method

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Abstract. Nutritional status is an important factor that influences health status. The main nutritional problem currently facing Indonesia, especially the East Java region, is the incidence of underweight and stunting toddlers. Need to analysis what models and factors have a significant influence on the nutritional status of underweight and stunting among toddlers in East Java based on the geographical location of each district/city. The analysis process was carried out using quantitative methods, namely Multivariate Geographically Weighted Regression (MGWR) analysis method. MGWR is used to overcome the influence of spatial heterogeneity in data caused by differences in the conditions of one location and another. In the MGWR model the weighting function used is the Adaptive Gaussian Kernel. Based on the results of the analysis carried out on the MGWR model, 38 models were formed for the underweight variable which could be grouped into 11 groups, likewise for the stunting variable 12 groups were formed based on influencing factors. Factors that have a significant influence on the nutritional status of underweight and stunting among toddlers in East Java in 2022 are the percentage of access to adequate drinking water, complete immunization, poor people, low birth weight, exclusive breastfeeding and malnutrition.

Keywords: Underweight, Stunting, Adaptive Gaussian Kernel, Multivariate Geographically Weighted Regression.

1 Introduction

More than 100 million children under the age of five are underweight, making it difficult to develop their human and socio-economic potential, as this food deficiency is the cause of death for 2.5 million children every year. Nutritional status problems are influenced by several factors. The causative factors include being influenced by proper food or drink, immunization, breastfeeding, poor nutrition, health services, income levels, conditions of toddlers at birth or toddler weight at birth [1].

In overcoming the problem of nutritional status of toddlers with underweight and stunting cases, it is first necessary to know that in the problem of nutritional status of toddlers in East Java for underweight and stunting variables must have a correlation or freedom relationship between underweight and stunting variables. Between the underweight and stunting response variables are not mutually free, meaning that the two variables are correlated. With this, the nutritional status problems of underweight and stunting can be overcome simultaneously.[2].

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Multivariate Geographically Weigthed Regression (MGWR) is one of the spatial models that is often used to overcome the problem of geographical factors, so it can be used to address the problem of underweight and stunting nutritional status in East Java which is influenced by geographical location. The advantage of the Multivariate GWR method compared to the multivariate regression model is that Multivariate GWR is able to provide a model locally, besides that Multivariate GWR is also able to show factors that affect the response variable on spatial aspects [3]. Based on the description above, the author wants to conduct research on modeling the nutritional status of underweight and stunted toddlers in East Java using the Multivariate Geographically Weighted Regression (MGWR) method.

2 Data and Method

Geographically Weighted Regression (GWR) is the development of a linear regression model into a weighted regression estimated using the Weighted Least Square (WLS) method by providing different weights for each location where the data is collected, therefore each observation location will have different regression parameter values [4]. Differences in the characteristics of one region from another can be known by the spatial heterogeneity test (Breusch-Pagan). One method to overcome spatial heterogeneity is Geographically Weighted Regression (GWR) [5]. The GWR model can be written as follows:

$$Y_i = \beta_0(u_i, v_i) + \sum_{j=i}^{p} \beta_j(u_i, v_i)x_{ij} + \varepsilon_i \,; i = 1,2,3, \dots, n \quad (1)$$

The data used in this study are secondary data sourced from the publication of the East Java Health Profile in 2022 with the number of observation units as many as 38 districts /cities in East Java Province. The population in this study is the percentage of nutritional status of toddlers, namely underweight and stunting cases in the Regency / City area in East Java Province. The sample used in this study is the percentage of nutritional status of toddlers, namely underweight and stunting cases in the Regency / City area in East Java Province in 2022. The variables used in this research are as follows:

Table 1. Description of Variables

Variables	Description
Y_1	Underweight
Y_2	Stunting
X_1	access to proper drinking water
X_2	complete immunization
X_3	poor population
X_4	low birth weight
X_5	exclusive breastfeeding
X_6	undernutrition

Data analysis in this study uses the Multivariate Geographically Weighted Regression (MGWR) method by RStudio software. The following are the analysis stages carried out in this research, namely:

1) Inputting data.

2) Conducting a spatial heterogeneity test with the Breusch-Pagan test.
3) Calculating the Euclidean distance and optimum bandwidth.
4) determining the weighting matrix using the adaptive kernel gaussian weighting function.
5) Determining the Multivariate Geographically Weighted Regression (MGWR) model parameter estimates.
6) Conducting a model fit test to determine whether there is a geographical influence on the MGWR model.
7) Testing the significance of the MGWR model parameters..
8) Interpretation of the model obtained.

3 Results and Discussion

a) Spatial Heterigenicity Test

The Breusch-Pagan test can be used to detect spatial heterogeneity.

Table 2. Result of Breusch-Pagan Test

Breusch-Pagan Test	p-value	Decision
17.549	0.00746	Reject H_0

Based on Table 2, the p-value of 0.00746 is smaller than $\alpha = 0.05$, so $H0$ is rejected, meaning there is a diversity of variance between observations or spatial heterogeneity. This problem was overcome by creating local modeling taking into account spatial aspects, so that an MGWR analysis was carried out which took into account spatial aspects, namely the diversity between observation locations.

b) Multivariate Geographically Weighted Regression

MGWR model estimation begins with calculating the optimum bandwidth value. Where the optimum bandwidth selection is based on the bandwidth that has the minimum CV value. Based on the calculation results, the bandwidth value is obtained with the adaptive kernel gaussian function which can be seen in Table 3 below:

Table 3. Parameter Estimation of MGWR on Underweight

Location	β0	β1	β2	β3	β4	β5	β6
Pacitan	-6.1273	0.0416	0.0810	0.3072	0.3578	-0.0474	0.8134
Ponorogo	-3.3954	0.0863	-0.0073	0.5104	0.0750	-0.0556	0.7040
Trenggalek	-0.3021	0.0610	-0.0057	0.3810	0.2000	-0.0549	0.6584
Tulungagung	6.1375	0.0210	-0.0270	0.2331	0.2199	-0.0513	0.6297
Blitar	16.7866	-0.1218	-0.0062	-0.1101	0.6637	-0.0475	1.0031
Kediri	10.9162	-0.0605	-0.0091	0.1533	0.5386	-0.0544	0.8289
Malang	24.5058	-0.2117	-0.0090	-0.2508	0.8135	-0.0455	1.2653
Lumajang	18.0450	-0.1604	0.0113	-0.2053	0.7023	-0.0532	1.4179
Jember	7.5771	-0.0725	0.0330	-0.1397	0.5667	-0.0458	1.4739
Banyuwangi	12.5979	-0.1207	0.0247	-0.1904	0.6194	-0.0369	1.4040
Bondowoso	1.0087	-0.0301	0.0530	-0.0894	0.5505	-0.0353	1.5041

Situbondo	6.8468	-0.0784	0.0410	-0.1547	0.6165	-0.0363	1.4692
Probolinggo	18.8698	-0.1835	0.0182	-0.2137	0.7356	-0.0423	1.4330
Pasuruan	-5.2241	0.0036	0.0892	0.0208	0.6689	-0.0252	1.1356
Sidoarjo	36.7994	-0.3369	-0.0177	-0.3532	0.9248	-0.0347	1.2638
Mojokerto	30.2689	-0.2869	0.0084	-0.3072	0.8965	-0.0384	1.2632
Jombang	21.0297	-0.1988	0.0261	-0.1738	0.7733	-0.0485	1.1899
Nganjuk	2.2676	-0.0151	0.0388	0.2577	0.4296	-0.0563	0.9213
Madiun	-2.7895	0.0762	-0.0135	0.5623	0.0254	-0.0546	0.7758
Magetan	-4.8545	0.0707	0.0246	0.4774	0.1582	-0.0543	0.7786
Ngawi	-4.4000	0.0284	0.0666	0.3776	0.2364	-0.0505	0.9168
Bojonegoro	0.8994	-0.0346	0.0582	-0.0581	0.6748	-0.0261	1.2097
Tuban	10.6896	-0.1113	0.0328	-0.1459	0.6380	-0.0327	1.3415
Lamongan	-6.2685	0.0063	0.1021	0.0451	0.6477	-0.0272	1.1165
Gresik	27.6306	-0.2676	0.0094	-0.3097	0.8674	-0.0304	1.3127
Bangkalan	21.1800	-0.2144	0.0202	-0.2541	0.8005	-0.0281	1.3569
Sampang	-5.8803	0.0050	0.0978	0.0371	0.6591	-0.0267	1.1196
Pamekasan	15.1872	-0.1629	0.0306	-0.2040	0.7373	-0.0320	1.4439
Sumenep	12.9202	-0.1368	0.0314	-0.1897	0.6957	-0.0325	1.4106
Kota Kediri	9.2684	-0.0443	-0.0072	0.1837	0.4985	-0.0546	0.8083
Kota Blitar	16.2176	-0.1159	-0.0056	-0.0970	0.6516	-0.0478	0.9900
Kota Malang	25.8152	-0.2238	-0.0113	-0.2605	0.8359	-0.0442	1.2486
Kota Probolinggo	18.8391	-0.1832	0.0182	-0.2132	0.7351	-0.0424	1.4334
Kota Pasuruan	32.8800	-0.3070	-0.0060	-0.2820	0.8690	-0.0409	1.3288
Kota Mojokerto	30.6989	-0.2920	0.0090	-0.3124	0.9011	-0.0380	1.2665
Kota Madiun	-2.6198	0.0762	-0.0158	0.5665	0.0160	-0.0545	0.7766
Kota Surabaya	32.4014	-0.3018	-0.0070	-0.3427	0.8987	-0.0317	1.2813
Kota Batu	29.4711	-0.2592	-0.0143	-0.2919	0.8931	-0.0422	1.2230

Based on the parameter estimation results in Table 3, it can be seen that there are 38 regression models for each location, where each location has its own underweight model. The following are also the results of MGWR parameter estimation on the Stunting response variable.

Table 4. Parameter Estimation of MGWR on Stunting

Location	β0	β1	β2	β3	β4	β5	β6
Pacitan	6.2581	-0.0626	0.0162	0.3907	1.3737	-0.0779	0.4958
Ponorogo	12.0650	-0.0016	-0.1409	0.6722	0.9393	-0.0915	0.4749
Trenggalek	14.5253	-0.0185	-0.1212	0.4638	0.9478	-0.1036	0.5190
Tulungagung	22.3250	-0.0358	-0.1442	0.1600	0.8311	-0.1304	0.5669
Blitar	36.2178	-0.1694	-0.1260	-0.3489	1.2334	-0.1434	0.7576
Kediri	27.4816	-0.1041	-0.1236	-0.0555	1.1501	-0.1435	0.7688
Malang	44.4589	-0.3051	-0.0925	-0.4623	1.3827	-0.1182	0.9510
Lumajang	35.8580	-0.2435	-0.0715	-0.3957	1.1158	-0.1180	1.2192
Jember	33.6167	-0.2364	-0.0742	-0.3532	0.9145	-0.1066	1.3989

Banyuwangi	31.7198	-0.2493	-0.0361	-0.3083	0.9781	-0.0966	1.3400
Bondowoso	35.3466	-0.2722	-0.0659	-0.3285	0.8901	-0.0984	1.4758
Situbondo	35.0774	-0.2810	-0.0464	-0.3256	0.9420	-0.0975	1.4367
Probolinggo	37.4282	-0.2918	-0.0525	-0.3601	1.1775	-0.1001	1.2480
Pasuruan	-0.4298	-0.0390	0.0796	-0.0087	1.4987	-0.0504	0.6842
Sidoarjo	77.7168	-0.7294	-0.0568	-0.4812	1.9099	-0.0686	0.9897
Mojokerto	55.6413	-0.4890	-0.0664	-0.4170	1.6908	-0.0723	0.9671
Jombang	39.9164	-0.3138	-0.0651	-0.2945	1.4610	-0.0935	0.9587
Nganjuk	18.2656	-0.0827	-0.0769	0.2059	1.0414	-0.1129	0.7736
Madiun	14.3159	-0.0034	-0.1704	0.7042	0.7931	-0.0936	0.5501
Magetan	11.8513	-0.0260	-0.1094	0.6155	1.0310	-0.0883	0.5021
Ngawi	13.0450	-0.0763	-0.0550	0.4540	1.0088	-0.0866	0.6798
Bojonegoro	12.8924	-0.1251	0.0329	-0.1359	1.2897	-0.0705	0.9304
Tuban	29.1968	-0.2459	-0.0159	-0.2454	1.0729	-0.0869	1.2256
Lamongan	-1.9224	-0.0354	0.0974	0.0113	1.5582	-0.0541	0.6394
Gresik	55.8847	-0.5192	-0.0501	-0.3682	1.6248	-0.0601	1.0733
Bangkalan	43.9987	-0.4019	-0.0389	-0.3167	1.4224	-0.0642	1.1506
Sampang	-1.3375	-0.0379	0.0922	0.0040	1.5502	-0.0534	0.6497
Pamekasan	36.1797	-0.3139	-0.0290	-0.3122	1.1103	-0.0843	1.3546
Sumenep	33.2395	-0.2799	-0.0263	-0.3019	1.0561	-0.0884	1.3294
Kota Kediri	25.6754	-0.0882	-0.1230	-0.0039	1.1002	-0.1406	0.7378
Kota Blitar	35.5683	-0.1641	-0.1258	-0.3298	1.2240	-0.1426	0.7494
Kota Malang	46.3445	-0.3226	-0.0966	-0.4726	1.4385	-0.1158	0.9181
Kota Probolinggo	37.3777	-0.2911	-0.0526	-0.3600	1.1766	-0.1002	1.2483
Kota Pasuruan	62.3787	-0.5478	-0.0652	-0.4258	1.6177	-0.0874	1.0377
Kota Mojokerto	56.6927	-0.5031	-0.0645	-0.4178	1.7030	-0.0707	0.9716
Kota Madiun	14.4941	-0.0022	-0.1740	0.7077	0.7744	-0.0939	0.5553
Kota Surabaya	66.7435	-0.6264	-0.0547	-0.4188	1.7599	-0.0612	1.0447
Kota Batu	51.7590	-0.3770	-0.1024	-0.5107	1.5719	-0.1110	0.8689

Based on the parameter estimation results in Table 4, it can be seen that the model formed is the same as the underweight model, namely there are 38 regression models for each location, where each location has its own stunting model.

c) Model Fit Test

The model fit test is conducted to determine whether there is a difference between the global regression model and the MGWR model. Based on the test results, the following results were obtained:

Table 5. Model Fit Test

F test	F table	Decision
6.233	1.941	Reject H_0

Based on the $H0$ rejection test criteria if F test> $Ftable$. From the test results obtained F = 6.233> $Ftable$ = 1.941 then with a significant level of 5% it can be concluded that $H0$ is rejected. This means that there is a significant difference between the global regression model and the MGWR model.

d) Parameter Significance Test

The MGWR model parameter significance test was conducted to determine the parameters that significantly affect the response variable. The MGWR model produces different model equations for each district / city. Below are the test results.

Table 6. Result of the Parameter Significance Test

F test	F table	Decision
39.851	1.792	Reject H_0

Based on Table 6 above, with a significance level of 5% it can be seen that the value of F Test > F tabel or 39.851 > 1.792, then reject H_0. So it can be said that there is at least one independent variable that simultaneously influences the underweight and stunting variables. From the results of the partial testing, 11 groupings of districts/cities based on predictor variables that significantly affect the underweight response variable and 12 groupings of districts/cities based on predictor variables that significantly affect the stunting response variable were obtained.

4 Conclusion

The conclusion obtained from this study is that in the MGWR model with adaptive kernel Gaussian weights, the variables of access to proper drinking water, complete immunization, poor population, low birth weight, exclusive breastfeeding and undernutrition have a significant effect on underweight and stunting in East Java. Then 11 district / city groupings are formed based on predictor variables that have a significant effect on the underweight variable and 12 district / city groupings based on predictor variables that have a significant effect on the stunting variable.

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