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Geographically Weighted Regression of Maternal Human Capital on Nutrition of Stunted Toddlers in Tin and Non-Tin Minning Areas

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Abstract

The perspective of maternal human capital on stunted toddler nutrition has a different spatial relationship between tin mining and non-tin mining areas. This study will look at which spatial patterns of maternal human capital influence the nutrition of stunted children under five in tin-mining villages. This study uses primary data on 346 stunted children under five in Bangka Belitung Islands Province, Indonesia. The analysis used geographically weighted regression (GWR) by dividing mining and nonmining areas of Bangka Island and Belitung Island. Maternal human capital that spatially influences the nutrition of stunted toddlers in tin mining and non-mining areas is maternal knowledge about nutritious food. Maternal knowledge of a clean and healthy environment has a negative effect on the nutrition of stunted children under five in the non-mining area of Bangka Island. Maternal education and skills to diversify fish food have an effect on the nutrition of children under five years old in Belitung Island tin mining area. Mothers' skills in diversifying fish food affect the nutrition of stunted children under five in 11 villages in the non-tin-mining area of Belitung Island.

Keywords: *Stunted Toddler Nutrition, Fish Food Diversification, Tin Mine, Non-Tin Mine*

INTRODUCTION

Indonesia's prevalence position in 2021 has dropped to 24.4 per cent, but maximum effort is still needed to reduce stunting to 15.6 per cent so that the target in 2025 is achieved. The Indonesian government targets to reduce the prevalence of stunting by 14 per cent by 2024. (Ministry of Health of the Republic of Indonesia & Nutrition Status Survey of Indonesia (SSGI), 2021).. Indonesia's reduction in the prevalence of stunting in children under 5 years old is still far from the WHO standard. This is due to the increase in prices of staple foods, fruits, vegetables, dairy products and the impact of weather disasters resulting in various pest attacks, as well as the Covid-19 pandemic. These factors make it difficult for low-income people to maintain a healthy diet (ADB, 2021). As a result of not maintaining healthy food patterns, toddlers are vulnerable to being given substitute foods in the form of cheap unhealthy snacks, causing the prevalence of stunting to increase (Vries et al. (2021)

The focus of this stunting research will be carried out in the Province of Bangka Belitung Islands, because based on the special index for handling stunting (IKPS) in 2019, the Province of Bangka Belitung Islands (60.7 per cent) is ranked 11th which has not yet reached Indonesia's IKPS (66.1 per cent). Even the achievement of the Bangka Belitung Islands Province IKPS in 2020-2021 is included in the medium category because the performance of reducing stunting is not significant and is still below the Indonesian IKPS. (Special Index Report for Stunting Handling (LIKPS 2020-2021, 2022)..

Child care and feeding practices are inadequate in the Province of Bangka Belitung Islands, as seen from the low practice of exclusive breastfeeding of infants aged 0-5 months at 36.2 per cent (number 1 in Indonesia). Meanwhile, the proportion of infants 6-23 months who received exclusive breastfeeding was 42.3 per cent (number 8 in Indonesia). Even children under two years old aged 0-23 months (toddlers) who received complementary food at the age of more than 6 months were 35.4 per cent (7th lowest in Indonesia). Based on the results of a study on nutritional status in Indonesia, stunted children in Bangka Belitung Islands Province

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have acute nutritional problems because the prevalence of stunting is still below 20 per cent. (Ministry of Health RI & SSGI, 2021)..

Bangka Belitung Islands Province is an island province that has more stunted toddlers than Riau Islands Province. In addition, Bangka Belitung Islands Province is geographically surrounded and directly adjacent to the high seas so that it has abundant capture fisheries potential. Research Irnawati et al. 2011 found that the superior capture fisheries of Bangka Belitung Islands Province consisted of red snapper, mackerel and crab, while potential capture fisheries commodities were sunu grouper, yellowtail, mayung, red quirisi and rays. Research Sianipar et al., 2021, Rindawati, 2022, Nugroho et al., 2023 revealed the importance of consuming fish to overcome stunting in toddlers. Research Dasgupta et al., 2021 found that the fulfilment of protein in fish consumption for stunted toddlers whose fathers work as fishermen is very high and they can get it for free.

In addition to having great potential in capture fisheries products, Bangka Belitung Islands Province is also the largest tin producing province in Indonesia. Bangka Belitung Islands Province is one of the tin producing areas, and providing legality for the community to exploit tin conventionally is legalised through Minister of Industry and Trade Decree No.146/MPP/Kep/4/1999. The decree states that tin in Bangka Belitung Islands Province is a free (unsupervised) item. Unconventional tin exploitation is carried out on land, in rivers, and at sea, causing siltation of rivers, pollution of rivers and seas, damage to coral reefs, and reduction of fishery resources.

So this study will examine which maternal human capital can improve the nutrition of stunted toddlers in mining and non-tin mining areas of Bangka Belitung Islands Province, Indonesia.

THEORETICAL FOUNDATION

Assumption Becker (1993) an increase in the amount of human capital, measured by the wage rate. Each person produces his own human capital by spending some of his time and goods on schooling, receiving on-the-job training, and so on. The rate of change of capital is equal to the difference between the rate of production and depreciation of investment by the formula:

$\Phi i = \psi i\ (tei\ ,\ xei\ )$.....(1)

Where Φi is the human capital output in years i and tei and xei are time and goods inputs. Then it becomes

$Ei+1 = Ei + \Phi i - dEi$ .....(2)

where Ei +1 is the investment at the beginning of period i+1, and d is the depreciation rate over the period. Each household maximises the utility function at:

$U = U(C1\ ,\ C2\ ,\ .....,Cn\ )$.....(3)

where Ct is the commodity consumed during period i. Ci is then produced "at home" with its own market goods and time inputs. Let the (composite) market good used in period i be xu and the (composite) amount of time combined with xi be ti , then it becomes

$Ci = i\ f(xi\ ,tci\ ),\ i = 1,.....n$ .....(4)

Where ,i f is the production function in period i. If it is initially assumed that time can only be allocated between consumption and labour force participation (called "work"). Then the production constraints of equations (3), (2), (1) and the budget constraints of time and goods are as follows;

$tci + twi + tei = t, i = 1,.....n$.....(5)

$\sum_{(i=1)}^{n}(x_i+x_{ei})/(1+r)^i = \sum_{(i=1)}^{n}(\ [\![\alpha iE]\!]\ _i\ t_{wi+v_i})/(1+r)^i$ .....(6)

where w = Ei αii and αi are the payments per unit of human capital in period i. If assumed to be Φi depends on tei and ψi is the same in all periods, and if the optimal solution has non-zero values at xi , tci , twi and tei .. The optimality condition of the first derivative is

$U\ fixi = \lambda\ 1/\ [\![(1+r)]\!]\ ^i\ \ i = 1,.....n$ (7)

$$U\,fixi = \lambda\,(\alpha_i E_i)/\ [(1+r)]\ ^i \quad i=1,.....n \qquad (8)$$

$$U\hat{} = \lambda\,[(\alpha_i E_i)/\ [(1+r)]\ ^i - \sum_{(j=i+1)}^{n}(\alpha_j t_{wi})/\ [(1+r)]\ ^i \quad (\partial E_i)/(\partial t_{ei})] \qquad (9)$$

Equations (7) and (8) assume that the current investment does not change anything. Hence, the derivation of equations (7) and (8) becomes equation (9). If te i.e. time, tends to decrease with age, but before reaching the peak age, the wage rate will move up. Then the time of use of the good depends on the interest rate, so there is an elasticity of substitution in production consumption. There are two differences, firstly the path of the wage rate is no longer given, but is determined by an endogenous variable Ei . The wage rate will peak before, or after the peak E . α_ii Second, the behaviour of tw is no longer simply complementary to the behaviour of te , as tw also depends on te , which is determined by equation (9).

Equation (9) is an equilibrium condition where the current marginal cost of human capital investment equals the future return. This equation shows that the amount of time spent investing in human capital tends to decrease with age for two reasons. One is because the present value of future returns declines with age. The second reason is that the cost of investment tends to increase with age, but the income foregone due to current capital investment will increase in the future (Et).

There are several consequences that tei tends to fall when i (interest rate) increases. One is that hours worked (tw) are lower at younger ages and will increase faster if there is no human capital investment. As a result, as long as tei is positive, the peak of tw will tend to be above tc , and could even be above wi . However, since te declines with age, i > p (interest rates will be larger than prices), the behaviour of tw (working time) will complement tc (consumption time).

If young time is allocated to human capital investment then the allocation of labour time does not exist (tw =0), tc and te will follow this young time. The marginal cost of investment will not be measured using the lost income, but measured using the marginal value of consumption time over lost income (tw > 0).

If twi = 0 then i = 1,....q then equations (7) and (9) combined with the first derivative condition of i = 1,.....q will be

$$U\,fixi = \lambda 1/\ [(1+r)]\ ^i \qquad i = 1,.....q \ (10)$$

$$U\,fixi = si \qquad i = 1,.....q \ (11)$$

$$si = \lambda\,[(\alpha_i E_i)/\ [(1+r)]\ ^i - \sum_{(j=i+1)}^{n}(\alpha_j t_{wi})/\ [(1+r)]\ ^i \quad (\partial E_i)/(\partial t_{ei})\ ] \qquad i = 1,.....q \ (12)$$

where si is the marginal utility of one additional time spent on consumption at time ith . If U fixi is substituted from si in equation (12), then

$$(U_i\,f_{ti})/\lambda = \sum_{(j=i+1)}^{n}(\alpha_j t_{wi})/\ [(1+r)]\ ^i \quad (\partial E_i)/(\partial t_{ei}), \qquad i = 1,.....q \ (13)$$

or the present value of the return on additional hours invested in human capital, will not be equal to the foregone income from that investment. But its monetary value is equal to the marginal utility of the additional hours spent in consumption.

When equation (11) is divided by (10), and the substitution st is made from (12), then

$$f_{ti}/f_{xi} = \sum_{(j=i+1)}^{n}(\alpha_j t_{wi})/\ [(1+r)]\ ^i \quad (\partial E_i)/(\partial t_{ei}), \qquad i = 1,.....q \ (14)$$

The ratio of the marginal product of time and goods is not equal to the wage rate because there is no time to work, but the monetary value of the marginal productivity of time used in investment. Even if wi for i < q is small, commodity production will be goods-intensive if the time return on investment is high.

METHODOLOGY

Data

This research survey was conducted on 346 *stunted* toddlers living in mining and non-tin mining areas. After the survey, 190 *stunted toddlers* lived in mining areas and 156 *stunted* toddlers lived in non-tin mining areas (Table 1).

Table 1. Distribution of *Stunted* Toddler Samples on Bangka Island in Tin Mine and Non-Timber Mine Areas

Bangka Island Tin minning Area			
District/City	**District**	**Village/Kel**	**Number of *Stunting* Toddlers**
West Bangka	6	35	77
Bangka	7	17	27
Central Bangka	3	12	23
South Bangka	2	3	3
Total	**18**	**67**	**130**
Bangka Island Not a Tin minning Area			
District/City	**District**	**Village/Kel**	**Number of *Stunting* Toddlers**
West Bangka	6	27	57
Bangka	6	9	12
Pangkalpinang	5	12	13
Central Bangka	3	5	8
South Bangka	3	10	27
Total	**23**	**63**	**117**
Belitung Island Tin minning Area			
District	**District**	**Village/Kel**	**Number of *Stunting* Toddlers**
Belitung	4	21	31
East Belitung	7	14	29
Total	**11**	**35**	**60**
Belitung Island is a non-tin mining region			
District	**District**	**Village/Kel**	**Number of *Stunting* Toddlers**
Belitung	4	13	27
East Belitung	5	7	12
Total	**9**	**19**	**39**

Source: processed (2023)

Table 1 shows that the largest number of *stunted* toddlers on Bangka Island is in West Bangka Regency, both mining and non-tin mining areas, with 60 per cent and 48.72 per cent of *stunted toddlers respectively*. While on Belitung Island, the *most stunted* toddler samples were in Belitung Regency, both mining and non-tin mining areas. Then all samples of *stunted toddlers* in the district / city will be combined based on the village / kelurahan where the *stunted* toddler lives, as a representative village / kelurahan studied.

DETERMINATION OF OPTIMUM BANDWIDTH

Bandwidth is a circle from the centre of the location and is the basis for calculating the weight of observations to form a regression model at each observation location. The optimum bandwidth affects the accuracy of the regression, one of the optimum bandwidth determinations can be done using *Cross Validation* (CV) formulated as follows:

$$\text{CV} = \sum_{i=1}^{n}(y_i - \hat{y}_{\neq 1}(h))^2 \quad (31)$$

where $\hat{y}_{\neq 1}(h)$ is the value of the estimator y_i with observations at location (u_i ,v_i) omitted from the estimation process. The bandwidth is optimum if CV produces the minimum value.

GWR Spatial Analysis Steps

Determining Spatial Global Autocorrelation with Moran's Index

Moran's index is a measure of global autocorrelation which is an extension of *Pearson's* correlation coefficient and is symbolised by I (Griffith, 2019). Moran's index is a technique in spatial analysis to calculate spatial relationships that occur in a space. (Gittleman & Kot, 2016).. Anselin (1988) states the Moran index as follows:

$$I = \frac{n}{W\sum_{i=1}^{n} z_i^2} \sum_{i=1}^{n}\sum_{i=1}^{n} w_{ij} z_i z_j \quad (32)$$

Where

$W = \sum_{i=1}^{n}\sum_{i=1}^{n} w_{ij}$, $z_i = (x_i - \bar{x})$, and $z_j = (x_j - \bar{x})$, I is the Moran index

Description:

n = Number of event locations

x_i = The number of specific events in region i

x_j = The number of specific events in region j

$\bar{x}$ =Average number of specific events

w_{ij} = Weighting matrix between regions i and j

W = Sum of all elements in the spatial weighting matrix.

LISA (Local Indicator of Spatial Association)

Global spatial autocorrelation, in this case the Moran index, does not provide information on spatial patterns in certain areas. Therefore, information is needed on the tendency of spatial relationships in each location with the *Local Indicator of Spatial Association (LISA)*. Anselin (1988) defines LISA as a statistic that fulfils the following two criteria:

The LISA value of each region can be used to provide clues to the clustering of significant spatial relationships of similar values around the region.

The sum of the LISA values for all regions is proportional to the Moran index value.

The LISA for each region i is written as follows;

$$Li = \frac{z_i}{m_2} \sum_{i=1}^{n} w_{ij} z_j \quad (33)$$

Where

$m = {}_2\frac{1}{n}\sum_{i=1}^{n} z_i^2$, $z_i = (x_i - \bar{x})$, and $z_j = (x_j - \bar{x})$, I is the LISA at region i.

Description:

n = Number of event locations

x_i = The number of specific events in region i

x_j = The number of specific events in region j

$\bar{x}$ =Average number of specific events

w_{ij} = Weighting matrix between regions i and j

The hypothesis for the parameter L_i is

$H_0 : L_i = 0$, no autocorrelation between locations

$H_1 : L_i = 0$, there is autocorrelation between locations

Then the LISA test statistic is performed with the formula:

$$Z\text{hitung} = \frac{L_i - E(L_i)}{\sqrt{Var(L_i)}} \quad (34)$$

Description:

Var(L) = the variance of Moran's index.

E(Li) = *expected value of the* Moran index.

This study will reject H_0 if $|Z\text{count}| > Z_{\alpha/2}$ or *p-value* < α = 1% to 10%, meaning that spatial autocorrelation is positive, indicating that there is a close relationship between observation locations.

Local Spatial Equation Model of Maternal Human Capital on Stunting Toddler Nutrition

$GSti = \alpha_0+\alpha_1EDi+\alpha_2BMIi+\alpha_3FDi+\alpha_4AD+\alpha_5CHEK+\alpha_6NFKi+e_{1i}$ (1)

It is then transformed by incorporating the spatial elements of the region into the equation into :

$$GSt_i = \alpha_{10}(u_i, v_i) + \alpha_{11}(u_i, v_i)\,ED + \alpha_{i12}(u_i, v_i)\,BMI + \alpha_{i13}(u_i, v_i)\,FD + \alpha_{i14}(u, v_{ii})\,AD + \alpha(u_{i15ii})CHEK + \alpha_{i16}(u_i, v_i)\,NFK_i + e_{17i} \quad (2)$$

Table 2. Operational Definition of Independent Variables

Independent Variable	Notation	Explanation
Mother's education	ED	Years of schooling completed
Body Mass Index	BMI	Maternal weight (kg) divided by height (metres)
Fish Diversification Skills	FD	Total ordinal score of 5 questions on fish/rice substitutes, diversification intensity, reasons for diversification and training.
Agricultural Diversification Skills	AD	
Clean Healthy Environment Knowledge	CHEK	Total ordinal score of 5 food and environmental knowledge questions
Nutritious Food Knowledge	NFK	

Source: processed from research (2023)

ANALYSIS AND DISCUSSION

OLS or GWR Model Feasibility Test

The spatial model suitability test compares the *adjusted* R^2 and AICc values using OLS and GWR regression models. The spatial regression model is said to be the best in describing maternal human capital on *stunted* toddler nutrition if the *adjusted* R^2 GWR is greater than OLS regression, while the AICc value of the GWR model is smaller than OLS regression.

Table 3. Feasibility Test of Global Regression and GWR Models of Maternal Human Capital on Nutrition of *Stunted* Toddlers in Tin Mine and Non-Mine Areas

Tin Mine Territory				
Ket	**Bangka Island**		**Belitung Island**	
	OLS Regression	**GWR**	**OLS Regression**	**GWR**
Adjusted R^2	0.162525	0.176309	0.288602	0.329847
AICc	62.561746	59.69262	100.269502	92.66098
Non-Red Mine Areas				
Ket	**Bangka Island**		**Belitung Island**	
	OLS Regression	**GWR**	**OLS Regression**	**GWR**
Adjusted R^2	0.243406	0.242565	0.421526	0.438738
AICc	136.928989	135.4976	122.333223	62.919775

Source: processed (2023)

Table 3 shows that based on the comparison of adjusted R2 and AICc of global regression and GWR results, the spatial model better estimates maternal human capital on stunted toddler nutrition than using the OLS regression model. Testing for spatial heterogeneity results in spatial diversity in each village data so that it can be modelled using the GWR model.

4.2. Spatial Patterns of Research Variables

Spatial analysis to calculate spatial relationships that occur in a space (Gittleman & Kot, 2016). Anselin (1988) Spatial autocorrelation is a measure of whether it is clustered or random. Testing for spatial autocorrelation is done with the Moran index, the standardised value (z-score) and probability value (p-value) have a 95% confidence level. The range of the Mpran index between -1 and +1 means that the spatial pattern of the variable area is spread (random) or referred to as negative spatial autocorrelation. Spatial patterns are clustered if the Moran index value is more than 0 or called positive spatial autocorrelation. So based on the results of the calculation of spatial autocorrelation between variables can be seen in Table 4.

Table 4. Spatial Pattern of Research Variables of Tin Mine and Non-Mine Areas

Tin Mine Territory		
Ket	**Bangka Island**	**Belitung Island**

	Mine	Not Mine	Mine	Not Mine
Nutrition Stunting	Clustered	Random	Random	Random
ED	Clustered	Clustered	Random	Random
BMI	Clustered	Clustered	Random	Random
FD	Clustered	Clustered	Clustered	Random
AD	Clustered	Clustered	Random	Random
CHEK	Clustered	Clustered	Random	Random
NFK	Clustered	Clustered	Random	Random

Source: processed (2023)

Table 4 shows that most maternal human capital variables are clustered in both tin-mining and non-tin-mining areas of Bangka Island. However, the variable of *stunted* toddler nutrition is only clustered in the tin mining area of Bangka Island. The only variable that has positive spatial autocorrelation and is clustered on Belitung Island in the tin mining area is the mother's skill in diversifying fish food.

PARAMETER ESTIMATION AND DISCUSSION

Indicators of *stunting* nutritional status in Indonesia, seen from the index of body weight according to length or height aged 0-60 years (BB/PB or BB/TB) consist of six categories (Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2020 concerning Child Anthropometry Standards, 2020). Due to the number of malnourished *stunted* toddlers is not too much, so categories 1 and 2 are combined into one category, namely *stunted* toddlers with good nutrition and poor nutrition.

Table 5. Nutrition of *Stunted* Toddlers in Bangka and Belitung Islands Tin Mine and Non-Mine Areas

Bangka Island				
Region	**Malnutrition**	**Undernourished**	**Good Nutrition**	**Total**
Tin Mine	6.0	63.2	30.8	100.0
Not a Tin Mine	6.9	62.3	30.8	100.0
Belitung Island				
Region	**Malnutrition**	**Undernourished**	**Good Nutrition**	**Total**
Tin Mine	2.6	28.2	69.2	100.0
Not a Tin Mine	1.7	31.7	66.7	100.0

Source: processed (2023)

Table 5 shows that the number of undernourished and malnourished *stunted* children is higher on Bangka Island in mining and non-tin mining areas. The number of well-nourished stunted children under five is more prevalent on Belitung Island in mining and non-tin mining areas. Based on observations in the field, well-nourished *stunted toddlers* have short height but tend to have normal weight and fatness. Undernourished and malnourished stunted children tend to be short in stature and underweight.

1.73 per cent of malnourished *stunted* toddlers suffer from congenital diseases such as telaseminia, TB, hydrocephalus and downsindrom. Based on observations in the field, when surveyors invite toddlers to play and interact, the response of undernourished/poorly nourished stunted toddlers tends to be slower than well-nourished *stunted toddlers*.

Based on the interview results, 42.8 per cent of mothers are aware that their toddlers are malnourished. Only 3.1 per cent of mothers of *stunted toddlers* stated that the current condition of *stunted toddlers was* due to the mother's iron deficiency and not consuming nutritious and nutritious foods when pregnant.

Table 6. Parameter Estimation of GWR Model of Maternal Human Capital on Toddler Nutrition *Stunting in* Villages in the Tin minning Area (Bangka Island and Belitung Island)

BANGKA ISLAND
GWR Coefficient Model

Variables	Min	Max	Mean	Percentage of Villages/Kel based on Significance (95% Level) of the t-test		
				$p \leq 0.05$(%)	Positive (%)	Negative (%)
Intercept	-2.66429	-2.66236	-2.6637	0	0	100
ED	0.008227	0.008292	0.00827	0	100	0
BMI	0.00321	0.003234	0.0032193	0	100	0
FD	-0.00941	-0.0093	-0.009376	0	0	100
AD	0.008992	0.009158	0.0091059	0	100	0
CHEK	-0.03493	-0.03480	-0.034877	0	0	100
NFK	0.065301	0.065403	0.065339	100	100	0
BELITUNG ISLAND						
GWR Coefficient Model						
Variables	**Min**	**Max**	**Mean**	**Percentage of Villages/Kel based on Significance (95% Level) of the t-test**		
				$p \leq 0.05$(%)	Positive (%)	Negative (%)
Intercept	-6.09252	-5.22957	-6.00202	100	0	100
ED	0.128115	0.140153	0.132303	100	100	0
BMI	0.017179	0.048681	0.02833	0	100	0
FD	-0.05653	-0.05205	-0.05639	0	0	100
AD	0.322901	0.338429	0.32935	100	100	0
CHEK	-0.18603	-0.11274	-0.16603	0	0	100
NFK	-0.08121	-0.06915	-0.07353	0	0	100

Source: processed (2023)

Table 6 shows that the variables that have positive coefficients on stunted toddler nutrition consist of mother's education, mother's BMI, diversification of agricultural food and knowledge of nutritious nutritious food, while diversification of fish food and knowledge of clean and healthy environment have negative coefficients. However, only knowledge of nutritious food significantly influences the nutrition of *stunted children under five* in all Bangka Island villages in the tin mining area.

Based on the field survey, 78 per cent of mothers in the Bangka Island mining area know the meaning of nutritious food, namely the four healthy five perfect foods. Mothers are also aware of the importance of providing formula milk to toddlers for bone health, with 51.54 per cent of mothers providing formula milk to toddlers in practice. According to mothers, the protein content in fish is very beneficial for the growth of toddlers' brain cells, in practice 59.2 per cent of the contents of toddlers' plates are fish. The discussion on which villages should improve their knowledge of nutritious food can be seen in the discussion of Figure 4.3.

The positively coefficient variables in the tin mining area of Belitung Island consist of mother's education, mother's BMI and agricultural food diversification skills. Whereas fish food diversification skills, maternal knowledge of a clean and healthy environment and nutritious food are negatively coefficient. The variables of education and agricultural diversification skills positively affect the nutrition of *stunted* toddlers in the tin mining area of Belitung Island. Unlike the research results of Ahlerup *et al.* 2019 which revealed that mining has a negative impact on education. This study shows that maternal education has a positive impact on children's nutritional achievement as revealed in the studies of Nepal (2018), Woldehanna *et al.* (2018). Women's empowerment across multiple dimensions can develop mothers' understanding of their children's nutritional status (Holland and Rammohan, 2019). (Holland and Rammohan, 2019). One of the empowerments that mothers must have is the skill of diversifying processed agricultural foods.

Table 7 shows the parameter estimation of the GWR model of Maternal Human Capital on Bangka Island in non-mining areas.

Table 7: Parameter Estimation of GWR Model of Maternal Human Capital on *Stunting* Toddler Nutrition in Villages in Non-Timeland Mining Areas (Bangka Island and Belitung Island).

BANGKA ISLAND					
GWR Coefficient Model					
Variables	**Min**	**Max**	**Mean**	**Percentage of Villages/Kel based on Significance (95% Level)**	

					of the t-test	
				***p* ≤0. 05(%)**	**Positive (%)**	**Negative (%)**
Intercept	-2.55235	-0.25502	-2.55101	100	0	100
ED	-0.00427	-0.00426	-0.004261	0	0	100
BMI	0.024615	0.0247	0.0246448	0	100	0
FD	-0.03973	-0.03089	-0.030943	0	0	100
AD	0.014102	0.14198	0.0141627	0	100	0
CHEK	-0.05415	-0.0541	-05412245	100	0	100
NFK	0.0494	0.04944	0.049408	100	100	0
BELITUNG ISLAND						
GWR Coefficient Model						
Variables	**Min**	**Max**	**Mean**	**Percentage of Villages/Kel based on Significance (95% Level) of the t-test**		
				***p* ≤0. 05(%)**	**Positive (%)**	**Negative (%)**
Intercept	-7.63418	-7.63229	-7.63299	100	0	100
ED	-0.12696	-0.00560	-0.09641	0	0	100
BMI	-0.72488	0.00768	-0.03743	0	63.16	36.84
FD	0.30036	0.30101	0.300692	57.89	100	0
AD	-0.27843	-0.20166	-0.22954	0	0	100
CHEK	-0.12245	0.0743	-0.01324	0	52.63	47.37
NFK	0.17226	0.1782	0.17253	100	100	0

Source: processed (2023)

Table 7 shows that maternal education, fish food diversification skills and knowledge of a clean and healthy environment have negative coefficients on the nutrition of *stunted* children under five in 100 villages on Bangka Island in the non-tin-mining area. Meanwhile, the variables of maternal body mass index (BMI), agricultural food diversification and maternal knowledge about nutritious food have positive coefficients on the nutrition of stunted children under five in 100 villages on Bangka Island in non-tin-mining areas. However, the most significant variables affecting the nutrition of *stunted* toddlers on Bangka Island in the non-tin mining area are knowledge of nutritious nutritious food and a clean and healthy environment.

The reason why knowledge of a clean and healthy environment negatively affects the nutrition of *stunted* toddlers is because mothers' knowledge of the environment is not accompanied by the practice of maintaining a clean and healthy environment. One of them is the practice of garbage disposal, there are still many mothers who dispose of garbage by burning, dumping or throwing it into the river. This is done because there are no garbage cans in front of the house and the village does not coordinate the collection of garbage to the final disposal. Another practice is that toddlers' houses in non-tin mining areas tend to have only one or two dirty water drainage channels in front of the house.

Whereas mothers with good knowledge about nutritious nutritious food are accompanied by nutritious nutritious feeding practices. 72.65 per cent of the plate contents of *stunted* toddlers in non-tin-mining areas of Bangka Island contained carbohydrates (rice) and protein, namely fish 53.85 per cent and eggs 18.8 per cent. The variable of mother's skill in diversifying processed fish food positively influences the nutrition of *stunted children under five* in 57.89 per cent or 11 villages on Belitung Island in non-tin-mining areas. Increasing the diversification of processed fish food is one way to increase fish consumption, especially in the fish scarcity season and complement other protein sources for *stunted* toddlers whose parents have low incomes (Dasgupta et al., 2015). (Dasgupta *et al*., 2021).. The clean and healthy environment knowledge variable has a positive effect on the nutrition of *stunted children under five* in 10 villages (52.63 per cent) and a negative effect in 9 villages (47.37 per cent) on Bangka Island in the non-tin mining area.

The human capital instrument of tin mining areas on Bangka Island has an optimum bandwidth of 16,949.1 metres or 16.95 km and on Belitung Island with a bandwidth of 8,653.881 metres or 8.65 km. This means that the circle radius of the optimum distance of influence between villages/sub-districts in the Bangka Island mining area is 16.95 km, if more than this distance, the influence between villages/sub-districts will be weaker, as well as on Belitung Island (Figure 1a).

The optimum distance of human capital observation between villages in the non-tin mining area of Bangka Island is 16,943.81 metres or 16.9 km and in Belitung Island is 5,597.008 metres or 5.6 km. The *adjusted* R^2 value of maternal human capital in the non-tin mining area of Bangka Island is 14.38 per cent (0.1438) and Belitung Island is 68.6 per cent (0.6860).While the local distribution of R^2 can be seen in (Figure 1b).

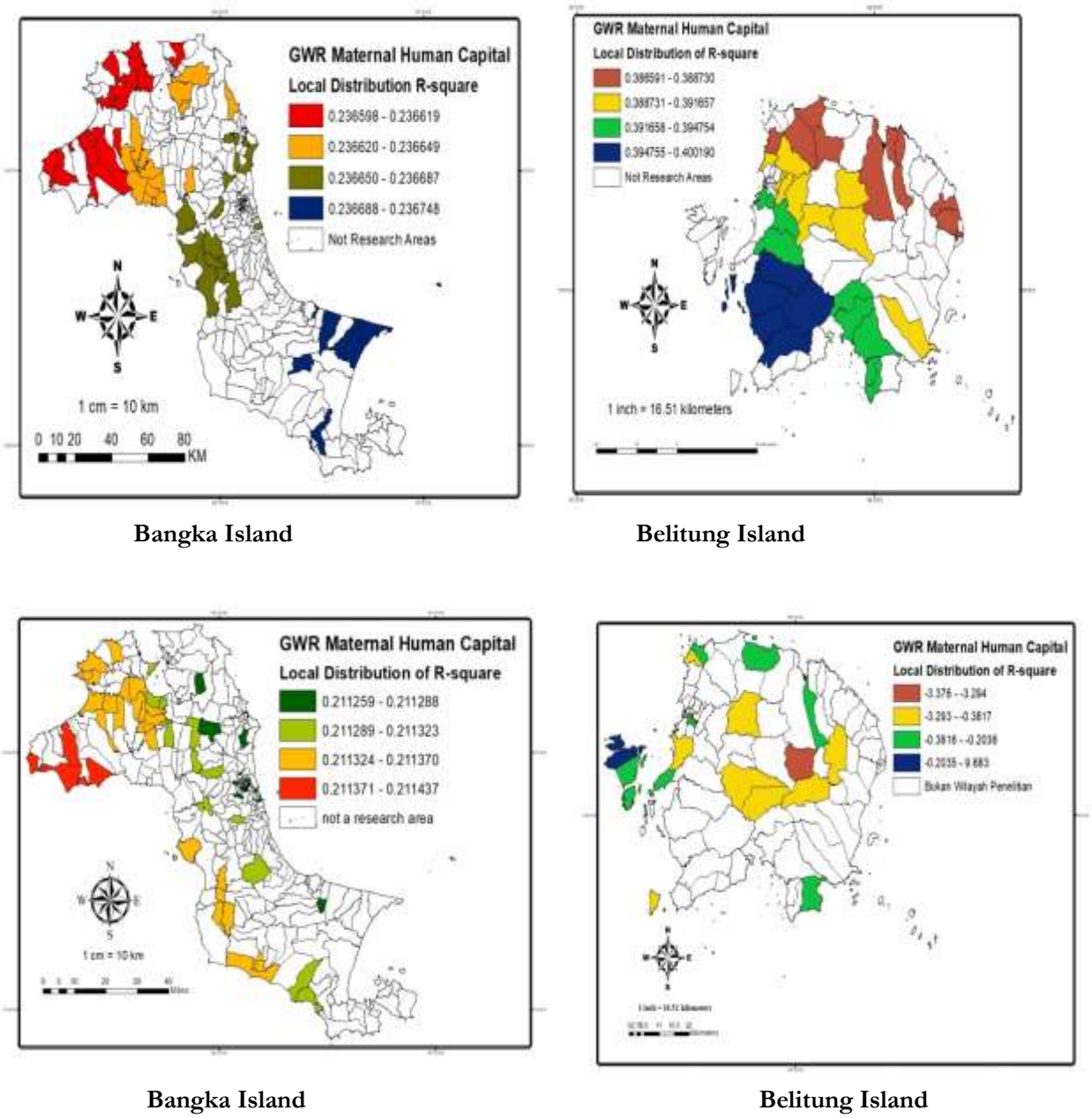


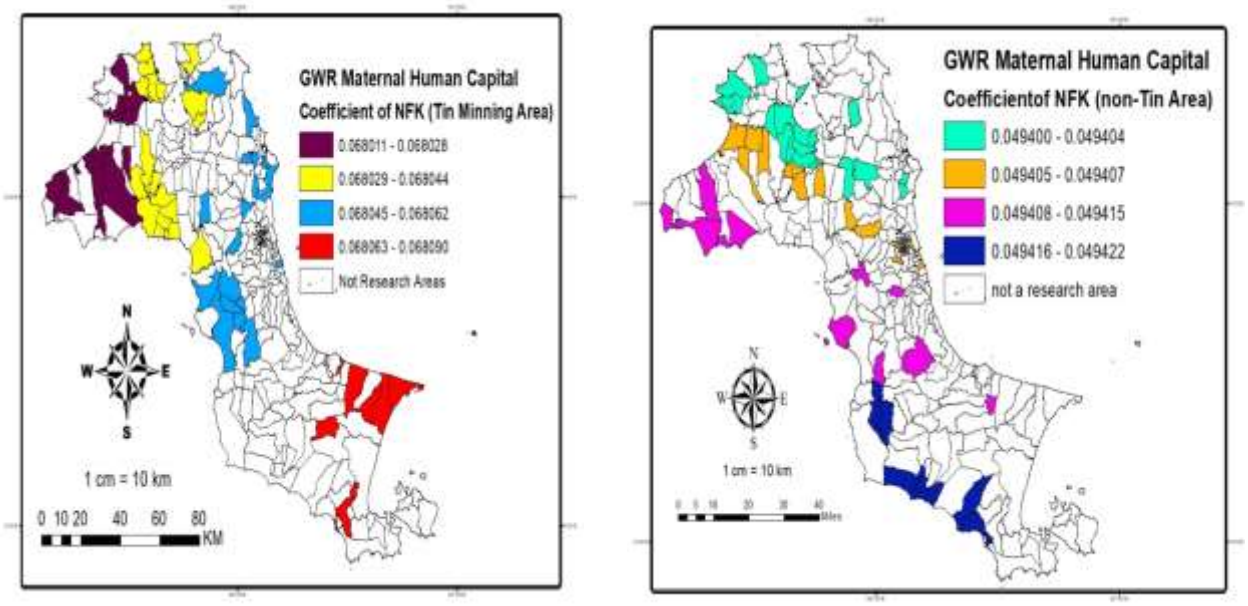
Figure 1 (a) Local Distribution of R-square of Maternal Human Capital on Nutrition of *Stunted* Toddlers in Bangka and Belitung Islands with Tin minning Areas; (b) Local Distribution of R-square of Maternal Human Capital on Nutrition of *Stunted* Toddlers in Bangka and Belitung Islands non- Tin minning Areas.

[2]Figure 1 (a) The local distribution of maternal human capital in the villages of Bangka Island tin mining area is 23.932 per cent (0.239320) to 23.943 per cent (0.239433). The lowest local distribution of R^2 is 0.239320 (23.93 per cent) to 0.239354 (23.94 per cent) in Labuh Air Pandan, Jada Bahrin, Petaling Banjar, Riding Panjang,

Penangan (Bangka Regency) and Melabun, Puput, Romadhon, Sarang Mandi, Sungai Selan Atas, Sungai Selan and Lampur (Central Bangka Regency) villages. ²The local distribution of maternal human capital in the villages of Belitung Island tin mining area is 38.66 per cent (0.386591) to 40 per cent (0.400199). Villages with the lowest local R^2 distribution of 38.66 per cent (0.286591) to 39 per cent (0.390018) consist of Air Batu Buding, Pelepak Pute, Sijuk (Belitung Regency) and Kurnia Jaya, Lalang Jaya, Limbongan, Mekar Jaya, Mengkubang, Pelepak Putek, Sijuk, Simpang Tiga, Sukamandi (East Belitung Regency). The local R^2 of these villages ranges from 0.386591 to 0.40019.

Figure 1(b) local distribution of R^2 maternal human capital in villages of non-tin-mining areas of Bangka Island starts from 21.1259 per cent (0.211259) to 21.1437 per cent (0.211437). The local distribution of R^2 of maternal human capital in villages of Belitung Island starts from 60.3838 per cent (0.603838) to 60.4434 per cent (0.604434). ²The lowest local distribution of human capital of 0.6038 (60.38 per cent) to 0.6039 (60.39 per cent) is in Kelubi, Lintang and Tanjung Batu Itam villages (East Belitung district).

Human capital variables that affect the nutrition of *stunted* toddlers in tin mining areas consist of maternal knowledge about nutritious nutritious food (Bangka Island), maternal education and skills in diversifying processed agricultural food (Belitung Island).



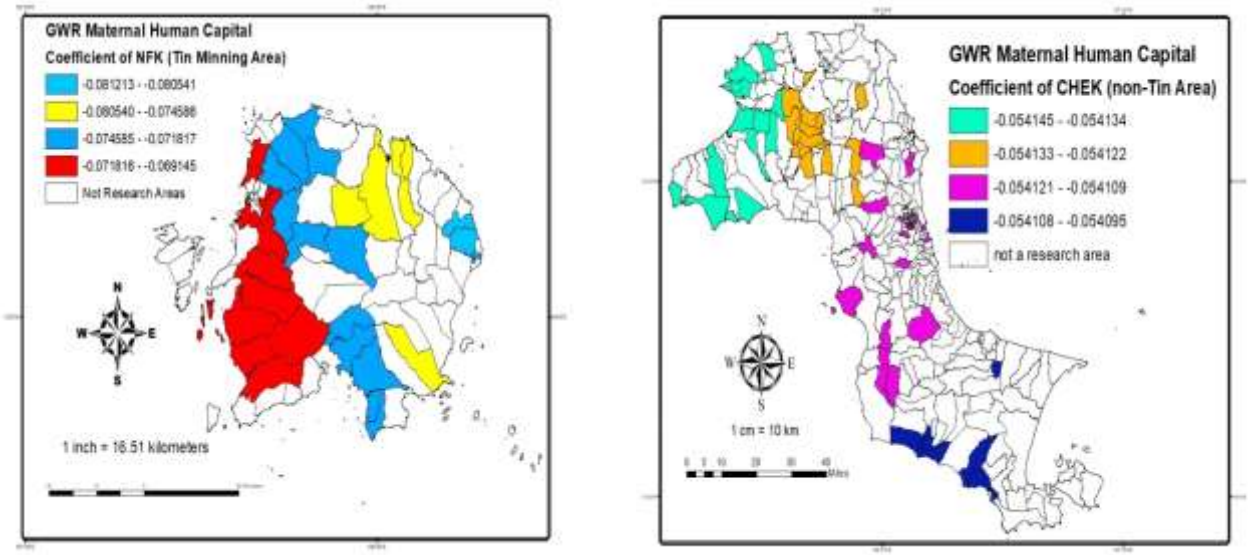


Figure 2 (a) Spatial Distribution of NFK Coefficient of Bangka Island with Tin minning Area; (b) Spatial Distribution of NFKCoefficient of Bangka Island non-Tin minning Area; (c) Spatial Distribution of NFK Coefficient of Belitung Island with Tin minning Area; (d) Spatial Distribution of CHEK Coefficient of Bangka Island non-Tin minning Area.

Figure 2 (a) It is important to increase mothers' knowledge about nutritious and nutritious food in the villages of Bukit Ketok, Deniang (Bangka Regency) and Air Gegas (South Bangka Regency) that have high knowledgeable mothers to the villages of Labuh Air Pandan, Jada Bahrin, Petaling Banjar (Bangka Regency), Tanjung Gunung (Central Bangka Regency). 87.5 per cent of mothers in Labuh Air Pandan, Jada Bahrin, Petaling Banjar (Bangka Regency), Tanjung Gunung (Central Bangka Regency) answered questions about the meaning of nutritious food correctly. However, 12.5 per cent of mothers correctly answered the question about foods containing iron and 15 per cent of mothers answered the question about carbohydrate substitutes. In fact, 37.5 per cent of *stunted children's* plates contained vegetable rice and egg rice, while 25 per cent contained fish rice. Although the question about the calcium content of formula milk being good for bones was answered correctly by 37.5 per cent of mothers, in practice formula milk was given by 62.5 per cent of mothers in the village, but only 37.5 per cent of children under five were exclusively breastfed. Mothers' knowledge of nutritious food came from their mothers and their experiences in caring for younger siblings or nieces and nephews. Only 4 per cent of mothers of *stunted* children recalled knowledge of nutritious food from school lessons.

Figure 2 (b) should be of concern to village governments to improve the nutrition of *stunted* children. These villages include Tanjung Pura, Kemingking and Belimbing (Central Bangka Regency). Knowledge of nutritious food that must be improved is about protein sources and carbohydrate substitutes. Mothers revealed that even fish has vitamins, so the toddler is fed with rice and vegetables (soup, spinach, taro and sweet potato). Mothers revealed that instant noodles are a carbohydrate substitute that is often consumed by *stunted toddlers* and families.

Figure 2 (c) highlights the knowledge of mothers in Mentawak and Tanjung Batu Itam villages (East Belitung district). Knowledge that needs to be improved is about the importance of calcium content in formula milk for bone growth of toddlers. In practice, mothers in Mentawak Village do not give formula milk to toddlers. When asked about the best carbohydrate substitute for rice, mothers in both villages answered instant noodles. In practice, toddlers are given instant noodles several times as a substitute for carbohydrates and according to mothers, instant noodles are practical to cook and make children eat well.

Figure 2 (d) *shows the* environmental knowledge of mothers in Simpang Yul Village (West Bangka Regency), Bakit Village (West Bangka Regency), Belimbing and Tanjung Pura (Central Bangka Regency). The thing that must be improved in the environment where *stunted* toddlers live on Bangka Island in non-tin mining areas is the practice of garbage disposal, 57.26 per cent of which is done by burning. Only 46.15 per cent of *stunting*

children's homes have complete sewerage (in the toilet, roof, and main drainage), 38.46 per cent have only two sewerage pipes, namely from the toilet and public sewer, and 15.39 per cent do not have sewerage pipes. A total of 52.99 per cent and 55.55 per cent of mothers interpreted a clean and healthy home and environment only as clean and overgrown with trees.

In practice, many homes of *stunting* toddlers are still far from the indicators of a clean and healthy home and environment. There are still many puddles of dirty water in homes and neighbourhoods that can trigger mosquito larvae. Rubbish was found scattered in several gardens and rivers. Mothers understand the importance of ventilation for air circulation but most homes are not equipped with air vents. High knowledge of a clean and healthy environment must be accompanied by the practice of hygiene and the availability of adequate sanitation facilities.

Demirgüç-kunt (2022) revealed that healthy food knowledge is influenced by maternal education, but based on the results of the study, maternal education in the tin mining area of Bangka Island does not affect the nutrition of *stunted* toddlers. Research Badriyah *et al.* (2017) found that maternal hygiene when feeding children also affects *stunting*. Augsburg and Lesmes (2018) revealed the importance of activities to raise awareness of families of *stunted* toddlers to maintain a clean environment, for example starting from equipping proper toilets and good sanitation at home.

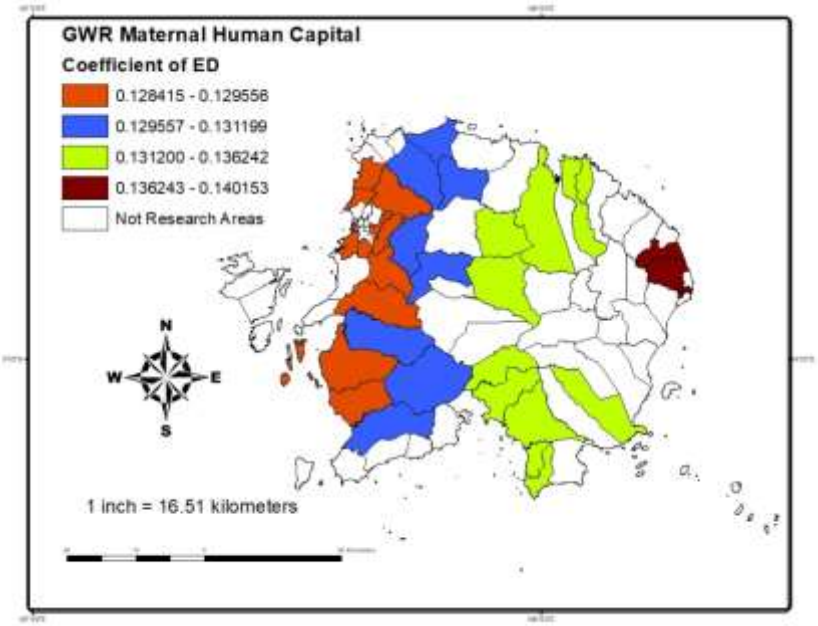


Figure 3. Spatial Distribution of ED Coefficient of Belitung Island Tin minning Area

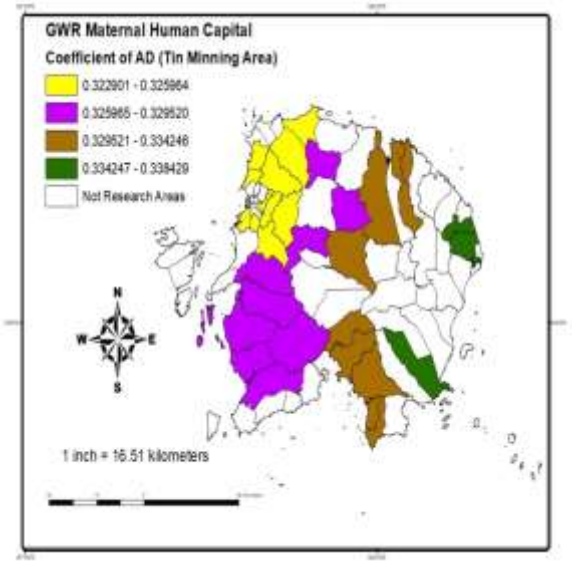
Mothers of stunted toddlers in Limbongan, Buding and Senyubuk villages (East Belitung) did not complete schooling up to junior high school (SMP) level. Mothers expressed the reason for not continuing their schooling due to high school fees, considering the distance from home to school is quite far. There is only one senior secondary school in each sub-district. Although the access road to the school was easy, a vehicle was needed to get there, while there was no public transport in the village. The mother dropped out of school to help earn a living for the family by becoming a palm oil/rubber farm labourer or an IT worker. Currently, the mother is not working because she prefers to take care of her toddler. The family income comes from her father's income as an IT labourer.

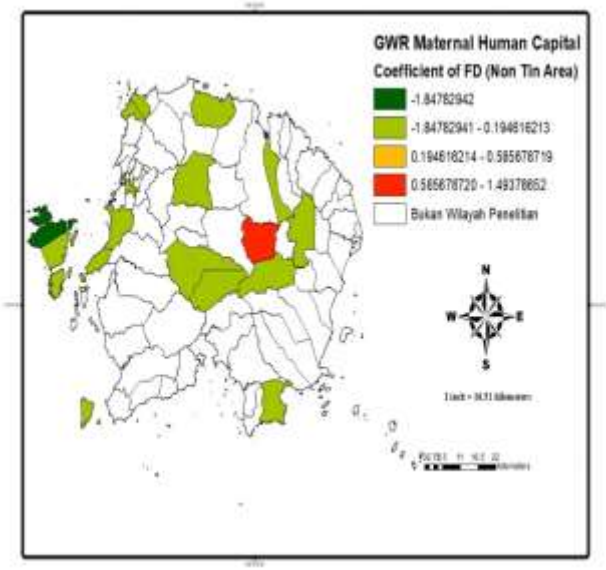
The mother of a toddler was married at 17 years and 18 years old, with the age of her first pregnancy at 18 years and 19 years old. The mother said that during her young pregnancy, she was often sickly, anaemic, and tended to eat less nutritious food. The knowledge of mothers of *stunted* toddlers about pregnancy comes from their mothers, and the experience of taking care of younger siblings and nieces and nephews.

Maternal education affects the nutrition of *stunted* toddlers on Belitung Island in the tin mining area, such as the results of research conducted by Nepal, 2018; Rashad and Sharaf, 2018;Takele *et.al*, 2020; Yaya *et.al*, 2020;

Zegeyeet.*al,* 2020. Figure 3 shows that maternal education affects 12.8415 per cent (0.128415) to 14.0153 per cent (0.140153) of *stunted* toddler nutrition in Belitung Island tin mining area.

The skill variable of diversification of processed agricultural food has a positive effect on the nutrition of *stunted* toddlers on Belitung Island in the tin mining area with a coefficient distribution ranging from 0.322901 (32.39 per cent) to 0.338429 (33.84 per cent) (Figure 4a). Meanwhile, the skill of diversification of processed fish food in the non-tin mining area of Belitung Island has an effect in 11 villages of Belitung Island with the lowest diversification coefficient of 0.3000356 per cent to 0.300526 per cent consisting of the villages of Sungai





Padang (Belitung Regency), Kelubi, Mentawak and Tanjung Batu Itam (East Belitung Regency) (Figure 4b).

(a) (b)

Figure 4a) Spatial Distribution of AD Coefficient of Belitung Island in Tin minning Area; (b) Spatial Distribution of FD Coefficient of Belitung Island in Non Tin minning Area

The explanation in Figure 4(a) is that it is necessary to pay attention to the mother's skills to diversify agricultural food to improve the nutrition of *stunted* toddlers in the villages of Mekar Jaya and Kurnia Jaya (East Belitung Regency) by 33.8145 per cent (0.338145) and 33.8429 per cent (0.338429). Meanwhile, in the villages of Simpang Rusa and Bantan (Belitung Regency) it was 32.7153 per cent (0.327153) and 32.626 per cent (0.32626). Toddlers in all four villages were undernourished while the types of diversification that mothers often gave to toddlers were foods containing carbohydrates and excessive oil, such as fried bakwan, fried banana, pempek gandum and kiping gandum. Mothers in Bantan Village (East Belitung Regency) and Mekar Jaya (Belitung Regency) provide instant noodles as a substitute for rice because it is practical to cook and the price is cheap. Meanwhile, mothers in Simpang Rusa (Belitung Regency) and Kurnia Jaya (East Belitung Regency) prefer sweet potatoes as a substitute for rice because it is free and favoured by children.

Even though mothers diversify agricultural foods, they still allow and give toddlers to snack on salty snacks. Expenditure on snacks for families of *stunted* toddlers in these villages is higher than buying formula milk. Mothers give snacks to toddlers as complementary food, because 90 per cent of *stunted toddlers have* difficulty eating. Mothers in these villages have never received training on diversification of processed fish foods from the government or other agencies. Mothers' knowledge about diversifying agricultural food is obtained from their mothers and other family members.

Agricultural food diversification skills on Belitung Island are unfortunately not included with the empowerment of vegetable cultivation for self-consumption, and can even be processed and sold. Baral *et al.* (2021) revealed that women's sensitivity to utilise home land to grow vegetables and other nutritious agricultural products can help improve family nutrition. Even the results of research Baral *et al.* (2021) empowering women in agriculture can reduce *stunting* when toddlers are aged 6 months to 29 months.

Figure 4(b) Tanjung Batu Itam village (East Belitung Regency) needs attention in improving mothers' skills in diversifying processed fish foods. The *stunted* toddlers in the village are malnourished (z-score 3.67 standard deviations) and the father does not work as a fisherman but as a palm oil labourer with an income of IDR 4,500,000. Fish consumption expenditure was the highest in the family. The *stunted* toddler's plate contained 70 per cent rice and fish. Mothers often replace fish as a source of protein with chicken meat which contains iron. The price of chicken in the village is similar to the price of fish at around Rp35,000 per kg to Rp40,000 per kg. Ibu has never received any training on diversification skills, she learnt to diversify fish by herself based on her previous experience. Therefore, it is better to improve the skills of mothers to diversify fish food through training from the village/kelurahan, district/city/provincial government and other agencies.

Mothers can overcome the high cost of fish consumption by diversifying fish diets, as mothers' diversification skills can provide a great opportunity to fulfil children's food access. (Choudhury *et al.* 2019).. Diversification should be done consistently to address food insecurity (Krauss et al. 2022). (Krauss *et al.* 2022).. Diversifying fish diets empowers and provides sustainability for fishing families (Carpenter, 2012). (Carpenter, 2012).

CONCLUSIONS

The spatial model of maternal human capital on *stunted* under-five nutrition in all villages in the tin-mining and non-tin-mining areas of Bangka Island is food knowledge (positively coefficient on *stunted* under-five nutrition). Environmental knowledge has a negative impact on *stunted under-five nutrition* in non-tin-mining villages on Bangka Island. Meanwhile, maternal education and skills to diversify agricultural food are spatially positively related to the nutrition of *stunted children under five* in all villages in the mining area of Belitung Island. The skill to diversify processed fish food positively affects the nutrition of *stunted children under five* in 10 villages in the non-tin mining area of Belitung Island and negatively in 9 villages. Mothers' skills in diversifying processed fish foods are only positively related to the nutrition of *stunted children under five* in 11 villages in the non-tin-mining areas of Belitung Island. Environmental knowledge and agricultural food diversification skills that are negatively related to the nutrition of *stunted children under five are* not due to parental or maternal education as suggested by Becker (1993a), Demirgüç-kunt (2022), Nepal (2018), Rashad and Sharaf (2018), Takele *et al.* (2020), Yaya *et al.* (2020), Zegeye *et al.* (2020). There needs to be awareness and practice of healthy and clean

environmental care in the home environment of *stunting* toddlers. Increasing agricultural food diversification skills should be carried out by empowering planting agricultural crops in home yards to improve the nutrition of stunting toddlers and families as expressed by Baral *et al.* (2021). Further research on knowing the root of the nutritional problems of *stunting* toddlers throughout Indonesia would be better researched further using the *geographically weighted regression (GWR) method.* This method can see the characteristics of each region and the right policies in alleviating *stunting and* other economic problems.

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