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Modeling of Life Expectancy Index in West Nusa Tenggara Province Using Spatial Panel Regression

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Abstract

One important indicator for evaluating the well-being and standard of living of people in a certain area is the life expectancy index. The goal of this study is to model the lifespan in the Province of NTB (West Nusa Tenggara). The number of impoverished individuals, adjusted per capita spending, and the typical number of years spent in school is the independent variables used. The data came from BPS-Statistics NTB Province and included a panel of ten districts/cities in NTB for the 2019-2023 period. Spatial panel regression was the analytical tevhnique used, leveraging queen contiguity and a specially designed weighted matrix based on transit routes. According to the examination, a) the spatial autoregressive panel model (SARFEM) was chosen as the model to study life expectancy in NTB; b) In one area, life expectancy is directily impacted by the life expectancy of nearby areas ; and c) a region's life expectancy is significantly impacted by its average years of education and modified per capita spending, both of which can raise lifespan in nearby areas. In order to improve general well-being and life expectancy in nearby regions, this link emphasizes the need for policies that give priority to improvements in economic and educational conditions in a spacific area while simultaneosly taking the larger geographic context into consideration.

Keywords: *Life expectancy, panel regression, spatial analysis.*

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1. INTRODUCTION

Assuming that current mortality trends do not change, the Life Expectancy Index (LEI) calculates an individual's average lifespan from birth. LEI serves as a tool for measuring the effectiveness of public health initiatives, focusing on both general welfare and specific aspects of public health. Environmental factors, socioeconomic issues, and health indicators are some of the major elements that affect LEI [1].

LEI is an indicator used to analyze government effectiveness in enhancing public welfare in general, and public health in particular. If a region's LEI is low, health development activities as well as other social programs, such as environmental health, nutrition and calorie provision, and poverty reduction, must be implemented [2]. When the LEI rises, it indicates that the community has improved access to health services, a cleaner environment, and a healthier lifestyle. This growth reflects human attempts to maintain and improve the quality of life, in accordance with God's intended outcome.

The results of the publication of the BPS-Staistics Nusa Tenggara West (NTB) Province show that the AHH of the province NTB has increased from 2019 to 2023. AHH NTB in 2023 reached 72.02 years [3]. This increase indicates enhancements in health services and the quality of life within the NTB community, which continues to encounter obstacles in achieving a higher national standard. Despite the annual increase in the LEI of NTB province, its 2023 level remains comparatively low on a national scale, ranking as the tenth lowest among 38 provinces in Indonesia [4]. This position highlights the ongoing necessity for specific interventions and policies to improve health services and living conditions in NTB. Addressing these challenges may enable the province to enhance its ranking and more effectively fulfill the needs of its residents. This situation has generated interest among researchers in examining the factors that affect LEI in NTB. Previous researchers have extensively studied the factors that influence LEI. Tanadjaja [5] identified factors that influence LEI in each district/city in Papua using the Geographical Weighted Regression method. The analysis's findings showed that the proportion of midwives per 10,000 people, the projected duration of education, duration of breastfeeding, and the availability of homes utilizing clean water to drink sources were the main factors impacting LEI in each Papuan district or city. Ramadhani et al. [1] analyzed the factors that influence LEI on the island of Sumatera in 2018 using spatial regression analysis for the regional approach. The analysis's findings showed that the percentage among toddlers who are undernoursihed, the percentage of towns with enough midwives per 1,000 residents, the percentage of homes having access to sanitary facilities, the proportion of the populace living the rate of illiteracy in poverty those 15 years of age and older, and he mean number of years of education were the factors that had the biggest spatial effects on. Using a weighted panel regression geographic model, Muliana [6] demonstrated that the percentage of households with proper drinking water sources, the percentage of households with proper sanitation, the percentage of the poor population, the mean years of schooling, and per capita expenditure all significantly affect LEI in South Sulawesi province. years and beyond, as well as the typical school years.

The percentage of households with a source of clean drinking water (AML), the percentage of households with decent housing (HL), the percentage of households with access to decent sanitation (ASL), the percentage of poor people (PPM), and the mean years of schooling (MYS) were all factors that Septianingsih [7] examined using the panel data regression method in order to determine the factors that affect life expectancy in Indonesia. According to the analysis's findings, life expectancy was significantly impacted by three independent variables: average years of education (MYS), the quantity of impoversihed people (NPP), and access to decent sanitation (ASL). Astuti et al. [6] used panel regression to examine LEI in NTB from 2011 to 2020 utilizing the variables of mean years of education, adjusted per capita expenditure, and the number of impoverished individuals. The study's findings partially demonstrate that in NTB province, LEI is significantly impacted by adjusted per capita expenditure and mean years of education. In the meantime, LEI is not significantly impacted by the number of impoverished individuals. In NTB province, the number of impoverished people, adjusted per capita spending as well as mean years of education all significantly impact LEI at the same time.

Previous studies have discussed LEI using panel regression and spatial regression methods. Panel regression excels in studying dynamic changes; it can measure unobservable influences on cross-sectional data. It can avoid multicollinearity problems and overcome the issue of lacking degrees of freedom in both section and time series data [9]–[12]. Spatial regression has the advantage of being able to reveal information about the total, indirect, and direct impacts of independent variables [13]–[16]. Studies that examine LEI by combining panel regression and spatial regression methods, namely spatial panel regression, have not been conducted by previous researchers. Therefore, this study uses spatial panel regression to model LEI in NTB Province. The study aims to understand the relationship between variables that affect LEI in detail, not only considering the time and individual observations but also the effects of observation locations.

This research utilizes the factors employed by Astuti et al. [8]. Nonetheless, it varies in the year of observation and the analytical methodology. The observation period for this study encompassed the years 2019 to 2023 for all variables. The employed analytical method was spatial panel regression. The selection of independent variables and the year of observation in this study was also influenced by the availability of data from BPS-Statistics NTB. The purpose of this study is to use a spatial panel regression approach to model the lifespan index (LEI) in the Proince of West Nusa Tenggara.

2. RESEARCH METHODS

2.1. Source of data

Secondary information from the BPS-Statistics NTB Province website is used in this study. The dataset comprises a panel featuring observation units from 10 districts and cities within the province of NTB, spanning the years 2019 to 2023.

2.2. Research Variables

Table 1 outlines the research variables employed in the modeling of the life expectancy index. Figure 1 illustrates the design of the variables.

Table 1. Research Variables

Variables	Unit	Code
Life Expectancy Index	Year	Y
Average Year of Education	Year	X_1
Number of Poor People	Soul	X_2
Per Capita Adjusted Spending	Million Rupiah	X_3

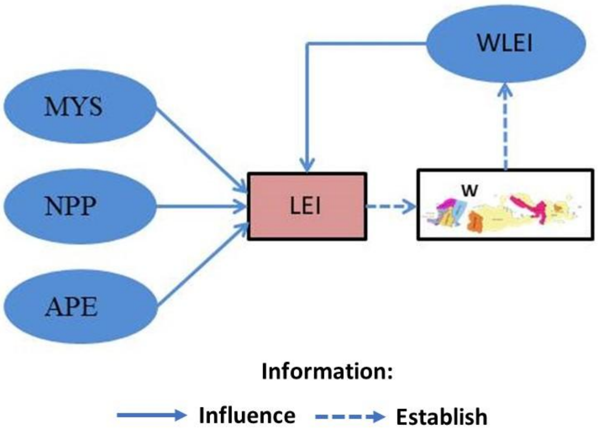


Figure 1. Design of Research

2.3. Sampling Techniques

Sampling method in this study used purposive sampling technique.

2.4. Data collection technique

Documentation approaches are used in this study's data collection method. This documentation technique aims to obtain data and information from various sources, such as: documents, archives, journals, or websites related to the research [17].

2.5. Data Analysis Methods

Panel data modeling by considering spatial effects is divided into three types, namely: spatial autoregressive panel models (SARPM), spatial Durbin panel models (SDPM), and spatial error panel models (SEPM) [16]. SARPM examines the spatial influence on the dependent variable. SDPM combines the spatial effects of the dependent and independent variables, thus capturing more complex indirect effects (spillovers) between spatial units. SEPM examines the spatial effects on error components. These three models generally consider individual-specific effects, both fixed effects and random effects, to capture heterogeneity between units in panel data. Equation 1 is SARPM. Equation 2 is SDPM. Equation 3 is SPEM.

$$Y_{it} = \rho \sum_{J=1}^{N} W_{ij} Y_{jt} + \beta_1 X_{1it} + \beta_2 X_{2it} + \cdots + \beta_K X_{Kit} + \mu_{it} \tag{1}$$

$$Y_{it} = \rho \sum_{J=1}^{N} W_{ij} Y_{jt} + \beta_1 X_{1it} + \beta_2 X_{2it} + \cdots + \beta_K X_{Kit} + \tau_1 W_{ij} X_{1jt} + \tau_2 W_{ij} X_{2jt} + \cdots + \tau_K W_{ij} X_{Kjt} + \mu_{it} \tag{2}$$

$$Y_{it} = \beta_1 X_{1it} + \beta_2 X_{2it} + \cdots + \beta_K X_{Kit} + \omega_{it}, \text{with } \omega_{it} = \lambda \sum_{J=1}^{N} W_{ij} \varepsilon_{it} + \mu_{it} \tag{3}$$

where

Y_{it} is the variable that is indpendent on for the i-th individual $i$at time i $t$with $i = 1,2,3, \dots, N$ and $t = 1,2,3, \dots, T$. The number of people or observations is N. The number of observation times is denoted by T. The spatial autoregressive coefficient is denoted by ρ. The spatial weighting matrix is W_{ij}. For the p-th individual at time ti, X_{pit} is the i-th independent variable. With p = 1,2,… K, where K is the number of independent variables, the coefficients for the independent variables are denoted by β_p. The spatial Durbin coefficient is denoted by τ. The error for the i-th person i at time t is denoted by μ_{it}.

2.6. Analysis Stages

The data is processed using R software. The analysis steps in this study includes: determine the level of significance, $\boldsymbol{\alpha} = \mathbf{5\%} = \mathbf{0.05}$; analyzing the relationship between variables; Using the panel regression approach to estimate parameters; Choosing a panel model by applying the Lagrange Multiplier, Hausman, and Chow tests; identifying the spatial weighting matrix (W), specifically the tailored weighted matrix based on transit routes and the queen contiguity weighted matrix; identifying the spatial regression model by performing a spatial dependency test using the Lagrange Multiplier and Moran Index tests; use the spatial panel regression approach to estimate parameters; calculating each geographic panel model's loglikelihood value, selecting the optimal model based on its smallest loglikelihood value, and analyzing the analysis's findings.

3. RESULTS AND DISCUSSION

3.1. Data Exploration

The first stage in modeling life expectancy index in NTB is to conduct data exploration. The results of data exploration are displayed in Table 2.

Table 2. Characteristics of Research Variables

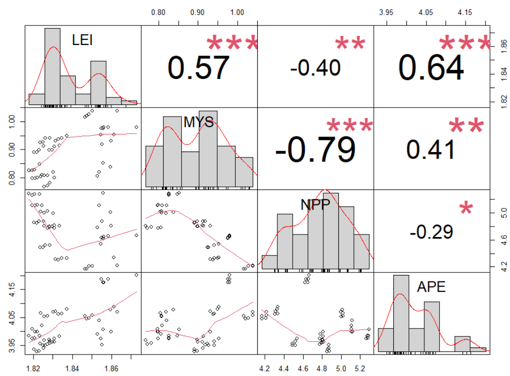
Variables	Statistics			
	Max.	Min.	Average	Standard Deviation
LEI	74.65	65.74	68.73	2.46
MYS	10.95	5.84	7.96	1.45
NPP	197,630	14,660	73,556	73,556
APE	15.890	8.468	10.655	10.55

The average life expectancy index for the NTB province from 2019 to 2023 stands at 68.73 years. The maximum LEI attains 74.65 years, whereas the minimum value stands at 65.74 years. The average duration of formal education in the NTB province over the specified timeframe stands at 7.96 years. The maximum MYS attains 10.95 years, while the minimum value is recorded at 5.84 years. The population of individuals living in poverty within NTB province averages 73,556, with a peak of 196,630 and a low of 14,660. The per capita expenditure for the NTB province has been adjusted to reflect an average of IDR 10,655,000. The upper limit attains IDR 15,890,000, whereas the lower limit stands at IDR 8,468,000.

3.2. Inferential Analysis Results

3.2.1 Analysis of Relationships Between Variables

The correlation analysis between variables in this study and its significance are ilustrated in Figure 2.



*** significant at α = 0%, ** significant at α = 1%, * significant at α = 5%

Figure 2. Scatter Plot of the Matrix of Relationships between Variables

Source: The image is processed utilizing R Software

Figure 2 shows, as a scatter plot, the findings of the correlation study between life expectancy, average years of education, the number of impoverished individuals, and modified per capita spending. The diagonal and lower triangle of the scatter plot display the distribution of each variable. The upper triangle displays the Pearson correlation coefficient value along with its level of significance. The index of life expectancy and the mean number of years of education are significantly correlated, as indicated by the Pearson correlation coefficient value of 0.57. This indicates that the life expectancy index is positively and significantly impacted by the average number of years of education. The lifespan index rises as the mean number of years spent in education increases. The Pearson correlation coefficient value of the number of poor people to the life expectancy index is -0.40, which is significant at $\alpha = 0\%$. This indicates that the life expectancy index is significantly and negatively impacted by the number of individuals living in poverty. The life expectancy index decreases as the number of impoverished individuals increases. The adjusted per capita spending variable and the life expectancy index have a significant Pearson correlation coefficient of 0.41 at $\alpha = 0\%$.. This figure indicates that the life expectancy index is positively and significantly impacted by adjusted per capita expenditure. The life expectancy index tends to rise in proportion to the adjusted per capita spending.

3.2.2 Panel Regression Analysis

The next step, following the examination of variable relationships, aims to use panel regression to estimate the parameters for REM, FEM, and CEM are models of random, fixed, and common effects, respectively. To distinguish between CEM and FEM, the author uses the Chow test; to distinguish between FEM and REM, the Hausman test; and to distinguish between CEM and REM, the Breusch-Pagan test. Table 3 shows the results of the examination.

Table 3. Panel model selection

Test	Statistics	p-value	Decision
Chow	10.99	0.000	FEM
Hausman	105.27	0.000	FEM
Breusch Pagan	135.73	0.000	REM

According to Table 3, the p-value is 0.000 and the Chow test value is 10.999. This suggests that FEM performs better than CEM. The Breusch-Pagan test statistic is 135.73, accompanied by a p-value of 0.000. This suggests that REM performs better than CEM. The value of the Hausman test is 105.27, accompanied by a p-value of 0.000. This result implies that FEM performs better than REM. As a result, the Fixed Effects Model (FEM) is the best panel effect model for examining the life expectancy index of NTB Province. Table 4 presents the outcomes of parameter estimation for FEM.

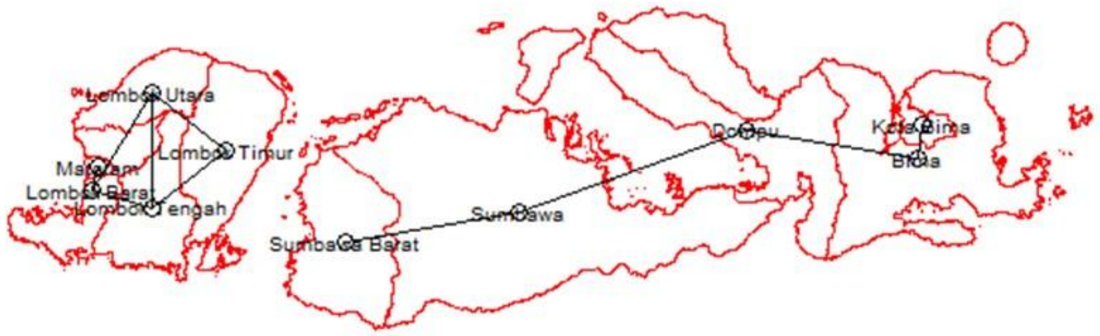
Table 4. Results of fixed effect model parameter estimation

Variables	Estimate	p-value
MYS	0.427	0.003
NPP	0.026	0.723
APE	0.526	0.000

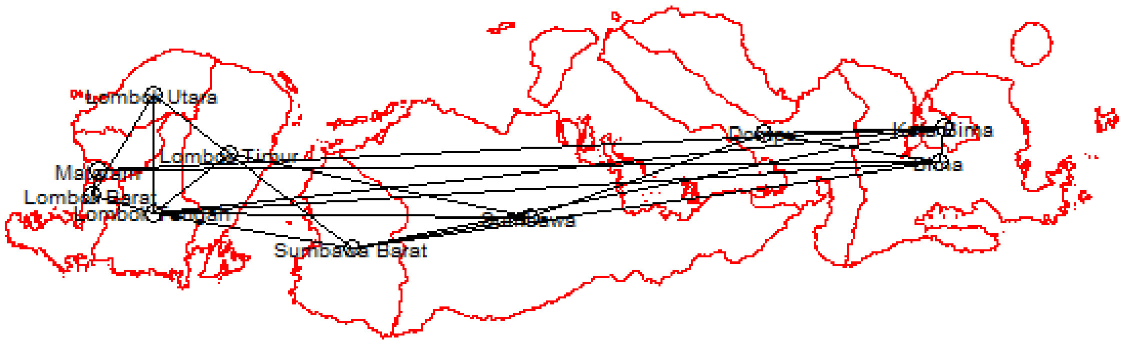
Table 4 informs that the p-value for the variable mean years of schooling is 0.003 and for the variable adjusted per capita expenditure is 0.000. Both variables' p-values are below the significance level of α = 0.01 = 1%. This indicates that the life expectancy index is positively and significantly impacted by the average number of years of education and adjusted per capita spending. Meanwhile, because the p-value is higher than the designated significance level, the number of poor people has no discernible impact on the life expectancy index.

3.2.3 Spatial Weighted Matrix

Queen's contiguity matrix and customized weight matrix are used to examine spatial influences between regions [11]. The queen matrix was chosen because it reflects the interconnectedness between regions that are directly adjacent geographically, such as North Lombok and West Lombok Regencies. Meanwhile, the customized weighted matrix is compiled based on socio-economic connectivity, including land, sea, and air transportation routes, so that it includes regions that are not directly adjacent but have socio-economic relationships, which is visible in Figure 3.



(a)



(b)

Figure 3. **Spatial Weighted Matrix: (a) Queen Contiguity, (b) Customized (Transportation Route).**

Source: The image is processed utilizing R Software

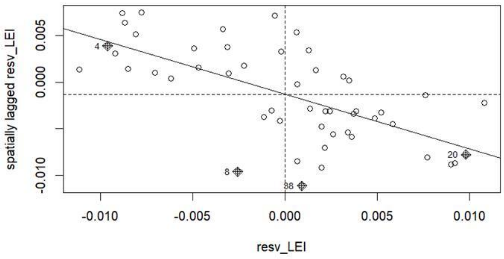
3.2.4 Spatial Dependence Test

The Lagrange Multiplier (LM) and Moran's I tests are used to determine if a regression model has spatial dependency, or attachment. Moran's I test shows the presence of global or overall spatial dependence. Spatial dependence on dependent variables (SAR and SDM) or model errors (SEM) is detected through the LM test.

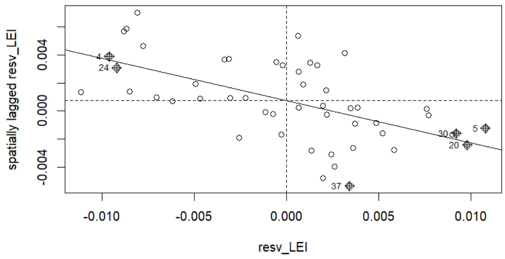
Table 5. **Results of the Spatial Dependence Test.**

Statistics	Queen Contiguity		Customized	
	Estimate	p-value	Estimate	p-value
Moran's I	-0.587	0.000	-0.303	0.006
LM1 (SEM)	-0.628	1,470	-0.628	1,470
LM2 (SAR or SDM)	6,964	0.000	5,170	0.000

The Moran's I values in the *Queen contiguity* and *Customized matrices* are -0.587 and -0.303, respectively. Both have p-values below the significance level of α=1%. Thus, there is a globally significant spatial dependence, both for *the Queen contiguity* and *Customized matrices*. This indicates that a district's or city's life expectancy is correlated with that of its neighboring districts or cities. The scatterplot of Moran's is visible in **Figure 4**.



(a)



(b)

Figure 4. Moran's I Scatterplot: (a) Queen Contiguity, (b) Customized

Source: The image is processed utilizing R Software

Figure 4 is a Moran's I scatterplot based on Queen and Customized weighting matrices. In **Figures 4(a)** and **4(b)**, a decreasing regression line pattern is seen, indicating negative spatial autocorrelation, namely: districts/cities with high residual values tend to be neighbors with districts/cities with low residuals, or vice versa. The case for analyzing life expectancy in West Nusa Tenggara using a geographic panel model technique is strengthened by this visualization.

3.2.5 Spatial Panel Regression Model

The spatial autoregressive fixed effect model (SARFEM) is the outcome of merging the fixed effect model and the spatial autoregressive model (SAR). Conversely, the spatial durbin fixed effect model (SDFEM) is the result of combining the fixed effect model with the spatial durbin model (SDM). The results of parameter estimation from SARFEM and SDFEM with the spatial panel regression method for the queen contiguity and customized weighted matrices are displayed in **Table 6**.

Table 6. Estimation results of the SARFEM and SDFEM.

Variables	SARFEM				SDFEM			
	Queen		Customized		Queen		Customized	
	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
WLEI (ρ)	0. 641	0.000	0. 806	0.000	0.347	0.002	-0.213	0.274
MYS	0.468	0.000	0.370	0.000	0.341	0.000	0.194	0.000
NPP	0.051	0.271	0.024	0.681	-0.022	0.599	-0.039	0.159
APE	0.302	0.006	0.215	0.078	0.675	0.000	0.861	0.000
WMYS	-	-	-	-	0.120	0.000	0.226	0.000
WNPP	-	-	-	-	0.031	0.000	0.057	0.000
WAPE	-	-	-	-	-0.013	0.357	-0.073	0.000
Loglikelihood	178.226		183.614		201.773		188.804	

Table 6 explains that the SARFEM model with the queen contiguity weighting matrix has the smallest loglikelihood value. Therefore, the model used to model the life expectancy in West Nusa Tenggara is SARFEM, which is written in **Equation (4)**.

$$\widehat{LEI}_{it} = 0.641 \sum_{J=1}^{N} W_{ij} LEI_{jt} + 0.468 MYS_{it} + 0.051 NPP_{it} + 0.302 APE_{it} \tag{4}$$

The spatial lag coefficient value (ρ) on life expectancy shows a positive value with p-value = 0.000. This indicates that the spatial autocorrelation is significantly positive. This indicates that the life expectancy in a city or district is directly impacted by the life expectancy in the nearby, geographically close districts or cities. For example, West Lombok Regency is geographically close to the city of Mataram. If life expectancy in the city of Mataram is high, then life expectancy in West Lombok Regency will also increase, or vice versa.

Mínguez et al. **[17]** and Kopczewska **[18]** asserted that the interpretation of parameter coefficients in spatial panel regression differs from that in ordinary regression. Marginal effects—more especially, direct and indirect effects—are used to measure how significant changes in independent variables affect the dependent variable. **Table 7** shows the marginal effects of adjusted per capita spending and the average number of years of education.

Table 7. The Marginal Effects of Independent Variables

Variables	Direct Effects	Indirect Effects	Total Effect
MYS	0.629	0.679	1.308
NPP	0.406	0.438	0.844

According to **Table 7**, a district or city's life expectancy can rise by 0.629 years for every year that the mean number of years of education in that district or city increases. Indirectly, life expectancy in the nearby districts and cities will rise by 0.679 years if the average number of years of education in a district or city increases by one year. This study is consistent with Febiola et al.'s research **[21].** Mean years of schooling reflects the level of education attained by the population in a region. An increase in the mean years of schooling indicates that people have better access to formal education, which has a direct impact on life expectancy index. More educated people tend to have a better understanding of healthy lifestyles and utilize health services effectively, which ultimately determines quality of life and longevity.

An increase in adjusted per capita expenditure of one million rupiah in a district/city can directly increase life expectancy by 0.406 years in that district/city. If adjusted per capita expenditure in a district/city increases by one million rupiah, then indirectly life expectancy in districts/cities adjacent to the observed district/city will increase by 0.438 years. For example, Sumbawa Regency is geographically adjacent to Dompu Regency. If adjusted per capita expenditure in Sumbawa Regency increases by one million rupiah, then life expectancy in Dompu Regency will increase by 0.438 years. The findings of this investigation are consistent with those of the Nurhayati and Wulandari [22] study. Increase Power buy individuals enable better access to basic needs that support health and well-being, such as health services, nutrition, and a healthy living environment. Spending more money allows people to live in safer and cleaner surroundings with access to sanitary facilities and clean water, which lowers the risk of illness and can promote health over time.

4. CONCLUSION

The findings of the analysis show that: a) the selected spatial panel model for the lifespan the spatial autoregressive panel model (SARFEM) in NTB, b) a region's life expectancy is directly affected by the life expectancy index of geographically neighboring areas, c) a region's life expectancy of life index is greatly influenced by its adjusted per capita income and mean years of education, which can subsequently raise the quality of life index in nearby areas. This connection emphasizes the need to implement laws that give priority to enhancements between economic circumstances and education within a single place while also considering the broarder geographic background. By improving these qualities, regions can create a ripple effect that enhances overall well-being and life expectancy in adjacent areas. Employing a spatial methodology to analyze life expectancy is essential for formulating equitable and efficient development strategies that address local requirements in NTB. Consequently, further researchers are anticipated to examine illiteracy rates employing alternative weighting matrices, specifically k-nearest neighbor and inverse distance. Moreover, subsequent researchers may employ non-linear regression techniques. This finding is substantiated by the correlation scatterplot matrix, which reveals a propensity for a non-linear connection between life expectancy and the independent factors.

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Author Contributions Statement

Table 8. The Author's Contribution

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Baiq Nurul Apriana	✓	✓	✓		✓	✓		✓	✓		✓		✓	✓
Alfira Mulya Astuti		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		
Fadrik Adi Fahrudin				✓			✓			✓		✓		

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict Of Interest Statement

Authors state no conflict of interest.

Informed Consent

Not available.

Ethical Approval

Not available.

Data Availability

The data that support the findings of this study are available on request from the corresponding author, AMA.

REFERENCES

[1] E. Ramadhani, N. Salwa, and S. Mazaya, "Identifikasi Faktor-Faktor yang Memengaruhi Angka Harapan Hidup di Sumatera Tahun 2018 Menggunakan Analisis Regresi Spasial Pendekatan Area," *Journal of Data Analysis*, vol. 3, no. 2, pp. 62–75, 2020.

[2] E. O. Resa and R. Aprirachman, "Analysis Of Factors Influencing Life Expectation Of West Nusa Tenggara Province," *J. Nusant. Econ. Sci.*, vol. 1, no. 3, pp. 105–112, 2023.

[3] BPS-Statistics NTB Province. 2025, *Nusa Tenggara Barat in Figures 2025*, vol. 45, 2025. [Online]. Available: https://ntb.bps.go.id/id/publication/2025/02/28/048c7d97797e293fa3af75b1/nusa-tenggara-barat-province-in-figures-2025.html

[4] BPS-Statistics Indonesia, *Indeks Pembangunan Manusia 2023*, vol. 18, 2024.

[5] A. Tanadjaja, "Pemodelan Angka Harapan Hidup di Papua dengan Pendekatan Geographically Weighted Regression," Institut Teknologi Sepuluh Nopember, 2017.

[6] Muliana, "Pemodelan Geographically Weighted Panel Regression Pada Data Angka Harapan Hidup Di Provinsi Sulawesi Selatan Muliana Pemodelan Geographically Weighted Panel Regression Pada Data Angka Harapan Hidup," Universitas Hasanudin, 2023.

[7] A. Septianingsih, "Pemodelan Data Panel Menggunakan Random Effect Model Untuk Mengetahui Faktor Yang Mempengaruhi Umur Harapan Hidup Di Indonesia," *J. Lebesgue J. Ilmu Pendidikan Matematika, Matematika, dan Statistika.*, vol. 3, no. 3, pp. 525–536, 2022, doi: 10.46306/lb.v3i3.163.

[8] A. M. Astuti, E. S. Ashri, and S. Sabri, "Modeling Life Expectancy Index in West Nusa Tenggara Province with Panel Regression Method," *Inferensi*, vol. 7, no. 1, p. 53, 2024, doi: 10.12962/j27213862.v7i1.20148.

[9] A. M. Astuti, "Fixed Effect Model Pada Regresi Data panel," *Beta J. Tadris Mat.*, vol. 3, no. 2, pp. 134–145, 2010.

[10] B. Baltagi, *Econometric analysis of panel data*. 2021.

[11] L. O. Alviani, E. Kurniati, and F. H. Badruzzaman, "Penggunaan Regresi Data Panel pada Analisis Indeks Pembangunan Manusia," *J. Ris. Mat.*, vol. 1, no. 2, pp. 99–108, 2021, doi: 10.29313/jrm.v1i2.373.

[12] D. N. Gujarati, *Essentials of Econometrics*, The SAGE: Los Angles. 2022.

[13] A. M. Astuti, Setiawan, I. Zain, and J. D. T. Purnomo, "A Review of Panel Data on Spatial Econometrics Models," *J. Phys. Conf. Ser.*, vol. 1490, no. 1, 2020, doi: 10.1088/1742-6596/1490/1/012032.

[14] A. M. Astuti, Setiawan, I. Zain, and J. D. T. Purnomo, "The extended algorithm for quasi maximum likelihood parameter estimation," *AIP Conf. Proc.*, vol. 2360, no. September, 2021, doi: 10.1063/5.0059509.

[15] A. M. Astuti, Setiawan, I. Zain, and J. D. T. Purnomo, "A modified generalized estimating equation approach for simultaneous spatial durbin panel model: Case study of economic growth in ASEAN countries," *Decision Science Letter*, vol. 12, no. 2, pp. 369–388, 2023, doi: 10.5267/j.dsl.2023.1.001.

[16] A. M. Astuti, Afifurrahman, and H. R. P. Negara, "Analysis of Human Development Index in West Nusa Tenggara Province with Spatial Panel Model," *International Journal of Computing Science and Applied Mathematics*, vol. 10, no. 2, pp. 113-118, 2024, doi: 10.12962/j24775401.v10i2.21957.

[17] L. N. I. Sari and W. D. Warsitasari, "Pengaruh Tingkat Partisipasi Sekolah, Tingkat Partisipasi Angkatan Kerja dan Angka Harapan Hidup terhadap Indeks Pembangunan Manusia (IPM) Di Provinsi Papua Tahun 2018-2021," *J. Ekon. Manajemen, Akunt. dan Perbank. Syari'ah*, vol. 12, no. 1, pp. 390–405, 2023.

[18] J. P. Elhorst, *Spatial Econometrics From Cross-Sectional Data to Spatial Panels*. 2014.

[19] R. Mínguez, R. Basile, and M. Durbán, "An introduction to pspatreg. A new R package for

semiparametric spatial autoregressive analysis," *Region*, vol. 9, no. 2, pp. R1–R15, 2022, doi: 10.18335/region.v9i2.450.

[20] K. Kopczewska, *Applied Spatial Statistics and Econometrics: Data Analysis in R*. London, 2021.

[21] A. Febiola, R. A. Lusia, and Y. S. Jaya, "Pengaruh Rata-Rata Lama Sekolah Dan Angka Stunting Terhadap Tingkat Harapan Hidup Pada Kabupaten Bangka Barat," *Proc. …*, pp. 75–79, 2021, [Online]. Available: https://www.journal.ubb.ac.id/index.php/snppm/article/download/3693/1993

[22] E. Wulandari and Siti Nurhayati, "Determinan Umur Harapan Hidup Di Indonesia," *J. Ekon. Trisakti*, vol. 4, no. 1, pp. 217–224, 2024, doi: 10.25105/jet.v4i1.18676.