Analysis of Human Development Index in West Nusa Tenggara Province with Spatial Panel Model

Alfira Mulya Astuti, Afifurrahman, and Habibi Ratu Perwira Negara

***Abstract*—The purpose of this article is to examine the factors that influence the human development index (HDI) in West Nusa Tenggara using a spatial panel model. This research is crucial because it can analyze correlations between regions and is more efficient, informative, and effective in HDI modeling. The data structure is panel data, where observation units are the cities and regencies in West Nusa Tenggara Province for 2010 to 2022. A human development index serves as the dependent variable. The independent variables were per capita expenditure, average length of school, length of school expectations, and life expectancy. The Rook contiguity and the customized matrix (transportation routes) are used to examine geographical impacts. The results of the analysis indicate: 1) there are spatial linkages between districts and cities in West Nusa Tenggara; 2) the SAR Fixed Effect model is the most appropriate spatial model to model the human development index; 3) the human development index can be improved simultaneously by factors such as life expectancy, expected length of schooling, average length of schooling, and per capita expenditure; and 4) life expectancy is the main factor affecting the human development index.**

Keywords: Spatial Analysis, Human Development Index, Panel Data.

I. Introduction

HUMAN Human development can be defined as a series of phases or actions taken to elevate the quality of human existence. The United Nations Development Programme (UNDP) establishes four main elements in human development, namely equity, productivity, empowerment, and sustainability [1]. High economic growth cannot always alleviate social issues like poverty and the general level of living. Thus, one indicator that requires attention is human development. The measurement of human development progress refers to the methods developed or popularized by UNDP, namely: Human Development Index or HDI [2].

Badan Pusat Statistik (BPS) defines that HDI is a statistical measure used to measure the progress and quality of life of people in a country or region based on three indicators, namely, health, education, and decent standard of living [3]. By considering these indicators, HDI can provide a more comprehensive picture of a country's progress in improving the quality of life of its people. HDI provides guidance for governments in designing more effective development policies, identifying social gaps, and directing efforts to improve overall quality of life.

A. M. Astuti, Afifurrahman, H. R. P. Negara are with the Universitas Islam Negeri Mataram, Gajah Mada Street, Mataram 83116, Indonesia e-mail: alfiramulyastuti@uinmataram.ac.id

Manuscript received July 18, 2023; accepted September 14, 2023.

One of the provinces aiming to raise the HDI value is West Nusa Tenggara (NTB). According to BPS of West Nusa Tenggara province, HDI of West Nusa Tenggara tends to increase [3]. Despite the increase every year, the HDI is still in the 29th position out of 34 provinces, which shows that West Nusa Tenggara province is in the category of the five lowest provinces in Indonesia in 2022.

There are several researchers who have studied the human development index of West Nusa Tenggara Province. Rayes [4] examined the human development index of West Nusa Tenggara using panel data for 2013–2017. Sapurah et al [5] studied the HDI of West Nusa Tenggara province using the fixed effect panel method for 2010–2017. Pramuja et al [6] studied the HDI of West Nusa Tenggara with the First Dif-ference Generalized Method of Moment (FDGMM) method for 2016 – 2020. Rayes [4], Sapurah et al [5], and Pramuja [6] used panel data structure. The benefits of using panel data are that the data is more informative, diverse, efficient, and able to measure effects that cannot be observed with pure cross-section data and pure time series [7] [8] [9]. They have not discussed spatial effects in their studies.

The spatial effect of a model is characterized by the presence of a weighted matrix (W) in the model and is first applied using cross section data [10] [11]. The advantage of spatial models is that they provide information about the direct, indirect, and total effects of independent variables [8] [12] [13]. Therefore, to complement the previous study, spatial effect studies need to be added to the study of human growth index in West Nusa Tenggara. This is because West Nusa Tenggara is a province consisting of 8 regencies and 2 cities that are connected to each other.

The purpose of this article is to examine the factors that influence the human development index in West Nusa Tenggara using a spatial panel model. There are 2 main differences from this study compared to previous studies. First, the analysis model used is the spatial panel model. Second, the observation time interval is 2010-2022.

In this study, we used 2 spatial weighted matrices. It aims to compare the performance of each spatial weighted matrix in modeling the human development index in West Nusa Tenggara and find out the factors that influence it based on the best model. The results of this analysis are expected to assist local governments in determin-ing policies related to the human development index.

The discussion flow begins by presenting the reasons for modeling the human development index with the spatial panel model, describing the spatial panel model in Section 2, discussing the factors affecting the human development index in West Nusa Tenggara for 2010-2022 based on the model selected in Section 3, concluding and presenting recommendations for the next article in Section 4.

II. Material and Methods

A. Human Development Index

The Human Development Index (HDI) measures the degree to which human development has had a positive influence on both people's physical (health and well-being) and non-physical (education) situations [2]. The UNDP defines human development as the process of giving people more choices in terms of their income, health, education, physical environment, and other factors. Longevity and healthy living (long life and health), knowledge, and living standards are the three funda-mental qualities that BPS [3] claims should be used as the benchmark for assessing the Human Development Index. According to Stanton [14], the HDI combines the human proxy for three fundamental abilities: health, education, and a respectable standard of life. It is a measure of human growth. A measurement of health is life expectancy (LE). School enrolment (ENR) and literacy (LIT) are used as education metrics. The education (E) index is created by adding together the literacy and school enrolment indices to get a weighted average. A measure of living standards is GDP per capita (Y). The fundamental idea of human evolution, in Harrison's view [15], is measuring three dimensions. The first is for people to live long and healthy lives; the second is for people to learn; and the third is for people to have access to the resources required for a respectable level of living. The unweighted average of the components of the life expectancy index, the index of educational achievement component, and the real per capita GDP index component (PPP $) is the HDI of a nation. HDI is divided into three categories by UNDP: low (HDI less than 50), low-medium (HCI between 50 and 65.99), upper-medium (HMI between 66 and 79.99), and high (HDI 80 and higher). Lower-middle class (lower-medium) to medium-top (upper-medium) socioeconomic status are included in Indonesia's regional HDI. The population's capacity to absorb and manage the sources of economic growth will be determined by the level of human development. A key component of achieving economic growth is having strong links with or against institutional technology [16].

B. Panel Data Model

Panel data combines cross-sectional and time-series data. Crosssectional data are gathered for multiple sample units simultaneously, whereas time-series data are gathered over time [17]. When using panel data, there is a difference in the coefficients for each crosssectional unit's slope and intercept [17]. The panel data regression model is generally written as shown in eq1 [7].

$$y_{it} = \mu + x_{it}\beta + u_{it} \tag{1}$$

$i = 1,2,\cdots,n$ and $t = 1,2,\cdots,T$, where subscript i represents the cross-sectional unit, t represents the time-series dimension, y_{it} is the dependent variable for the $i-$th cross-sectional unit and the $t-$th period, μ is the scalar or constant (intercept), x_{it} is the independent variable for the $i-$th crosssectional units and the $j-$th period, β is the $K \times 1$ parameter vector, K is the number of independent variables, and u_{it} is the error component [7].

The error component in panel data regression consists of a general component and a specific component. The general error component (ε_{it}) is the error for the $i-$th individual and the $t-$th period. The specific error component consists of an unobserved individual-specific effect (v_i) and an unobserved time-specific effect or λ_t [18]. The error component in the panel-data regression model is expressed as follows:

$$u_{it} = v_i + \lambda_t + \varepsilon_{it}, \tag{2}$$

Based on the error component, the model for the panel data consisted of one-way and two-way error component models. A model in which there are only an individual-specific effects or a time-specific effects is called a one-way error component model. The panel data model consisting of these two specific effects is called a two-way error component model. Based on the parameter estimation method, there are three model approaches that are commonly used for parameter estimation in panel data regression: pooled effect, fixed effect, and random effect models [18]. The selection of the research object can be used as a determinant to determine the effect of the panel on the model. The fixed-effect model is the right model if the researcher chooses the object. Meanwhile, if the object is chosen randomly from the population, the random-effects model is the right model to use [17]. This study focused on a fixed-effect model with a one-way error component. This was because the object was chosen by the researcher. This can be expressed as follows [18].

$$y_{it} = \mu + v_i + x_{it}\beta + \varepsilon_{it}, \tag{3}$$

C. Spatial Econometrics Model

A spatial model is a statistical model related to the geographical conditions of the observation location [19]. The spatial econometrics model is aimed at data in the economic field that contains regional (geographical) elements. In this case, it is related to spatial dependency and regional heterogeneity. Spatial dependency or spatial autocorrelation describes the dependencies between regions. Spatial heterogeneity or spatial structure describes the diversity/variation of the model for each region [20].

Spatial dependency testing is the early detection of spatial dependencies in each model. Two popular tests are used to assess spatial effects: the Moran's I test and the Lagrange multiplier (LM) test [19]. The Lagrange multiplier test presents more detailed results than Moran's index test. This is because the LM test can detect the location of the spatial dependence that occurs, spatial lag or spatial error. Both methods were applied to test the spatial effects of the model.

Spatial Autoregressive Model. A model that incorporates a simple regression model with a spatial lag on the dependent variable using cross-sectional data is called the spatial autoregressive (SAR) or spatial lag model [19]. The SAR model requires the spatial effect to be on the dependent variable. The spatial effect is represented by the matrix $\mathbf{W}$. eq4 is the general form of SAR.

$$y_i = \rho \sum_{j=1}^{n} w_{ij} y_j + \sum_{k=1}^{K} \beta_k x_{ki} + \varepsilon_i ; i = 1, 2, \cdots, n \quad (4)$$

with ρ is the spatial autocorrelation coefficient.

Spatial Error Model (SEM). A model in which there is a spatial correlation in the error. The general form of SEM for cross-sectional data can be seen in eq5.

$$y_i = \sum_{k=1}^{K} \beta_k x_{ki} + \varphi_i, \text{ where } \varphi_i = \pi \sum_{j=1}^{n} w_{ij} \varphi_j + \varepsilon_i \quad (5)$$

$i = 1, 2, \cdots, n$, with π is the spatial autocorrelation coefficient.

D. Spatial Panel Model

Panel data modeling, which also examines the spatial effect of the dependent variable, is called the spatial autoregressive panel model. The spatial error panel model examines the spatial effect of error. The individual-specific effect was chosen as a characteristic of the panel data. eq6 and eq7 are forms of the spatial auto-regressive panel model and spatial error panel model with a fixed effect, respectively.

$$y_{it} = \rho \sum_{j=1}^{n} w_{ij} y_{jt} + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it} \quad (6)$$

$$y_{it} = \sum_{k=1}^{K} \beta_k x_{kit} + \varphi_{it}, \text{ where } \varphi_{it} = \pi \sum_{j=1}^{n} w_{ij} \varphi_{jt} + \varepsilon_{it}. \quad (7)$$

E. Methodology

The panel data utilized in this study was obtained from the Badan Pusat Statistik of West Nusa Tenggara Province and was released on the BPS West Nusa Tenggara's official website. The observation units are the following cities and regencies in West Nusa Tenggara Province: Mataram City, Bima City, North Lombok Regency, East Lombok Regency, Central Lombok Regency, West Lombok Regency, Sumbawa Regency, West Sumbawa Regency, Dompu Regency, and Bima Regency. There are 13 years of observation, namely 2010 to 2022. A human development index (HDI) serves as the dependent variable. The independent variables were per capita expendi-ture (PCE), average length of school (ALS), old school expectations (OSE), and life expectancy (LE). Fig. 1 presents the connection between variables used in this study. The data in this study was analyzed using the R software.

III. Result and Discussion

A. Exploration

A thematic map depicting the evolution of the human development index in West Nusa Tenggara over the previous six years is shown in figure2. In NTB, HDI typically rises yearly. Thematic maps with color differences make it obvious

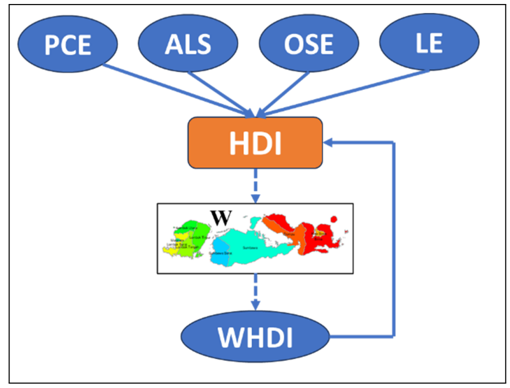


Fig. 1: The connection of the variables

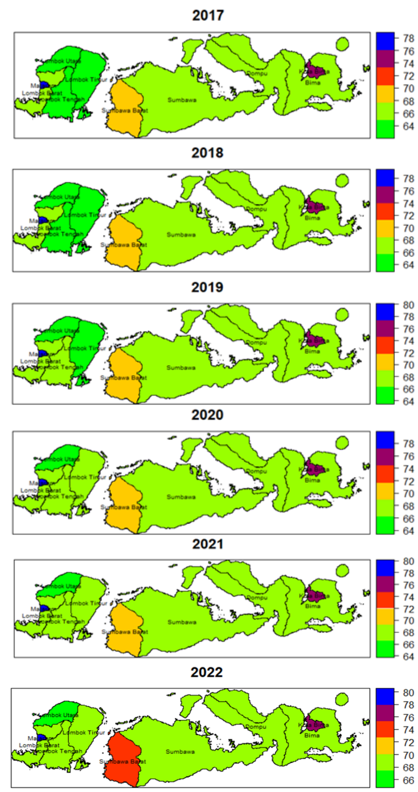


Fig. 2: Human development index growth of west nusa tenggara from 2017 to 2022

that HDI in-creased in West Lombok, East Lombok, and West Sumbawa.

figure2 demonstrates the spatial dependence of the human development index between districts and cities in West Nusa Tenggara. On the distribution map, the close color resemblance of neighboring cities or districts serves as a clue. Cities or districts that are close to each other contain attributes that are similar.

B. Inferential

The panel regression models' parameters were first estimated in this work. The common effect model (CEM), the fixed effect model (FEM), and the random effect model (REM) are the three models that can be produced by modeling using the panel regression approach. table1 shows the outcomes of parameter estimation.

TABLE I: Parameter estimation results for panel regression models

Variable	Common effect model		Fixed effect model		Random effect model	
	Estimate	*p*-value	Estimate	*p*-value	Estimate	*p*-value
Intercept	0.026	0.159			0.018	0.567
lnLE	0.480	0.000***	0.461	0.000***	0.467	0.000***
lnOSE	0.207	0.000***	0.207	0.000***	0.205	0.000***
lnALS	0.127	0.000***	0.124	0.000***	0.126	0.000***
lnPCE	0.146	0.000***	0.157	0.000***	0.154	0.000***

*** Significant at α = 1%.

table1 demonstrates that for all three panel regression models, the *p*-values for the variable's life expectancy, length of schooling, average length of schooling, and per capita expenditure were 0.000. All independent variables' P-values are lower than 0.01. This indicates that for all three panel models at α = 0.01, the human development index is positively and significantly influenced by life expectancy, predicted length of schooling, average length of schooling, and per capita expenditure. The Chow test and Hausman test were used to determine which panel model was the best. Test of Chow to decide whether to use FEM or CEM. Test of Hausman to determine whether to use FEM or REM. table2 displays the outcomes of both assessments.

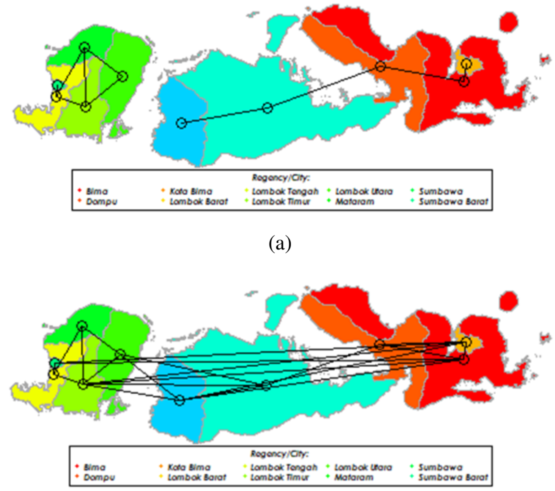
TABLE II: Parameter estimation results for panel regression models.

Chow test		Hausman test	
F statistic	*p*-value	Chi-square statistic	*p*-value
27.695	0.000***	7.201	0.126*

Significant at: *** α = 1%, * α = 15%.

The Chow test's *p*-value was 0.000, which indicates that it was a statistically significant result based on the analysis shown in Table 2's findings. Thus, comparing CEM and FEM, FEM is the better model. The p-value was 0.126 for the Hausman test. FEM is the model of choice if utilizing α = 15%. This indicates that at least one fixed district (region) is influencing the model. Consequently, the fixed effect model was selected as the panel model to continue in the spatial analysis.

The Rook contiguity matrix and the customized matrix (socioeconomic relations approach) are the weighted matrices (W) used to examine geographical impacts. The intersection of the regional sides connecting sites led to the selection of the rook contiguity matrix to portray the interrelationships. Regionally intersecting areas are seen as having similar characteristics, such as the North and West Lombok Regencies. Because the two districts physically border one other or intersect geographically, they are seen as having spatial links. The customized weighted matrix was selected because places without side junctions may be connected to other regions due to economic ties or the proximity of other socioeconomic factors [9] [11] [19]. Routes for land, sea, and air transportation are used as a guide when creating a customized weighted matrix. figure3 illustrates the spatial weighted for side intersections and transport flows.



(a)

(b)

Fig. 3: Spatial weighted matrix plot: (a) rook contiguty, (b) transportaion route.

The Moran I test and the Lagrange Multiplier (LM) can be used to detect whether there are spatial dependencies (entanglement) in a regression model [12] [21] [22]. The Moran I test demonstrates global or thorough spatial entanglement. The spatial reliance on endogenous factors or error of model is revealed by the LM test. table3 displays the outcomes of the Moran I and LM tests. According to table3, there

TABLE III: Results of spatial dependence test

Statistic	Rook Contiguity		Customized	
	Estimate	*p*-value	Estimate	*p*-value Moran I
0.508	0.000***	0.404	0.000***	
LM1 (SEM)	15.622	0.000***	15.622	0.000***
LM2 (SAR)	0.934	0.351	0.015	0.988
CLM1 (SAR)	5.362	0.000***	2.391	0.016
CLM2 (SEM)	18.188	0.000***	15.656	0.000***
LMH (SAR and SEM)	244.93	0.000***	244.06	0.000***

Significant at: *** α = 1%, * α = 15%.

are global spatial dependencies at α = 1%, as indicated by the Moran I values for the Rook contiguity and customize weighted matrices. According to the LM value, there is a spatial dependency on both lag (SAR) and error (SEM) for both weighted matrices employed at α = 5%. The weighted matrix that will be used for additional modeling will therefore be the Rook contiguity and customized weighted matrix.
A fixed effect model and a spatial autoregressive model are coupled to form the SARFE model (SARFEM). The fixed effect model and the spatial error model are combined to form the SEFE model (SEFEM). table4 displays the estimation outcomes of the SARFEM and SEFEM for the rook contiguity and customized weighted matrix.

In both the customized matrix and the rook contiguity weighted matrix, table4 shows that the value of the spatial effect coefficient on the dependent variable (HDI) is clearly negative. A significant influence on $\alpha = 1\%$ was seen for

TABLE IV: Parameter estimation results for spatial panel models

Estimate	Weighed Matrix			
	Rook Contiguity		Customized	
	SARFEM	SEFEM	SARFEM	SEFEM
WlnHDI	-0.084***		-0.026	
lnLE	0.536***	0.452***	0.487***	0.459***
lnOSE	0.214***	0.217***	0.209***	0.209***
lnALS	0.133***	0.129***	0.126***	0.125***
lnPCE	0.172***	0.150***	0.161***	0.155***
π		0.647***		0.249***
R^2	0.99987	0.99981	0.99984	0.99983
Loglikelihood	836.025	718.959	821.593	691.370

Significant at: *** α = 1%.

the spatial effect on the HDI variable for the rook contiguity weighted matrix. Customized weighted matrices, however, do not follow this specific rule. For the rook contiguity and customized weighted matrices, the value of the spatial effect coefficient on error exhibits a positive and significant sign. Both for the rook contiguity weighted matrix and for the customized weighted matrix for SARFEM and SEFEM, life expectancy, length of schooling, average length of schooling, and per capita expenditure had a positive and substantial impact on the human development index at $\alpha = 1\%$. The SARFEM with the rook contiguity weighted matrix, denoted by eq8, has the highest R^2 and loglikelihood value is the most effective model for simulating the human development index in West Nusa Tenggara.

$$\begin{aligned}\ln HDI_{it} = -0.084 \sum_{j=1}^{n} w_{ij} \ln HDI_{jt} + \\ 0.536 \ln LE_{it} + 0.214 \ln OSE_{it} + \\ 0.133 \ln ALS_{it} + 0.172 \ln PCE_{it} + v_i\end{aligned} \tag{8}$$

where $i = BR, DR, BC, WL, CL, EL, NL, MC, SR, WS$; $t = 2010, 2011, \cdots, 2022$; and v_i is a fixed effect (district or city), which value is shown in table5.

TABLE V: Regency or city effects.

id	Code	Regency/city	Effect
1	BR	Bima regency	0.004
2	DR	Dompu regency	0.001
3	BC	Bima city	-0.003
4	WL	West Lombok regency	0.001
5	CL	Central Lombok regency	0.001
6	EL	East Lombok regency	0.000
7	NL	North Lombok regency	0.002
8	MC	Mataram city	-0.008
9	SR	Sumbawa regency	0.003
10	WS	West Sumbawa regency	-0.002

The following describes the model's interpretation of eq8:

a. The Bima district will be used as an example area for the spatial autoregressive fixed effect model (SARFEM) to calculate the human development index. Dompu regency and Bima city are regions and cities that cross the boundaries of the Bima district. eq9 can be used to get the human development index in the Bima regency.

$$\begin{aligned}\ln HDI_{BR,2022} &= -0.084 \\ &\left(\frac{1}{2}\ln HDI_{DR,2022} + \frac{1}{2}\ln HDI_{BC,2022}\right) \\ &+0.536\ln LE_{BR,2022} + 0.214\ln OSE_{BR,2022} \\ &+0.133\ln ALS_{BR,2022} + 0.172\ln PCE_{BR,2022} + v_{BR} \\ &= -0.042\left(\ln HDI_{DR,2022} + \ln HDI_{BC,2022}\right) \\ &+0.536\ln LE_{BR,2022} + 0.214\ln OSE_{BR,2022} \\ &+0.133\ln ALS_{BR,2022} + 0.172\ln PCE_{BR,2022} + 0.004\end{aligned} \tag{9}$$

Furthermore, it is known that the life expectancy, school length expectancy, average length of schooling, and per capita expenditure of Bima district in 2022 are 66.87 years, 13.58 years, 8.17 years, and Rp. 8,699,000 per year, respectively. The HDI of Dompu regency and Bima city in 2022 is 69.15 percent and 76.84 percent, respectively. Based on eq9, the following formula is used to determine the human development index for Bima regency in 2022:

$$\begin{aligned}\ln HDI_{BR,2022} &= -0.042\left(\ln(69.15) + \ln(76.84)\right) \\ &+ \left(0.536 \times \ln(66.87)\right) \\ &+ \left(0.214 \times \ln(13.58)\right) \\ &+ \left(0.133 \times \ln(8.17)\right) \\ &+ \left(0.172 \times \ln(8.699)\right) + 0.004 \\ \ln HDI_{BR,2022} &= 4.2942 \\ HDI_{BR,2022} &= exp(4.2942) = 73.27\end{aligned}$$

Using a spatial autoregressive fixed effect model, the human development index of the Bima Regency in 2022 results in 73.27 percent. Based on BPS statistics for 2022, there is a 5.7 percent difference in the HDI of the Bima district.

If other variables are constant, a spatial effect coefficient with a negative and significant sign indicates that the human development index in West Nusa Tenggara can be decreased by districts or cities that are bounderies to the reference district or city.

b. A value of 0.536 indicates that, given all other factors remain constant, if life expectancy improves by 1 percent, West Nusa Tenggara's human development index will similarly rise by 0.536 percent.

c. If all other factors remain constant, a value of 0.214 indicates that if the length of school expectancy rises by 1 percent, the human development index in West Nusa Tenggara will similarly grow by 0.214 percent.

d. If all other factors remain constant, a value of 0.133 indicates that if the average length of education grows by 1 percent, West Nusa Tenggara's human develop-ment index will similarly rise by 0.133 percent.

e. If all other factors remain constant, a value of 0.172 in-dicates that if per capita expenditure grows by 1 percent, West Nusa Tenggara's human development in-dex will similarly rise by 0.172 percent.

IV. Conclusion

Based on the analysis and discussion, it is possible to draw the following conclusions: there are spatial linkages between districts and cities in West Nusa Tenggara, the SAR Fixed effect model is the most appropriate spatial model to use when modeling the human development index; the human development index can be improved simultaneously by factors such as life expectancy, expected length of schooling, average length of schooling, and per capita expenditure; and life expectancy is the main factor affecting the human development index.

V. Implications and Recommendations

The analysis's findings indicate that life expectancy has the most influence on how the human development index is calculated. The level of health and wellbeing of the population is better in a place where life expectancy is higher. The government ought to attempt to raise public awareness of the need to maintain a healthy lifestyle and make it simpler for individuals to access medical facilities. The government is also expected to consider the state of the immediate neighborhood, as well as any areas connected by transit networks, when determining policy.

Examining economic variables outside that employed in this study will help researchers improve the study's findings further. Researchers can also create studies of the spatial effects connected to the usage of weighted matrices. Additionally, the next researchers can study economic elements not only as single equations but also as simultaneous equations.

References

[1] H. Sarkoro and Z. Zulfikar, "Dana alokasi khusus dan pendapatan asli daerah terhadap indeks pembangunan manusia (studi empiris pada pemerintah provinsi se-indonesia tahun 2012-2014)," *Riset Akuntansi dan Keuangan Indonesia*, vol. 1, pp. 54–63, 2016.

[2] Y. Yolanda, "Analysis of factors affecting inflation and its impact on human development index and poverty in indonesia," *European Research Studies Journal*, vol. XX, pp. 38–56, 2017.

[3] T. BPS, "Indeks pembangunan manusia (human development index)."

[4] F. Rayes, "Human development analysis: The role of demographic factors in west nusa tenggara in the period of 2013-2017," 2019.

[5] S. Sapurah, I. Gunartha, and N. Fitriyani, "Panel data regression analysis of human development index in west nusa tenggara province with fixed effect model," *Eigen Mathematics Journal*, 2021.

[6] R. Pramuja, N. Sari, Z. Arifin, M. Azizurrohman, and S. Supiandi, "Long- and short-term analysis on the human development index in west nusa tenggara," *Journal of Enterprise and Development*, vol. 5, pp. 58–72, 2023.

[7] B. Baltagi, "Econometric analysis of panel data," *John Wiley Sons*, 2005.

[8] A. Astuti, S. Setiawan, I. Zain, and J. Purnomo, "A review of panel data on spatial econometrics models," *J Phys Conf Ser. 1490*, 2020.

[9] A. Astuti, S. Setiawan, I. Zain, and J. Purnomo, "The extended algorithm for quasi maximum likelihood parameter estimation," in *In: AIP Conference Proceedings*, 2021.

[10] L. Anselin, "Spatial econometrics: Methods and models," *Springer Netherlands*, 1988.

[11] A. Astuti, S. Setiawan, I. Zain, and J. Purnomo, "A modified generalized estimating equation approach for simultaneous spatial durbin panel model: Case study of economic growth in asean countries," *Decision Science Letters*, vol. 12, pp. 369–388, 2023.

[12] J. LeSage, *Applied Econometrics Using MATLAB*. 1999.

[13] I. Jaya and Y. Andriyana, "Analisis data spasial: Perspektif bayesian," *Alqaprint Jatinangor*.

[14] A. Elizabeth, *The Human Development Index: A History*. Amherst, 2007.

[15] H. Makiko Ito, *The Human Development Index: a search for a measure of human values*. 2014.

[16] A. Ramirez, G. Ranis, and F. Stewart, *Economic Growth and Human Development*. 1998.

[17] D. Gujarati and D. Porter, *Basic Econometrics*. New York: The McGraw-Hill Companies, 2009.

[18] B. Baltagi, *Econometrics*. New York: Springer, 2021.

[19] G. L. J. H. Anselin, L., *Spatial Panel Econometrics. In: The Econometrics of Panel Data*. Berlin: Springer Netherlands, 2008.

[20] Y. Edi, *Quasi-maximum Likelihood untuk Regresi Panel Spasial (Studi Kasus: Laju Pertum-buhan Ekonomi)*. 2012.

[21] P. R. LeSage, J.P., *Introduction to Spatial Econometrics*. New York: Taylor Francis Group, 2009.

[22] S. Stakhovych and T. Bijmolt, "Specification of spatial models: A simulation study on weights matrices," *Papers in Regional Science*, vol. 88, pp. 389–408, 2008.