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Determination Of Development Inequality Between Regions On The Island Of Sumatra

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ABSTRACT

This study aims to analyze the condition and influence of urban hierarchy, road density, and the Human Development Index (HDI) on economic development inequality among regions in Sumatra Island during the period 2019–2024. Development inequality in Sumatra remains considerably high, as reflected by the significant disparities in economic growth rates, infrastructure quality, and human resource quality across provinces. This study employs secondary panel data from ten provinces in Sumatra, analyzed using panel data regression. Based on the Chow Test and Hausman Test, the Fixed Effect Model (FEM) was selected as the most appropriate model. The results indicate that partially, only the urban hierarchy variable has a positive and significant effect on economic development inequality, suggesting that the better and more structured the urban hierarchy of a province, the more evenly distributed its economic activities tend to be across regions. Meanwhile, road density and HDI do not show significant partial effects. Simultaneously, all independent variables together have a significant effect on economic development inequality, with the model demonstrating a very high ability to explain the variation in inequality across provinces. This study recommends the development of new growth centers beyond major cities, more equitable road infrastructure development toward remote areas, and the acceleration of human resource quality improvement in provinces with low HDI.

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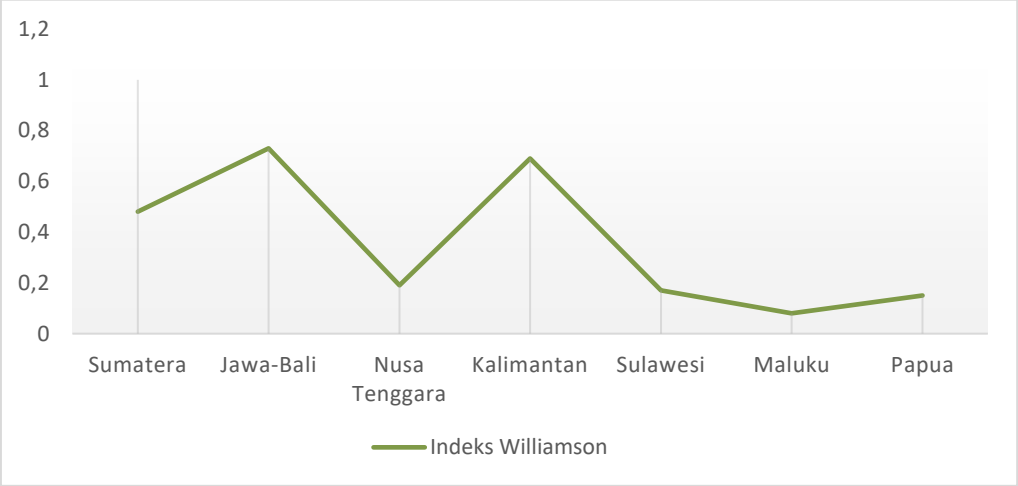
1. INTRODUCTION

The Indonesian economy has long experienced inequality in development between regions. During the New Order era, the centralized and dominant development pattern on the island of Java caused development inequality and poverty levels. As a result, this development pattern caused internal conflicts to occur in areas outside Java, such as the Free Aceh Movement, Free Riau, Free East Kalimantan, and the Free Papua Organization. Due to reforms, government has been decentralized. Regional management now has the right to act independently, and the central government provides funds to poor regions to provide public services. The principle of equality is at the core of this policy

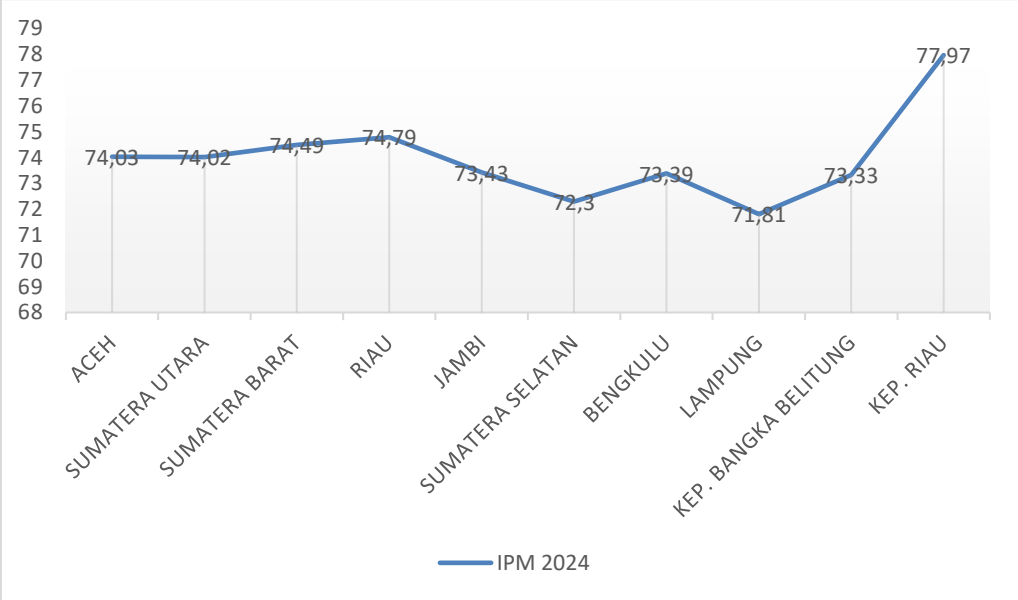
his inequality is caused by various regional differences. These differences make regions different in terms of their ability to increase economic growth and encourage development. Therefore, in a region there are relatively developed areas and relatively underdeveloped areas.

The cause of development differences between regions is variations in natural resources and geographical conditions. To achieve equitable development and equal distribution of investment in island countries, differences in topographic characteristics and accessibility make it difficult. BPS data for 2023 shows that Java Island contributed 57.02% of the national Gross Domestic Product

(GDP) in 2024, far above Sumatra (22.12%) and Kalimantan (8.24%) (BPS, 2024). According to the Williamson Index value in the 2020–2024 National Medium Term Development Plan Document (RPJMN), regional inequality in Indonesia is very different between groups of development regions. The Java–Bali and Kalimantan regions show the highest inequality (Maisaroh & Amin, 2025).



Sufficient income levels also provide room for individuals to access various essential services, including health, education and infrastructure. These three dimensions interact with each other and simultaneously become the basis for assessing the success of human development in a region.



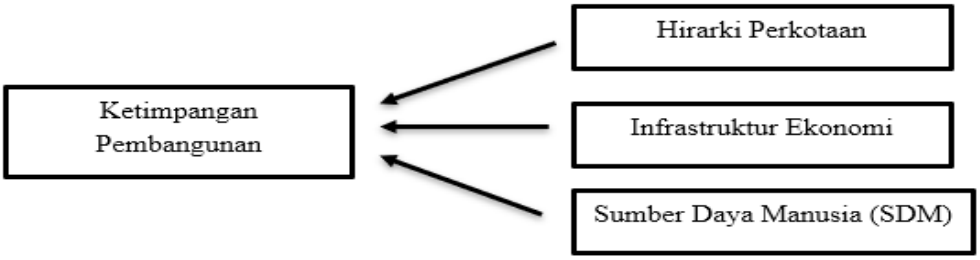
(Badan Pusat Statistik, 2022)

Based on the data in the figure "Human Development Index (HDI) per Province on Sumatra Island in 2024", it can be seen that there are variations in the level of human development between provinces in the region. Riau Islands Province occupies the highest ranking with an HDI value of 77.97, which reflects the relatively better quality of human resources compared to other provinces in Sumatra. This achievement was influenced by rapid economic development in the industrial, trade and service sectors, accompanied by high levels of education and community income due to increasingly intensive investment flows and urbanization.

Even though it benefits central cities, this phenomenon often extends development disparities between regions. Rural areas and small towns far from growth centers often lag behind in terms of access to basic services and infrastructure. The difference in GDP per capita shows this imbalance. This can also be seen in welfare indicators such as the Human Development Index (HDI). Based on the description that has been presented and the background phenomena above, the author is interested in conducting research with the title "Determination of Development Inequality Between Regions on the Island of Sumatra".

Human Resources (HR) are a vital component in development which includes individual abilities, knowledge and potential which must be managed in order to make an optimal contribution to the progress of a region. The quality of human resources, such as health, education and skills, influences productivity and encourages equitable economic growth. The Human Development Index (HDI) is the main measuring tool for the quality of human resources. Disparities in the quality of human resources between regions can increase the gap in economic development, so equal access to education, health and employment is very important so that development can be inclusive and sustainable.

Thus, development inequality between regions on the island of Sumatra cannot be explained by one variable alone, but is formed through the mutually influencing relationship between urban hierarchy, the quality and availability of economic infrastructure, and the level of quality of Human Resources (HR). Urban hierarchy plays a role in determining growth centers and patterns of movement of economic activity, while economic infrastructure is the main factor that supports the mobility of goods, services and investment flows. At the same time, the quality of human resources determines a region's ability to manage existing potential and adapt to economic changes. The interrelationship of these three aspects simultaneously forms regional capacity to encourage accelerated development, reduce gaps, and realize more balanced growth throughout the Sumatra Island region.



Gambar 5 Kerangka Pemikiran

2. RESEARCH METHOD

This research uses quantitative methods. Quantitative research is a research approach that produces scientific findings through the application of statistical procedures and other methods based on the measurement process. This approach focuses on studying phenomena in human life that have certain characteristics and are then defined as research variables. Within a quantitative research framework, relationships between variables are analyzed systematically based on objective theories, so that the results obtained can be measured, tested and explained rationally (Sujarweni, 2020)

The Williamson index calculation is based on GDP data for each region, and the formula used for the calculation is as follows:

$$Vw = \frac{\sqrt{\sum (y_i - y)^2 \left(\frac{f_i}{n}\right)}}{y}$$

The Theil Index calculation is used to examine the dynamics of geographic concentration in a certain period and provide a deeper understanding of the level of development inequality between regions. Through a decomposition approach, this index is able to separate inequality into two main components, namely inequality between regions and inequality within regions. The Theil Index equation is formulated as follows:

$$\boldsymbol{I_T = \sum_{i=1}^{n} y_i \ln \left(\frac{y_i}{x_i}\right)}$$

To answer the second problem formulation using the method in this research using panel regression will show whether the dominance of large cities is related to greater inequality between regions. Panel data regression analysis is a form of combined data that integrates time series data and cross-section data. An econometric model is categorized as a panel data model if its formulation utilizes

both types of data simultaneously, then an estimation process is carried out involving time and individual or regional dimensions. The use of a combination of time series and cross section data in econometric analysis is not without methodological considerations. The application of the panel data model is based on a number of important reasons, especially because of its ability to capture wider variations in data and provide more informative estimation results compared to using just one type of data (Wahyudi, 2020). Panel data regression analysis has many models to choose from, as is the case with multiple linear regression used in this research. In panel data analysis, there are three main types of models that can be used, namely the common effect model (CEM), the fixed effect model (FEM), and the random effect model (REM). These three approaches represent different assumptions in capturing data characteristics between individuals and across time. The estimation techniques applied in panel data models generally use the Panel Ordinary Least Squares (OLS Panel) Wahyudi (2020) method. In the final stage of panel analysis, these models are tested to determine which one fits best. The choice of the best model is made to show the relationship between the independent variable and the dependent variable.

$$Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \epsilon_{it}$$

The Common Effect Model (CEM) is often seen as the simplest approach in panel data-based regression analysis. Empirically, the resulting estimation results often do not show significant differences compared to conventional regression models. This is due to the main objective of implementing CEM, namely obtaining an adequate number of observations in the estimation process without having to rely on time series data over a long period. Therefore, combining time series and cross section data is a practical alternative. In this model, the time dimension and individual characteristics are not differentiated, so it is assumed that the behavior of the cross section units is homogeneous over time. The estimation process is generally carried out using the Panel Ordinary Least Squares (POLS) approach or least squares method (Wahyudi, 2020).

Fixed Effect Model (FEM) is a more sophisticated approach than the Common Effect Model for analyzing urban hierarchy and economic development inequality in Sumatra. The Fixed Effect Model (FEM) is based on the main assumption that differences in characteristics between individuals, which are represented by unobserved factors, allow for correlation with the independent variables in the model. The estimation process in this approach is carried out using the Panel Ordinary Least Squares (Panel OLS) method. In practice, there are several estimation techniques that can be applied, including least square dummy variable (LSDV), between estimator, and within estimator Wahyudi (2020). This model explicitly recognizes that there are "unique and constant differences" within each region (province, district, or city) that influence levels of economic development and inequality. Therefore, FEM allows researchers to produce more relevant and accurate results by distinguishing the impact of the components under study from the influence of the unique characteristics of each area.

According to the Random Effect Model (REM), a panel data analysis method, the differences between several regions (for example, provinces or districts/cities) in Sumatra that influence economic growth are random factors, not fixed. This model is built on the main assumption that differences in characteristics between individuals, which are represented by unobserved factors, have no relationship or correlation with the independent variables. Thus, this approach is used to estimate panel data in conditions where the error component allows for correlation, both between time periods and between individuals Wahyudi (2020). With this assumption, the model becomes more efficient and makes it possible to measure the influence of variables that do not change over time.

The regression parameter test method is used to test hypotheses about population conditions with sample data. The regression parameter test is used in this research to evaluate how much the components studied (such as economic infrastructure, investment and labor) influence the level of development inequality between regions on the island of Sumatra. Apart from that, the regression parameter test is also used to evaluate how suitable the urban hierarchical analysis model used is.

Simultaneous testing of the significance of the regression model is carried out by paying attention to the significance value (sig). If the significance value is below 0.05, it can be concluded that the independent variables together have an influence on the dependent variable. The F statistical test is used to prove the simultaneous influence of all independent variables on the dependent variable in the regression model used

The t statistical test shows how far the influence of an independent variable or individual explanatory variable is in explaining the dependent variable Sujarweni, (2020). The t test determines

whether factors such as economic infrastructure, investment and labor have a significant influence on development inequality between regions in each region of Sumatra Island.

The coefficient of determination (goodness of fit) symbolized by R^2 is an important measure in regression analysis. The R^2 value reflects the ability of the independent variable to explain variations that occur in the dependent variable. This analysis aims to find out how much influence the independent variable has on the dependent variable. Thus, the R^2 value shows the proportion of total variation in the dependent variable that can be explained by the independent variables in the model. The higher the resulting R^2 value, the greater the ability of the independent variable to explain changes in the dependent variable (Sujarweni, 2020).

The normality test is used to determine whether the dependent variable and independent variables in a regression model have a normal data distribution or not. Data normality testing can be done using the one-way Kolmogorov–Smirnov test. Determination of test results is based on the significance value obtained, where data is declared normally distributed if the significance value is > 0.05. Conversely, if the significance value is <0.05, then the data does not meet the normal distribution assumption (Sujarweni, 2020).

Multicollinearity is a condition when there is a very strong or perfect linear relationship between some or all of the independent variables in a regression model. The existence of multicollinearity can cause regression coefficients to become unstable and produce very large standard error values, thus potentially causing bias in model specifications. Therefore, a multicollinearity test was carried out to determine whether there was a correlation between the independent variables in the regression model. A good regression model should not show a correlative relationship between the independent variables used. This method for testing multicollinearity can be seen from the tolerance value or variance inflation factor (VIF). Where the tolerance value limit is > 0.1 or the VIF value is smaller than 10, multicollinearity does not occur (Sujarweni, 2020).

The heteroscedasticity test is a test carried out to determine whether there is a condition of inconsistency in the variance of confounding errors in each independent variable in a regression model. A good regression model should be free from heteroscedasticity problems, so that the residual variance is constant. Heteroscedasticity testing can be carried out using the Glejser test by assessing the level of significance of the test results. This method is carried out by regressing the independent variable (X) on the absolute value of the regression residual which is not standardized as the dependent variable. If the resulting significance value is greater than 0.05, it can be concluded that heteroscedasticity does not occur. Conversely, if the significance value is below 0.05, then the regression model indicates heteroscedasticity (Sujarweni, 2020). Research chronological, including research design, research procedure (in the form of algorithms, Pseudocode or other), how to test and data acquisition (Cronje, 2020). The description of the course of research should be supported references, so the explanation can be accepted scientifically (Fryer & Dinsmore, 2020).

3. RESULTS AND DISCUSSIONS

Variabel	t-Statistik	Prob.	α = 0,05	Kesimpulan
X1 (Hirarki Perkotaan)	3.692205	0.0006	< 0,05	Berpengaruh Signifikan
X2 (Kepadatan Jalan)	0.284957	0.7769	> 0,05	Tidak Berpengaruh Signifikan
X3 (IPM)	-1.298911	0.2003	> 0,05	Tidak Berpengaruh Signifikan

a. Based on the results of testing economic development inequality using the Theil index, the Urban Hierarchy (HP) variable using the Primacy Index shows a coefficient of 5,168.686 with a probability value of 0.0001, which is smaller than the significance level of α = 0.05. Meanwhile, inequality of economic development using the Williamson index, the Urban Hierarchy (HP) variable using the Primacy Index shows a coefficient of 6,243.248 with a probability value of 0.0006, which is smaller than the significance level of α = 0.05. This indicates that the Urban Hierarchy has a positive and significant influence on the inequality of economic development between regions on the island of Sumatra during the 2019–2024 period. This coefficient value means that every one point increase in the Primacy Index will be followed by a decrease in development inequality for the Theil index of 5,168.686, while the Williamson index is 6,243.248, assuming other variables remain constant (ceteris paribus).

Strengthening the role of main cities also contributes to increasing the efficiency of public services, accelerating infrastructure development, and developing industrial areas. This condition is ultimately able to improve the welfare of the people in the connected areas. Therefore, an urban structure that is structured hierarchically and organized can encourage a more systematic distribution of development and reduce disparities between regions in the medium and long term. These results are in line with research by Sihombing (2023) which states that urban hierarchy has an important role in shaping development patterns, where cities with higher hierarchical levels are able to encourage the development of infrastructure and services that have a positive impact on the surrounding area. Similar findings were also presented by Hutahean (2020), who showed that urbanization and strengthening city centers contributed to economic growth through increasing economic activity and infrastructure development. However, these results are different from the research of Li et al. (2015) which states that cities with higher administrative hierarchies tend to develop more quickly and have the potential to widen inequality if they are not balanced with equalization policies. These differences are thought to be influenced by variations in geographical conditions, research period, and development redistribution policies in each region. In line with that, research by Setiawan et al. (2025) emphasize that urban hierarchical structures indirectly influence inequality patterns if the growth process is not accompanied by adequate regional equalization policies. In the context of Sumatra Island, the results of this research show that the strengthening of urban hierarchy during the 2019–2024 period has produced quite a large spill-over effect to the surrounding area, so that overall it has a negative impact on inequality or is able to reduce disparities between regions.

b. Based on the results of the Theil Index test, the Road Density (KJ) variable shows a coefficient value of 2,057.620 with a probability of 0.4200, which is above the significance level of α = 0.05. Meanwhile, the results of testing the WIliamson Index for the Road Density (KJ) variable show a coefficient value of -7493.3801 with a probability of 0.7769, which is above the significance level of α = 0.05. This indicates that Road Density has a positive influence on economic development inequality using the Theil index while the Williamson index has a negative influence, but both are not significant on economic development inequality between regions on the island of Sumatra during the 2019–2024 period. These results are not in line with the initial hypothesis which predicted a negative influence, but this condition can be explained through several considerations.

   This phenomenon is in line with the view that centralized infrastructure development will encourage the formation of economic agglomeration, not equal growth. On the other hand, the insignificant effect of road density can also be explained by aspects of infrastructure quality, because increasing the length of roads does not always reflect their quality and effectiveness in supporting economic activity. Roads that are damaged or poorly maintained are not able to optimally reduce transportation costs or increase connectivity between regions, so their impact on reducing inequality is limited. This finding is in line with research by Iqbal et al. (2019) which shows that road infrastructure does not have a significant effect on regional economic inequality in Aceh Province, arguing that uneven development has not been able to reduce disparities. Similar results were also found by Yaqin et al. (2021) in South Kalimantan Province, which states that infrastructure has not had a significant impact on development inequality in the research period. However, these results are different from the findings of Sukwika (2018) and Azim A et al. (2022) who concluded that road infrastructure has a significant influence on development inequality in Indonesia. These differences may be influenced by variations in the study area, research period, and the quality and characteristics of infrastructure in each region. In addition, Nasution et al. (2025) emphasized that although economic growth has the potential to reduce inequality, uneven infrastructure development can actually worsen inequality if it is concentrated in certain areas. This condition is relevant to the situation on the island of Sumatra, where the construction of the Trans-Sumatra Toll Road which is still ongoing in stages has not been able to create comprehensive distribution of development during the 2019–2024 period.

c. Based on the results of testing economic development inequality using the Theil Index, the Human Development Index (HDI) variable shows a coefficient of -94.160453 with a probability value of 0.1898, which is higher than the significance level of α = 0.05. Meanwhile, the results of testing inequality in economic development using the Williamson Index, the Human Development Index (HDI) variable shows a coefficient of -913.2072 with a probability value of 0.2003, which is higher than the significance level of α = 0.05. This indicates that HDI has a negative influence on both searches, but is not significant on the inequality of economic development between regions on the island of Sumatra during the 2019–2024 period. The negative direction of the coefficient is in line with the initial hypothesis which states that improving the quality of human resources has the potential to reduce inequality. However, the relatively small magnitude of the effect meant that this relationship was not detected as statistically significant.

   The insignificance of the influence of HDI on development inequality can be explained from several aspects. First, although all provinces in Sumatra experienced an increase in HDI throughout the research period, this increase tended to occur evenly. As a result, differences in HDI values between provinces have not changed large enough to significantly influence the level of inequality. Thus, variations in HDI between regions are still relatively narrow and have not been able to become the main determining factor in explaining development disparities.

   On the other hand, the impact of HDI on economic development inequality is long-term. Improvements in aspects of education, health and people's purchasing power as the main components of HDI require quite a long time to produce significant structural changes. Therefore, in the relatively short observation period, namely 2019–2024, this impact cannot yet be seen in real terms. This finding is in line with research by Nasution et al. (2025) which shows that HDI has a positive but not significant effect on development inequality in North Sumatra. Similar results were also found by Hakim et al. (2024), which states that HDI can have a significant effect but actually has the potential to widen inequality if the increase occurs more quickly in developed regions compared to underdeveloped regions. In contrast, research by Azim A et al. (2022) found that HDI has a negative and significant influence on development inequality, which shows that improving the quality of human development can play a role in reducing disparities between regions. These differences in results may be influenced by differences in research area coverage, where the study of Azim A et al. covers all provinces in Indonesia so it has greater variation in HDI in explaining inequality. Furthermore, Raharja and Lestari (2022) stated that HDI acts as a mediating variable in the relationship between investment and development inequality. This shows that the influence of HDI is not always direct, but rather through other variables such as investment and economic growth. Thus, in the context of Sumatra Island during the 2019–2024 period, the increase in HDI is not strong enough to independently reduce development disparities between regions, so other policy support is needed, such as equal distribution of investment and infrastructure development, so that the impact on reducing disparities can be more optimal.

The urban hierarchical structure which has been proven to have a negative and significant influence on inequality in economic development on the island of Sumatra indicates that strengthening the urban system can be an effective policy instrument in reducing disparities between regions. In this context, the government needs to direct the development of medium-sized cities and small towns as alternative growth centers by strengthening their role in providing economic, educational and health services. In addition, efforts to decentralize investment and develop economic areas in underdeveloped areas need to be a priority, supported by integrated spatial planning. Through this strategy, it is hoped that the distribution of economic activity from primate cities to the surrounding areas will be more even, so that development inequality can be minimized more effectively. Although the road density variable has not been proven to have a significant influence in reducing development inequality, this finding actually emphasizes the need to improve the strategy for developing road infrastructure on the island of Sumatra. Policy direction should no longer focus on a demand-based approach, but instead shift to an approach that emphasizes equality by prioritizing disadvantaged, remote and outermost areas. On the other hand, accelerating the construction of the Trans-Sumatra Toll Road which is integrated with a network of connecting roads

to rural areas and production centers needs to be strengthened so that the distribution of infrastructure benefits is more even. Apart from the quantity aspect, attention to the quality and maintenance of roads is also crucial to increasing transportation efficiency and strengthening its contribution to reducing inequality in sustainable development.

The insignificant influence of HDI on development inequality indicates that improving the quality of human resources in various provinces of Sumatra Island is still taking place unevenly and has not yet produced a real redistribution effect. This condition requires the government to accelerate human resource development in a more focused manner, especially in areas with low HDI such as Lampung, Aceh and Bengkulu, through expanding access to education, improving the quality of teaching staff, strengthening vocational education, as well as developing health and social security services. This step also needs to be supported by improving nutrition, providing health facilities, and equal distribution of medical personnel in order to improve the welfare of society as a whole. In the end, this policy will be more effective if it is synergized with infrastructure development and strengthening urban systems, so that it can create inclusive development while simultaneously reducing inequality in a sustainable manner.

4. CONCLUSION

In general, the condition of urban hierarchy, road density, Human Development Index (HDI), as well as economic development disparities between regions on the island of Sumatra during the 2019–2024 period show quite striking variations between provinces. Judging from the urban hierarchy as measured through the Primacy Index, the Riau Islands, North Sumatra, consistently recorded the highest score, reaching 1,882 in 2019, which was influenced by the city of Batam as the center of industry and trade, while in 2024, North Sumatra recorded the highest, reaching 1,741, which was influenced by the dominance of Medan City as the center of economic and urban activities. In contrast, the Bangka Belitung Islands show relatively stable lowest values in the range of 0.0227–0.0240. In terms of road density, the Riau Islands occupy the highest position with a value of 0.693 in the 2019–2022 period, which is driven by limited land area and the high intensity of development in the Batam and Tanjungpinang areas. Meanwhile, South Sumatra has the lowest level of road density, namely around 0.214–0.233, due to the large area dominated by plantations, swamps and mining activities. In terms of HDI, the Riau Islands again recorded the highest score, while Lampung was in the lowest position, which reflects the gap in quality of life, access to education and health services between regions. Overall, the level of development inequality as measured using the Williamson Index and Theil Index is still quite high, which is influenced by differences in economic growth, infrastructure availability and the quality of human resources in each province.

Based on the results of panel data regression estimation using the Fixed Effect Model (FEM) selected through the Chow Test and Hausman Test, partially only the Urban Hierarchy variable is proven to have a positive and significant effect on economic development inequality on the island of Sumatra. These results indicate that the better and more structured the urban hierarchy of a province, the more evenly the distribution of economic activity between regions will be so that the level of development inequality tends to decrease. This reflects that the development of more balanced urban functions and structures between provinces has an important role in reducing development gaps on the island of Sumatra. However, simultaneously all independent variables consisting of Urban Hierarchy, Road Density, and Human Development Index together have a significant effect on economic development inequality, with the model's ability to explain variations in inequality between provinces being classified as very high

Considering that urban hierarchy has been proven to have a significant influence on development inequality, both the central government and regional governments on Sumatra Island need to direct policies towards developing new growth centers outside main cities such as Medan, Palembang and Pekanbaru. Strengthening the role of medium-sized cities and small cities as alternative growth centers needs to be carried out through improving urban functions, services and facilities, so that the distribution of economic activity and population can be more even. In addition, the implementation of fiscal decentralization policies accompanied by planned spatial planning and based on regional hierarchies is expected to be able to encourage more balanced regional development. In this way, the concentration of economic activity which has been concentrated in certain regions can be reduced, so that disparities between regions can be reduced more effectively.

Even though road density has not shown a statistically significant effect in reducing development inequality, this condition actually emphasizes the importance of improving road infrastructure development strategies on the island of Sumatra. The government needs to ensure that the development of the road network is not only focused on developed areas, but is also directed to remote and underdeveloped areas so that the benefits can be felt more evenly. Apart from that,

accelerating the construction of the Trans-Sumatra Toll Road accompanied by the development of connecting roads to rural areas and agricultural production centers needs to be a top priority. With this approach, road infrastructure is expected to be able to act as a driver of inclusive economic growth, so that development disparities between regions on the island of Sumatra can be reduced more effectively.

The results which show that HDI has not had a significant influence on reducing development inequality indicate that the increase in HDI between provinces on the island of Sumatra is still not taking place evenly and has not been able to produce a real redistribution impact. Therefore, the government needs to accelerate the implementation of human resource development programs in a more targeted manner, especially in provinces with relatively low HDI levels such as Lampung, Aceh and Bengkulu. These efforts can be made through increasing access and quality of education services, expanding the reach of health insurance, and accelerating regional-based poverty reduction. In addition, the implementation of an affirmative program that prioritizes regions with low HDI is expected to reduce the gap in the quality of human resources between provinces, so that increasing HDI in the future can make a more real contribution in reducing economic development inequality on the island of Sumatra

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