Sustainable Development in Central Sulawesi: A Quadrant Approach and Variables that Shape Sustainability

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ABSTRACT

Sustainable development in Central Sulawesi is demonstrated by long-term disparities between regions, which highlight the imbalance between economic, social, and environmental aspects. This study set out to examine the regional sustainability performance and explain the underlying structural factors that contribute to the existing disparities. This study uses secondary data from 2021 to 2024 to create a Sustainable Development Index (SDI) and combines it with quadrant analysis to identify patterns of regional sustainability. It also uses data regression panels to test the main economic, social, and environmental determinants. The research results show that no regency or city has achieved a completely balanced sustainability position, with areas spread across the quadrants of underutilization, overexploitation, and ecological emergency. The econometric results show that human development, unemployment dynamics, and environmental quality excert a profound impact on sustainability, while economic growth and per capita GDP do not have a significant effect. Model fixed effects confirm there is strong structural heterogeneity across regions, highlighting the importance of spatial and institutional context. This study contributes to theory by improving the understanding of sustainable development and regional development, and it shows that regional sustainability inequality is formed in a structural way and cannot be explained just by growth-based indicators.

1. Introduction

Sustainable development is currently a key concept in modern development studies, highlighting the importance of maintaining a balance between economic progress, community welfare, and environmental sustainability. Since the publication of the Brundtland Report, sustainable development has been perceived not only as a normative goal, but also as a complex process influenced by the interactions and trade-offs between various dimensions of development that occur throughout time and place (Perrings & Ansuategi, 2000). While the initial framework for sustainable development assumed that progress in the economic and social sectors would support environmental protection, subsequent theoretical developments called question this linear view. Some experts argue that economic growth and improved quality of life do not automatically guarantee the achievement of sustainable development if ecological factors as well as structural imbalances are ignored (Daly, 2017; Sachs., 2015)

Research on sustainable development has been widely used composite indices and regional mapping over the past few years to assess the level of sustainability in various regions. This approach is used to combine indicators related to economic, social, and environmental factors into more systematic measures to facilitates a more streamlined comparison of the state of sustainability in different regions (Jyoti & Khanna, 2021; Wang et al., 2024). Through indexes and mapping, it can be explained how the relative position of an area within the framework of sustainability-driven development (Geddam et al., 2024). However, this approach is generally more focused on presenting measurement results, so understanding the differences in sustainability pathways between regions still requires a more in-depth conceptual explanation. Therefore, sustainability mapping is not only important to show the state of a region, but it must also be linked to the structural factors that affect the achievement of sustainable development (D'adamo et al., 2024; Sachs., 2015)

Achievements in sustainable development based on a theoretical point of view must be understood as the result of different development patterns of different structures. Awais et al. (2019) emphasizing that each region has its own characteristics related to economic composition, labor market dynamics, institutional capabilities, and ecological capacity, which collectively affect the way of interaction between economic, social, and environmental aspects. Sachs (2015) suggests that income growth or human development can go hand in hand with environmental damage, on the contrary. Świąder et al. (2020) and Skiter et al. (2022) Finding that areas with good ecological conditions cannot always transform environmental advantages into social and economic well-being. These patterns show that sustainable development is no single path applicable to all regions or individuals, yet it functions as an evolving process that is highly dependent on the scope of study and is formed through the interaction between development dimensions.

Sustainability assessment requires analytical tools that can capture multidimensional performance as well as structural differences between regions. Recent studies indicate that composite indices and spatial/clister analyses are often used as an approach to compare sustainability outcomes in different regions because they can summarize a number of indicators into a more practical measure (D'adamo et al., 2024). In line with this, a quadrant-based approach offers potential analysis by grouping regions according to the balance between socio-economic conditions and environmental quality, thus forming a four-quadrant typology that makes it easier to understand the relative position of the region (Lim et al., 2025). Based

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on a robust theoretical framework, quadrant analysis can be used to reveal variations in sustainable development patterns through balanced conditions, untapped potential, pressures from exploitation, and ecological vulnerabilities and serve as a basis for determining different strategies between typologies (Xia et al., 2024). However, in field applications, quadrant mapping is often still more often used as a summary of positions or typologies, so it is necessary to combine with explanatory models through panel data regression to provide a typological interpretation that has a stronger analytical basis for factors that affect sustainability (Biggeri et al., 2025).

Based on the existing theoretical framework, sustainable development in Central Sulawesi Province is a strategic empirical context to be analyzed. In recent years, Central Sulawesi Province has experienced economic changes due to natural disasters and the COVID-19 outbreak, which have complicated efforts to maintain economic stability and impacted the welfare of the community (BPS, 2024). On the other hand, social indicators measured by the Human Development Index (HDI) show a gradual increase, although this progress does not fully reflect the advancement quality of societal quality of life proportionately, especially in terms of education and poverty reduction (Rahmawati et al., 2024). Meanwhile, environmental pressures related to urbanization, industrial activities, and natural resource utilization tend to increase, in line with the findings of various studies that highlight the impact of urban growth and industrialization on environmental damage and reduced ecological carrying capacity (Pourebrahim et al., 2023; Świąder et al., 2020). These very different conditions raise important analytical questions about the extent to which economic and social progress in Central Sulawesi is aligned with environmental sustainability, as well as whether current development patterns reflect balance or instead reflect structural imbalances in sustainable development (Liu et al., 2018).

Despite increased policy attention to sustainable development in Central Sulawesi, assessments are generally focused on indicator reporting and performance monitoring. Some recent research suggests that indicator-oriented approaches often emphasize measuring results but have not fully outlined the structural mechanisms behind differences in sustainable development outcomes across regions (D'adamo et al., 2024). As a result, attention paid to understanding how structural factors, such as economic growth, income levels, labor market conditions, human development, and environmental quality interact with each other in shaping sustainability outcomes at the regional and subregional levels is still limited (Siddikee et al., 2022). It can be seen that there is still a gap in the literature on analyses that simultaneously reconcile economic, social, and environmental dimensions to clarify the divergence in the sustainability of development achievement between districts and cities, especially in the context of developing regions (Rahma et al., 2019). Therefore, these gaps emphasize that achieving the sustainability of development is an evolving, context-dependent process rather than a uniform result, necessitating a deeper analysis of the unique structural drivers within each region.

This study attempts to fill the paucity by repositioning sustainability mapping within the framework of theory-based analysis. Specifically, this study combines a quadrant sustainability approach with panel data regression analysis to examine sustainable development patterns in 13 districts and cities in Central Sulawesi Province. In this study, quadrant mapping is not only a tool for administrative evaluation but also an analytical representation of structurally

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different development patterns. In addition, the panel data estimation is used to recognize the economic, social, and environmental factors that shape the development pattern while still considering the heterogeneity of the area that cannot be observed. In order to achieve these goals, this study formulated specific objectives, among others: (1) mapping the sustainability position of districts and cities in Central Sulawesi Province using an integrated sustainability index and quadrant framework, and (2) analyzing the impact of economic growth, Gross Regional Domestic Product (GDP) per capita, unemployment rate, human development, and environmental quality on the achievement of sustainability in the region. Thus, this research provides a theoretical contribution through development in sustainability mapping as well as an empirical contribution in the form of data-based evidence on structural factors that support sustainable development at the regional level, in line with the goals of the Sustainable Development Goals (SDGs).

2. Literature Review

Sustainable development is a key view in today's economy, especially in relation to regional development in developing countries. This idea emphasizes that there is a need to balance economic growth, community well-being, and environmental preservation as part of interconnected development. In Indonesia, in the context of regional development, the sustainability aspect is not only seen from how fast the economy grows, but also from the extent to which a region can improve the living standards of its citizens and protect the environment in the long term.

This study applies a sustainable development method based on the Triple Bottom Line (TBL) and combines it with the structural area development approach as the main basis of analysis. The TBL concept introduced by Elkington in 1997 emphasizes that in order to achieve sustainable development, there needs to be an integration of three main aspects: economic (profit), social (people), and environmental (planetary) aspects. This method is often used in research on development and public policy because it is able to describe sustainability as a whole (Awais et al., 2019). Even so, in relation to regional analysis, TBL needs to be added with a structural perspective in order to reveal differences in development performance between regions.

From the economic dimension, sustainable development is often associated with stable and equitable economic growth. The measurement of this phenomenon is predominantly quantified through the lens of GDP or GDP per capita growth, applied across national and subregional boundaries. Damayanti & Idris (2024) revealed that GDP per capita has a positive effect on economic and environmental sustainability. In accordance with Michael et al. (2019), the results underscore that sustainable economic expansion can improve the quality of life if balanced with income equity. However, these studies still do not fully delineate the variation in sustainable development achievement caused by differences in economic structure between regions.

In addition to economic growth, the Human Development Index (HDI) is an important indicator in the social dimension of sustainable development. HDI reflects the quality of life of the community through aspects of health, education, and decent living standards (BPS, 2024). Increasing HDI contributes to regional productivity and competitiveness, as well as strengthening social sustainability (Damayanti & Idris, 2024; Michael et al., 2019). However,

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most studies still position HDI as an indicator of outcomes, rather than as a factor that interacts with labour market dynamics and regional economic structure.

Unemployment is a structural problem that can hinder the achievement of sustainable development. The high unemployment rate reflects the low absorption of labor and the weak quality of economic growth. Picatoste & Rodriguez-Crespo (2021) Picatoste and Rodriguez-Crespo (2021) and Ajayi et al. (2024) show that unemployment negatively impacts social well-being and the achievement of sustainable development goals. However, previous research has still tended to partially analyze unemployment without linking it to human development and environmental quality.

The environmental dimension is also an important factor in sustainable development, especially in areas that are under pressure due to urbanization and the use of natural resources. Alehile et al. (2024) and Khan et al. (2024) show that environmental damage, especially carbon emissions, negatively affects the sustainability of development and the quality of life of the community. Research by Qian et al. (2015), Yang et al. (2019), and Pourebrahim et al. (2023) confirms that urbanization as well as irregular land-use changes can lead to prolonged ecological stressors. However, these studies generally do not combine the economic and social dimensions comprehensively.

Literature review reveals that previous research still tends to focus on measuring sustainable development indicators separately and is still descriptive. The relationship between economic growth, the Human Development Index, unemployment rate, and environmental quality is more often analyzed individually, so it has not been possible to uncover the structural mechanisms that explain the differences in sustainable development outcomes in different regions. In the context of regional development in Central Sulawesi, there is a development imbalance despite an increase in income and the overall Human Development Index. Thus, this study tries to bridge paucity of the exist research with a structural and integrated approach. The researchers examine the sustainability of development by simultaneously investigating the intricate relationship between economic growth, per capita income, the unemployment rate, human development, and environmental quality. It is hoped that this approach can make an empirical contribution and appropriate policy recommendations for sustainable and inclusive regional development.

3. Research Method

A quantitative method is employed in this study which is intended to evaluate the dynamics development of regional sustainability in Central Sulawesi Province. The analysis was conducted through two main stages, namely the preparation of the Sustainable Development Index (SDI) and quadrant mapping, as well as inferential analysis based on panel data regression to explain the structural mechanisms that affect sustainability variation between regions. The secondary data around 2021–2024-year period was utilized which derived from the Central Statistics Agency (BPS), the Environment Agency, as well as official publications related to sustainable development. The results of the analysis is depicted in Table 1.

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Tabel 1. Variable Operationalization and Data Sources of the Research

Variable	Variable Operationalization	Data/Indicators	Data Source
Sustainable Development Index (SDI) (Dependent Variable)	A composite index that measures the level of sustainability of regional development based on the integration of economic, social, and environmental dimensions	Index of normalization results and weighting of economic, social, and environmental indicators (scale 0–1)	The results of the researcher's processing are based on BPS and the Environment Agency
Economic Growth (G)	Growth rate of Gross Regional Domestic Product (GDP) on A Constant Price Basis 2010	Annual GDP growth percentage (%)	BPS Central Sulawesi Province
GDP/capita (GDPcap)	Average regional income per capita	GDP per capita (rupiah)	BPS Central Sulawesi Province
Human Development Index (HDI)	A composite index that describes human development achievements through the dimensions of education, health, and living standards	Annual HDI value (index)	BPS Central Sulawesi Province
Open Unemployment Rate (OUR)	Percentage of the workforce that is not working and is looking for work	Open unemployment rate (percent)	BPS Central Sulawesi Province
Regional Environmental Quality Index (EQI)	An index that reflects the environmental quality conditions of the region	Regional environmental quality index (index)	Environment Agency / KLHK

Descriptive analysis to provide a map of development sustainability in Central Sulawesi using the sustainability quadrant. The analysis is carried out using min-max normalization (to measure between 0 and 1) to be fairly compared with the following formulations:

$$\text{Normalization Value} = \frac{\text{Indicator Value} - \text{Min Value}}{\text{Max Value} - \text{Min Value}} \text{ x } 100 \quad \text{.....(1)}$$

The calculation of the Sustainable Development Index uses the following entropy weight formula:

$$wj = \frac{(1-Ej)}{\sum_{i=n}^{n}(1-Ej)} \quad \text{.....(2)}$$

Where: wj: Weights calculated for indicator j, which describes the contribution of the indicator to the overall index. Ej: The entropy value for indicator j that measures the diversity of data for that indicator. The entropy formula for the Ej indicator is:

$$E_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij} \quad \text{.....(3)}$$

Where pij is the proportion of the data value i for indicator j, which is calculated as:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad \text{.....(4)}$$

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Where xij is the data value for indicator j in unit i, and m is the number of units (districts). k is a constant used to normalize the value of entropy, that is: $k = \frac{1}{\ln(m)}$, $\sum_{i=1}^{n}(1 - E_j)$ Summing of the components (1-Ej) for all indicators j. This is to get the total contribution of all indicators to the sustainability index.

The results of the calculation of the sustainability index were then analyzed using a sustainable and continuous quadrant framework, which came from the Triple Bottom Line (TBL) approach and the perspective of structural area development. This quadrant analysis is not just a descriptive mapping method but also serves as an analytical tool to understand the dynamics of regional development through the interaction and imbalance between economic, social, and environmental aspects. The results of the calculation were further analyzed using the following continuous quadrants:

a. Quadrant I (Ecological Civilization), if social, economic, and environmental indicators are in a balanced condition
b. Quarter II (Underutilized): Unoptimized Resources, if the environment is in good condition, but the welfare of the community is still relatively low
c. Quadrant III (Over-Exploitation), if the welfare of the community is high, but achieved at the expense of the environment
d. Quadrant IV (Ecological Emergency), if welfare is low and the environment is in a degraded condition

Inferential Analysis to measure the influence of independent variables (GDP Rate, GDP per capita, Human Development Index, open unemployment rate, and Regional Environmental Quality Index on Development Sustainability. General model of equations for multiple linear regression (Wahyudi, 2020):

$$Y_i = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \alpha_i + \mu_{it} \quad \text{..... (5)}$$

Where: Y is the bound variable, X is the independent variable, i is the cross-section, t is the time series data, α is the cross-section difference value, and μ is the interference error. The equation is applied through five predictors, namely:

$$SDIit = \beta_0 + \beta_1 G_{it} + \beta_2 PGDPcap_{it} + \beta_3 HDI_{it} + \beta_4 OUR_{it} + \beta_5 EQI_{it} + ei \quad \text{.....(6)}$$

Where Y is the Development Sustainability Index, G is economic growth, GDP/cap is per capita income, HDI is the Human Development Index, TPT is the Open Unemployment Rate, IKLHD is the regional Environmental Quality Index, β is the partial regression coefficient, and e is the disruptive variable.

The selection of the best model is carried out through the Chow test, Hausman test, and Lagrange Multiplier (LM) test to ensure the compatibility of the model specifications with the data characteristics of the panel. The Fixed Effects model is chosen when there is a correlation between individual effects and independent variables, indicating structural and spatial heterogeneity between regions. To improve methodological accuracy, regression estimation is complemented by standard diagnostic tests, including multicollinearity testing and the use of robust error standards against heteroscedasticity. The analysis of panel data parameters used Common Effect (CE), Fixed Effect (FE), and Random Effect (RE) models. Common Effect (CE) uses the Ordinary Least Squares (OLS) Panel approach, which assumes that the behavior of cross-sectional data differs over time, with the following formulations:

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$$Y_{it} = \beta_0 + \beta X_{it} + \varepsilon_{it} \quad \text{.....(7)}$$

Where Yit is the variable bound to the first unit of observation and time, Xit is the independent variable of the first unit of observation and its time, β is the coefficient of the variable, β0 is the intercept, and Ɛ is the error component of the unit of observation.

Fixed Effect (FE) uses the Least Squares Dummy Variable (LSDV), which assumes that differences between individuals can correlate with independent variables. Formulation as follows:

$$Y_{it} = \beta_0 + \alpha_1 + \sum_{k=2}^{N} a_k D_{ki} + \beta X_{it} + \varepsilon_{it} \quad \text{.....(8)}$$

Random Effect (RE) uses the Generalized Least Squares (GLS) approach, which assumes that differences between individuals should not correlate with independent variables. Formulation as follows:

$$Y_{it} = \alpha_i + \beta X_{it} + \varepsilon_i \quad \text{.....(9)}$$

The selection of the best model from the data regression estimation of the panel data will be tested by the Chow, Hausman, and LM tests. The hypothesis for the Chow Test is as follows:

H_0: Fixed effect (FE) not required

H_1: Fixed effect (FE) required.

Hypothesis for the Hausman Test:

H_0: Random effect (RE) is more efficient

H_1: Fixed effect (FE) is more efficient

Interpretation:

If the p-value < 0.05, then H_0 is rejected, which indicates that Fixed effect (FE) is better used.

If the p-value > 0.05, then H_0 is accepted, which indicates that the Random effect (RE) can be used.

Hypothesis for LM Test:

H_0: Common Effect (CE) is more appropriately used.

H_1: Fixed effect (FE) and Random effect (RE) are more accurately used

Interpretation:

If the p-value < 0.05, then H_0 is rejected, which indicates that the Fixed effect (FE) and Random effect (RE) are more appropriately used.

If the p-value > 0.05, then H_0 is accepted, which indicates that Common Effect (CE) is more appropriately used.

4. Results and Discussion

Central Sulawesi Province is an administrative region consisting of 12 districts and 1 city. Geographically, Central Sulawesi Province has an area of ±61,841 km^2 with a pluralistic topography ranging from coasts, valleys, lowlands, to mountains. Central Sulawesi Province has an important role as a link for the mobility of goods and services because of its strategic location as a central hub on the island of Sulawesi.

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Data analysis of the Sustainable Development Index (SDI) and the Sustainability Quadrant

In this study, the results of the Sustainable Development Index (SDI) revealed that there is a significant variation in achievements between districts/cities in Central Sulawesi Province during the 2021–2024 period. Palu City stands out with the best performance, achieving an average SDI value of 0.63, which reflects its position as a center of economic, government, and public service activities. In regional development theory, core areas generally have a higher concentration of economic activity, institutional capacity, and better quality of human resources. In regional development theory, core areas generally have a higher concentration of economic activity, institutional capacity, and better quality of human resources. Therefore, they can connect economic, social, and environmental dimensions in a more balanced manner compared to peripheral areas (Capello et al., 2024; Todaro & Smith, 2015). These findings confirm that the achievement of sustainable development depends not only on the amount of economic output, but also on the structural ability of the region to manage the development process holistically.

Morowali Regency also showed a high SDI achievement with a score of 0.59 and experienced an upward trend since 2022, but this pattern reflects rapid economic growth driven by industrialization and investment, which has not been fully accompanied by social and environmental sustainability. From the perspective of the Triple Bottom Line, economic growth that is not balanced with the strengthening of social aspects and good environmental management shows that there is trade in development that can lead to long-term unsustainability (Awais et al., 2019; Perrings & Ansuategi, 2000). It emphasizes that the success of an economy that relies on extractive sectors or heavy industries does not necessarily guarantee sustainable development if it is not supported by improved quality of human development and protection of the environment.

On the other hand, Banggai and Parigi Moutong Regencies showed the lowest SDI scores, namely 0.09 and 0.22, which indicate a weak integration of the sustainable development dimension. In the framework of regional development, this situation illustrates the low structural capacity of the region, such as the quality of human resources and limitations in creating added value of the local economy as well as weak labor absorption, which simultaneously hinder the improvement of welfare and sustainability of development (Todaro & Smith, 2015). Buol, Sigi, and North Morowali districts are in the medium category with SDI values between 0.37 and 0.40, which shows the potential for sustainable development, but is still affected by an imbalance between its dimensions. In aggregate, Central Sulawesi Province has an SDI score of 0.48, which shows that the main challenge in sustainable development is rooted in structural inequality between regions so that it requires a policy approach that is differentiatory and based on regional characteristics (Capello et al., 2024). Figure 1 depicts the results of the Sustainable Development Index (SDI) across various regions in Central Sulawesi.

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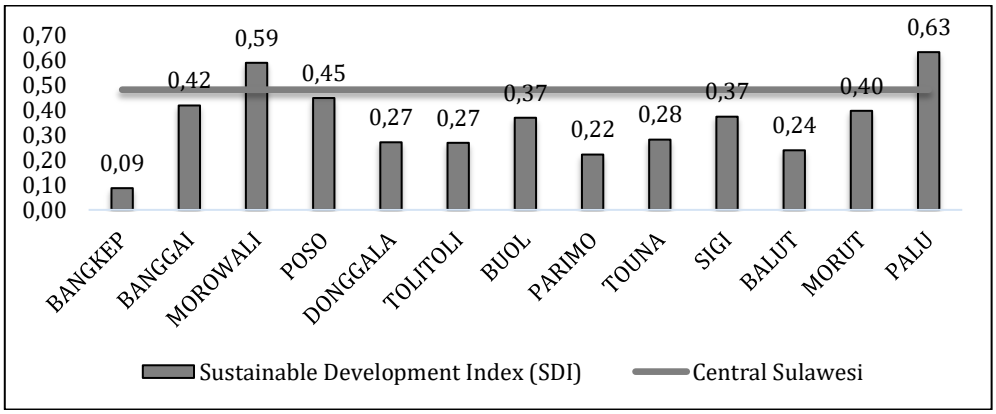

Figure 1. The average Sustainable Development Index (IdPB) of districts/cities in Central Sulawesi Province

Source: Central Sulawesi Provincial Environment Agency (data reprocessed)

The results of the quadrant analysis using the Central Sulawesi Province area as a benchmark have a Socio-Economic Index (SEI) of 0.33 and an Environmental Quality Index (EQI) of 0.91. The development sustainability quadrant of 13 districts and cities can be seen in Table 2.

Table 2. Analysis of the Sustainable Development Quadrant of City Regencies in Central Sulawesi Province in 2021-2024

Regency/city	Socio-Economic	Environment	Quadrant Position	Brief Interpretation
Bangkep	0,01	0,00	Quadrant IV - Ecological Emergency	Very low on both dimensions; Needs comprehensive intervention.
Banggai	0,22	0,92	Kuadran II – Underutilized	The environment is very good, socio-economic situation is not optimal.
Morowali	0,59	0,49	Quadrant III – Over-Exploitation	High economy, enormous ecological pressure.
Poso	0,27	0,89	Kuadran II – Underutilized	High environment, socio-economic enough, but still below the benchmark.
Donggala	0,06	0,74	Quadrant IV - Ecological Emergency	Basic services and environmental quality are still low.
Tolitoli	0,11	0,51	Quadrant IV - Ecological Emergency	Low on Socio-economic and Environmental, prone to lag.
Buol	0,13	0,93	Kuadran II – Underutilized	The environment is very strong, socio-economic needs to be improved.
Parimo	0,09	0,39	Quadrant IV - Ecological Emergency	Both are low; Requires a lagging alleviation strategy.
Touna	0,05	0,64	Quadrant IV - Ecological Emergency	Medium conditions but far from the benchmark; requires strengthening access to basic services.
Sigi	0,14	1	Kuadran II – Underutilized	The best environment in the province; Economic potential has not been maximized.

Regency/city	Socio-Economic	Environment	Quadrant Position	Brief Interpretation
Balut	0,09	0,32	Quadrant IV - Ecological Emergency	High vulnerability in the two dimensions of development.
Morut	0,43	0,03	Quadrant III – Over-Exploitation	The economy is growing, but the environmental damage is severe.
Palu	0,72	0,01	Quadrant III – Over-Exploitation	The economic center of the province but extreme environmental pressure.
Central Sulawesi (Benchmark)	0,33	0,91	Benchmark	Comparative standards for all districts/cities.

Source: Analysis of Microsoft Office, data reprocessed

The quadrant approach produces the identification of the relative position of each district/city based on the two main dimensions of sustainable development, namely the Socio-Economic Index (SEI) and the Environmental Quality Index (EQI). Based on the results of the analysis, there are no districts that are in Quadrant I (Ecological Civilization). Sigi and Buol Regencies have a high EQI but have not been followed by socio-economic development optimization, so that ecological benefits have not been fully translated into community welfare. Quadrant III (Over-Exploitation) shows the condition of SDI in Morowali Regency and Palu City, which illustrates the pressure of industrial activities, urbanization, and resource exploitation. This situation poses long-term sustainability risks if it is not balanced with environmental recovery and protection policies. Quadrant IV (Ecological Emergency) is occupied by Tojo Unauna, Tolitoli, Parigi Moutong, and Banggai Laut Regencies, which have low socio-economic achievements and unstable environmental quality, so they require comprehensive intervention through improving basic services, poverty alleviation, and strengthening environmental capacity. Overall, the quadrant approach reveals the need for differential development strategies, adjusting to the specific conditions of each region, so that the transformation towards sustainable development in Central Sulawesi can take place more inclusively, equitably, and insightfully. SDI quadrant mapping is presented in Figure 2

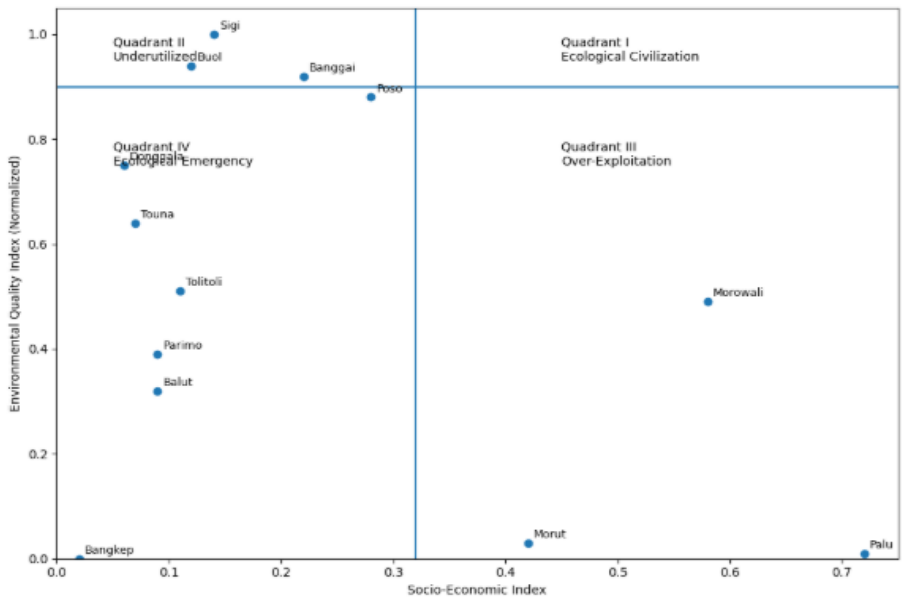

Figure 2. Sustainable Development Index Mapping Quadrant.

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The influence of variables of economic growth rate, GDP per capita, open unemployment rate, Human Development Index, and Regional Environmental Quality on sustainable development in Central Sulawesi.

Panel data regression analysis was carried out to measure the influence of variables of economic growth rate (G), GDP per capita (GDP/cap), open unemployment rate (OUR), Human Development Index (HDI), and Regional Environmental Quality Index (EQI) on development sustainability in Central Sulawesi. The results of the panel data analysis, which included analysis based on the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). The regression estimate of the panel data using Eviews 13 is presented as follows.

Table 3. Estimation of the CEM approach

Dependent Variable: SDI

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.035774	0.231283	-8.802085	0.0000
G	0.006904	0.002104	3.281296	0.0020
GDP/cap	0.038963	0.035683	1.091908	0.2806
HDI	0.021128	0.003471	6.087122	0.0000
OUR	0.030993	0.013380	2.316440	0.0250
EQI	0.007729	0.001297	5.957979	0.0000
R-squared	0.827835	Mean dependent var		0.353077
Adjusted R-squared	0.809122	S.D. dependent var		0.158766
S.E. of regression	0.069364	Akaike info criterion		-2.390719
Sum squared resid	0.221325	Schwarz criterion		-2.165575
Log likelihood	68.15868	Hannan-Quinn criterion.		-2.304404
F-statistic	44.23724	Durbin-Watson stat		0.854734
Prob(F-statistic)	0.000000			

Source: Eviews 13, data processed results.

The results of the CEM estimation in the table above show that the Sustainable Development Index (SDI) is significantly influenced by economic growth, human development, unemployment rate, and environmental quality, with a probability value of below 0.05 for each, so that these variables are proven to be the main determinants of regional sustainability. Economic growth contributes positively to the increase in SDI, meaning economic dynamics support the achievement of sustainability. HDI is the most powerful and significant factor, which confirms that the quality of education, health, and welfare of the population are the main foundations of sustainable development. EQI also has a positive and significant effect, showing that environmental quality has an important role in maintaining ecological balance that supports the socio-economic dimension. Meanwhile, OUR has a positive effect, which indicates that the structural dynamics of the labor market are in the economic recovery phase due to natural disasters and the COVID-19 pandemic. In contrast, GDP per capita has no significant effect, indicating that average income levels do not adequately explain the variation in sustainability between regions. With an R-squared value of 0.8278, the model is able to explain more than 82 percent of the SDI variation in a strong and significant way. Overall, based on the CEM estimates, this study emphasizes that human development, economic growth, and environmental quality are the main pillars in shaping regional sustainability in Central Sulawesi.

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Table 4. Estimation of the FEM approach

Dependent Variable: SDI				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.852088	0.969412	1.910528	0.0645
G	0.001973	0.002405	0.820294	0.4178
GDP/cap	0.020373	0.042395	0.480544	0.6339
HDI	-0.033739	0.013630	-2.475337	0.0185
OUR	0.041730	0.020386	2.047036	0.0484
EQI	0.008899	0.001416	6.285769	0.0000
Fixed Effects (Cross)				
BANGKEP—C	-0.281941			
BANGGAI—C	0.049347			
MOROWALI—C	0.263208			
POSO—C	0.184518			
DONGGALA—C	-0.194276			
TOLITOLI—C	-0.131518			
BUOL—C	-0.067697			
PARIMO—C	-0.146058			
TOUNA—C	-0.168371			
SIGI—C	-0.050331			
BALUT—C	-0.171719			
MORUT—C	0.078567			
PALU—C	0.636272			
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.927118	Mean dependent var		0.353077
Adjusted R-squared	0.890677	S.D. dependent var		0.158766
S.E. of regression	0.052494	Akaike info criterion		-2.788793
Sum squared resid	0.093693	Schwarz criterion		-2.113363
Log likelihood	90.50862	Hannan-Quinn criterion.		-2.529849
F-statistic	25.44172	Durbin-Watson stat		1.309042
Prob(F-statistic)	0.000000			

Source: Eviews 13, data processed results.

The results of the Fixed Effects (FE) model estimation show that the variation in the Sustainable Development Index (SDI) is strongly explained by a combination of economic, social, and environmental variables, with an R-squared value of 0.9271, indicating that it is 92.71 percent. Partially, the HDI variable has a negative and significant effect on SDI, with a value of p = 0.0185, which means that the increase in HDI has not been fully followed by an increase in overall sustainability, which can be influenced by disparities in basic services or regional internal inequality. OUR had a positive and significant effect with a value of p = 0.0484, indicating a structural variation in the labor market where an increase in labor force participation or the post-disaster transition phase caused a positive relationship with SDI. Meanwhile, environmental quality (EQI) is the strongest and most significant variable with a value of p = 0.0000. This explains that the ecological dimension plays a central role in the sustainability of district-city development in Central Sulawesi Province. However, the variables of economic growth (G) and GDP per capita do not have a significant effect, illustrating that the improvement of macroeconomic indicators has not been able to encourage sustainable development in Central Sulawesi. The fixed effect between regions shows a structural heterogeneity where Palu City, Morowali Regency, and Banggai Regency have a positive fixed effect, while other districts show a negative fixed effect. This difference shows that there is a

fundamental difference in the capacity of sustainable development between districts and cities in Central Sulawesi. Overall, based on the FE estimation model, it is emphasized that the sustainability of the region in Central Sulawesi Province is influenced by environmental quality, labor market dynamics, and social dimensions compared to traditional macroeconomic indicators.

Table 5. Estimation of the REM approach

Dependent Variable: SDI				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.430736	0.165390	-14.69701	0.0000
G	0.009409	0.001750	5.376744	0.0000
GDP/cap	0.006028	0.029187	0.206529	0.8373
HDI	0.025961	0.002071	12.53338	0.0000
OUR	0.017702	0.008585	2.062109	0.0449
EQI	0.010798	0.001029	10.48890	0.0000
Random Effects (Cross)				
BANGKEP—C	0.153187			
BANGGAI—C	-0.025824			
MOROWALI—C	-0.025413			
POSO—C	-0.169372			
DONGGALA—C	0.028791			
TOLITOLI—C	0.059730			
BUOL—C	-0.038151			
PARIMO—C	0.052708			
TOUNA—C	-0.086975			
SIGI—C	-0.048006			
BALUT—C	0.043081			
MORUT—C	-0.004921			
PALU—C	0.061165			
	Effects Specification			
Cross-section random				
	Weighted Statistics			
R-squared	0.727479	Mean dependent var	0.353077	
Adjusted R-squared	0.697857	S.D. dependent var	0.158766	
S.E. of regression	0.087270	Sum squared resid	0.350338	
Durbin-Watson stat	0.870959			
	Unweighted Statistics			
R-squared	0.433990	Mean dependent var	0.353077	
Adjusted R-squared	0.372467	S.D. dependent var	0.158766	
S.E. of regression	0.125770	Sum squared resid	0.727632	
Durbin-Watson stat	0.419347			

Source: Eviews 13, data processed results.

The results of the Random Effects (RE) estimation illustrate that the Sustainable Development Index (SDI) is significantly influenced by economic growth, human development, open unemployment rate, and environmental quality, where all these variables have a probability value below 0.05, except for GDP per capita, which is not significant with a value of p = 0.8373. Economic growth and HDI are the main driving factors for the increase in SDI, each with a positive and very significant coefficient that shows that economic acceleration and improvement of human quality have a real impact on the sustainability of inter-district-city development in Central Sulawesi. The EQI variable also has a positive and strong influence, which emphasizes that the ecological dimension has an important role in supporting balanced development. Conversly, OUR excerts a substantial influence but with a small coefficient,

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meaning that there are complex variations in the labor market at the district/city level. Meanwhile, GDP per capita has no significant effect, which shows that an increase in average income is not enough to drive sustainability without social and environmental factors. A balanced R-squared value of 0.727 means that about 72.7 percent of the SDI variation can be explained by the model. Random effects between districts/cities show variations in sustainability capacity, where Palu City, Tolitoli Regency, Parigi Moutong Regency, and Banggai Laut Regency have positive random effects, while Poso, Tojo Unauna, Sigi, and Buol Regencies show negative effects, which means that there are fundamental differences in socio-economic and ecological structures between regions. Overall, the RE model emphasizes that dynamic economic dimensions, human quality, and environmental quality are the main driving forces for sustainable development in Central Sulawesi.

Selection of the best models

The selection of the best models is through the Chow test and the Hausman test. The following is an estimate of the Chow Test.

Table 6. Chow Test Estimation

Redundant Fixed Effects Tests Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	3.859698	(12,34)	0.0009
Cross-section Chi-square	44.699874	12	0.0000

Source: Eviews 13, data processed results.

What stands out in the table of the Redundant Fixed Effects Test showed if the model with cross-section fixed effects was statistically better than the model without a fixed effect (pooled OLS), as shown by the Cross-section F value of 3.8597 with a probability of 0.0009 and the Cross-section Chi-square of 44.6999 with a probability of 0.0000, both of which were well below the significance threshold of 0.05.

Table 7. Hausman Test Estimate

Correlated Random Effects - Hausman Test Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	45.074273	5	0.0000

Source: Eviews 13, data processed results.

The Hausman test yielded a Chi-square value of 45.074 ($df = 5$; $p < 0.05$), so the null hypothesis was rejected and showed that the Random Effects model was inconsistent. Together with the results of the Chow test, these findings confirm that the Fixed Effects Model (FEM) is the most appropriate specification, indicating significant differences in interception between districts/cities and the importance of region-specific characteristics. Thus, FEM is better able to capture structural heterogeneity that is not observed related to social, economic, institutional, and geographical conditions between regions in Central Sulawesi.

The results of the FEM estimate show that the Sustainable Development Index (SDI) is jointly influenced by economic growth, GDP per capita, human development, unemployment rate, and environmental quality. Economic growth has only a very small impact on sustainability, while GDP per capita has a positive but limited effect. In contrast, the Human Development Index (HDI) is negatively correlated with SDI, suggesting that increased human

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development does not automatically promote sustainability in areas with structural inequality. The Open Unemployment Rate (OUR) shows a positive relationship with SDI, which reflects the dynamics of the labor market in transition and post-disaster areas. Among all variables, the Environmental Quality Index (EQI) had the strongest positive influence, which affirmed the central role of environmental conditions in shaping the sustainability of regional development. The estimation model is as follows:

SDI = 1.85208815331 + 0.00197288641995*G + 0.0203726379622*GDP/cap - 0.033738633338*HDI + 0.0417303593169*OUR + 0.00889892937548*EQI + [CX=F]

The regression equation shows that the Sustainable Development Index (SDI) is influenced by five main variables by considering the differences in the characteristics of each district/city through the Cross-Section Fixed Effects approach. The constant value of 1.8521 represents the base value of SDI when all independent variables are zero. The value of the G Coefficient (economic growth) of 0.00197 shows that every 1 percent increase in economic growth only increases the SDI by 0.00197 points, so the effect is relatively small. The GDP coefficient per capita of 0.02037 indicates that the increase in average income has a positive influence, but it needs to be tested for significance to understand its real contribution. The Human Development Index (HDI) variable has a negative coefficient of –0.0337, which means that the increase in HDI is followed by a decrease in SDI in the context of this model. This is likely due to the internal inequality of certain socio-economic areas. The Open Unemployment Rate (OUR) variable, with a coefficient of 0.04173, shows that the increase in the unemployment rate is positively correlated with SDI, which reflects the dynamics of the labor market in the research area as a transition or post-disaster area. Meanwhile, the Environmental Quality Index (EQI) variable has a coefficient of 0.00890, which means that improving environmental quality makes a positive contribution to regional sustainability. The presence of the [CX = F] sign indicates that each district/city has a different intercept, depicting structural heterogeneity that is not observed, so that this model is better able to capture the differences in characteristics inherent in each region in explaining the variation in sustainable development.

Discussion

The FEM analysis demonstrates that sustainability in Central Sulawesi stems from the complex interplay of economic, social, and environmental factors. However, the empirical results of this study do not fully support the traditional theoretical assumptions within the framework of the Triple Bottom Line which argue that improving the quality of human development and economic performance will automatically strengthen sustainability. The finding that the Human Development Index (HDI) has a negative and significant impact on the Sustainable Development Index (SDI) actually tests this assumption. These results indicate that improvements in the field of life, especially through education and health, do not always lead to an increase in economic capacity and a good environmental carrying capacity, especially in regions that experience structural inequality between regions. Therefore, the results of this study enrich the theory of sustainable development by emphasizing that human development must be seen from the context and is greatly influenced by ecological constraints, social infrastructure, and institutional capabilities in a region (Rahmawati et al., 2024).

Another theoretically important finding is the positive and significant relationship between the Open Unemployment Rate and the Sustainable Development Index, which differs from the common view that unemployment always negatively impacts sustainability. In the context of Central Sulawesi, this relationship reflects the dynamics of the region's economic

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structural transition, particularly in post-disaster areas and areas with industrial expansion, where changes in the labor structure are often accompanied by temporary imbalances in the labor market. These results enrich regional development theory by showing that unemployment can function as an indicator of structural change, not solely as a failure of development, as stated in the literature on the dynamics of development and employment (Ajayi et al., 2024; Picatoste & Rodriguez-Crespo, 2021).

In contrast, the Environmental Quality Index (EQI) emerged as the most dominant and significant variable in improving SDI, providing strong empirical support for ecological economic approaches and environmental carrying capacity theory. These findings emphasize that environmental quality is a binding constraint for sustainable development, so that economic and social progress will lose its durability if it is not supported by ecological stability. Thus, the results of this study improve the Triple Bottom Line framework by placing the environmental dimension not just as one of the pillars, but as the main foundation for the sustainability of regional development (Pourebrahim et al., 2023; Świąder et al., 2020).

The variables of economic growth (G) and GDP per capita that are insignificant also have important theoretical implications. These findings show that macroeconomic performance does not adequately explain the variation in development sustainability if it is not accompanied by a fair distribution of social benefits and environmental protection. This challenges the growth-oriented approach to development and reinforces the argument that sustainability requires quality growth, not just quantitative growth (Damayanti & Idris, 2024; Michael et al., 2019).

In addition, significant differences in interregion interceptions in the FEM model indicate the presence of structural heterogeneity and persistent spatial inequality. Palu City and Morowali Regency have a large positive fixed effect due to superior economic capacity, infrastructure, and spatial position, while most other districts show negative fixed effects reflecting structural lag. This pattern reinforces the core–periphery theory in regional development, which explains that inequality of development and sustainability is spatially inherent and dependent on the trajectory of regional development (path-dependent). These findings are also consistent with the results of the quadrant analysis, which shows that some regions achieve socio-economic progress at the expense of environmental quality, while other regions have ecological strength but have not been able to optimize socio-economic well-being.

Overall, by combining Fixed Effects-based panel regression analysis and a quadrant sustainability approach, the study not only provides policy implications, but also refines the theoretical framework of sustainable development and regional inequality. The results of this study confirm that sustainability inequality between regions is not a random phenomenon, but the result of systematic structural and spatial processes, so development theory and analysis need to explicitly consider regional context, ecological capacity, and structural dynamics in explaining development inequality and sustainability.

5. Conclusion

This research reveals that the sustainability of regional development in Central Sulawesi Province is shaped by structural and spatial dynamics, not solely by uniform economic progress. Quadrant analysis shows that most districts/cities are in a middle and unbalanced position, where achievements in the economic, social, and environmental dimensions do not develop simultaneously. This pattern shows that the sustainability of regional development is characterized by persistent trade-offs and asymmetry, which reflect differences in

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development capacity and diversified regional development trajectories, rather than just transitional or temporary conditions.

More importantly, the results of econometric estimation provide a theoretical understanding of the mechanisms underlying regional development inequalities. The finding that economic growth and GDP per capita are insignificant challenges the assumption of growth-oriented development alone. The negative relationship between the Human Development Index (HDI) and sustainability enriches the theory of human development by showing that improved education and health do not automatically improve sustainability when ecological capacity, institutional quality, and spatial justice are still limited. Similarly, the positive relationship between the Open Unemployment Rate (TPT) and sustainability reflects the dynamics of the labor market that are nonlinear in the context of the structural transformation of post-disaster and industrialization regions, so that unemployment does not necessarily represent development failures.

The role of environmental quality as the strongest determinant of the Sustainable Development Index (SDI) strengthens the theory of ecological economics and regional development that places environmental carrying capacity as a binding constraint for long-term sustainability. Together with the strong effects of inter-regional stays, these findings validate the core–periphery perspective and structural heterogeneity, which confirm that sustainability inequalities are spatially inherent and path-dependent. Overall, this study makes a theoretical contribution by refining the framework for sustainable development and regional development and shows that sustainability inequality between regions is not a coincidental phenomenon, but rather the result of structural interactions between economic structure, human development, labor dynamics, and ecological boundaries.

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References

Ajayi, A. J., Musa, I., & Ismail, Y. (2024). Nexus between Unemployment and Sustainable Development in Nigeria. *International Journal of Innovative Finance and Economics Research*, *12*(4), 96–110. https://doi.org/10.5281/zenodo.14243550

Alehile, K. S., Yakubu, A., & Ebeh, J. E. (2024). *Examining The Linkages Between Environmental Quality And Sustainable Development In Nigeria*. *12*(4), 1–20. https://doi.org/10.1142/S2345748124500234

Awais, M., Samin, T., Gulzar, M. A., & Hwang, J. (2019). The Sustainable Development of the China Pakistan Economic Corridor: Synergy among Economic, Social, and Environmental Sustainability. *Sustainability*, *11*(24), 7044. https://doi.org/10.3390/su11247044

Biggeri, M., Francescutto, A., Ferrone, L., & Ferrannini, A. (2025). Analysing Transitions Towards Sustainability and Human Development in European Regions. *Regional Studies, Regional Science*, *12*(1), 124–148. https://doi.org/10.1080/21681376.2025.2456489

ISSN (print) 1858-165X | ISSN (online) 2528-7672

BPS. (2024). *[Metode Baru] Indeks Pembangunan Manusia menurut Provinsi, 2022-2024*. Badan Pusat Statistik Provinsi Sulawesi Tengah. https://www.bps.go.id/id/statistics-table/2/NDk0IzI=/-metode-baru-indeks-pembangunan-manusia-menurut-provinsi.html

Capello, R., Caragliu, A., & Dellisanti, R. (2024). Integrating Digital and Global Transformations in Forecasting Regional Growth: The MASST5 Model. *Spatial Economic Analysis*, *19*(2), 133–160. https://doi.org/10.1080/17421772.2023.2278514

D'adamo, I., Di Carlo, C., Gastaldi, M., Rossi, E. N., & Uricchio, A. F. (2024). Economic Performance, Environmental Protection and Social Progress: A Cluster Analysis Comparison towards Sustainable Development. *Sustainability (Switzerland)*, *16*(12). https://doi.org/10.3390/su16125049

Daly, H. E. (2017). Toward Some Operational Principles of Sustainable Development. *Sustainability*, *2*, 291–296. https://doi.org/10.4324/9781315241951-26

Damayanti, M., & Idris. (2024). Determinants of Sustainable Development : Case Studies Middle and Advance Economic Countries in ASEAN Concept Sustainable Development. *Media Riset Ekonomi Pembangunan (MedREP)*, *1*(4), 671–679.

Geddam, S. M., Babu, T. M., Kanishka, K., Selvan, C., & N, N. (2024). *Quadrant Analysis of Sustainability: Understanding G20 SDG Performance*. https://doi.org/10.2139/ssrn.5034370

Jyoti, G., & Khanna, A. (2021). Does Sustainability Performance Impact Financial Performance? Evidence From Indian Service Sector Firms. *Sustainable Development*, *29*(6), 1086–1095. https://doi.org/10.1002/sd.2204

Khan, F., Sarwar, G., Khan, M. A., Noor, S., & Rehman, Z. U. (2024). Assessing the Link Between Environmental Quality and Life Expectancy in Developing Nations: An Empirical Analysis for Sustainable Development. *International Social Science Journal.* https://doi.org/https://doi.org/10.1111/issj.12553

Lim, C. J., Jo, J. H., & Kweon, D. (2025). Ecosystem Services–Based Spatial Prioritization of Uninhabited Island Forests in South Korea. *Forest Science and Technology*, *21*(4), 465–485. https://doi.org/10.1080/21580103.2025.2552249

Liu, Y., Zeng, C., Cui, H., & Song, Y. (2018). Sustainable Land Urbanization aand Ecological Carrying Capacity: A Spatially Explicit Perspective. *Sustainability (Switzerland)*, *10*(9), 1–16. https://doi.org/10.3390/su10093070

Michael, A., Korankye, B., Arthur, E. A., & Yeboah, E. D. (2019). The Impact of GDP Growth on Achieving Sustainable Development in Ghana. *International Journal of Academic Management Science Research*, *3*(3), 61–71.

Perrings, C., & Ansuategi, A. (2000). Sustainability, Growth And Development. *Journal of Economic Studies*, *22*(1/2), 19–54.

Picatoste, X., & Rodriguez-Crespo, E. (2021). *Decreasing Youth Unemployment as a Way to Achieve Sustainable Development* (Issue Ilo 1999, pp. 244–253). https://doi.org/10.1007/978-3-319-95867-5_61

Pourebrahim, S., Hadipour, M., Emlaei, Z., Heidari, H., Goh, C. T., & Lee, K. E. (2023). Analysis of Environmental Carrying Capacity Based on the Ecological Footprint for the Sustainable Development of Alborz, Iran. *Sustainability (Switzerland)*, *15*(10). https://doi.org/10.3390/su15107935

Qian, Y., Tang, L., Qiu, Q., Xu, T., & Liao, J. (2015). A Comparative Analysis on Assessment of Land Carrying Capacity With Ecological Footprint Analysis and Index System Method. *PLoS ONE*, *10*(6), 1–17. https://doi.org/10.1371/journal.pone.0130315

Rahma, H., Fauzi, A., Juanda, B., & Widjojanto, B. (2019). Development of a Composite Measure of Regional Sustainable Development in Indonesia. *Sustainability*, *11*(20), 5861. https://doi.org/10.3390/su11205861

Rahmawati, S., Kuncoro, M., Sading, Y., Lutfi, M., & Jaya, A. H. (2024). *The Impact Of Poverty,*

Malnutrition, And Household Income On Human Development In Central Sulawesi, Indonesia : A panel data analysis. *8*(13), 1–16.

Sachs., J. D. (2015). *The Age of Sustainable Development*. Columbia University Press.

Siddikee, M. N., Zahid, J. R., Sanjida, A., & Oshchepkova, P. (2022). Sustainable economic growth and unemployment nexus of SDG 2030: Bangladesh in Asia. *SN Business & Economics*, *2*(1), 12. https://doi.org/10.1007/s43546-021-00190-2

Skiter, N. N., Rogachev, A. F., Ketko, N. V., Simonov, A. B., & Tarasova, I. A. (2022). Sustainable Development of Enterprises in Conditions of Smart Ecology: Analysis of The Main Problems and Development of Ways to Solve Them, Based on Artificial Intelligence Methods and Innovative Technologies. *Frontiers in Environmental Science*, *10*(June), 1–9. https://doi.org/10.3389/fenvs.2022.892222

Świąder, M., Szewrański, S., & Kazak, J. K. (2020). Environmental Carrying Capacity Assessment The Policy Instrument and Tool for Sustainable Spatial Management. *Frontiers in Environmental Science*, *8* (November). https://doi.org/10.3389/fenvs.2020.579838

Todaro, M., & Smith, S. C. (2015). *Economic Development. In Economic Development*. *9571*(2), 12–17.

Wahyudi, S. T. (2020). *Konsep dan Penerapan Ekonometrika Menggunakan Eviews* (Monalisa (ed.); Kedua). PT RajaGrafindo Persada.

Wang, F., Gu, J., Wu, J., & Wang, Y. (2024). Perspective Taking and Public Acceptance of Nuclear Energy: Mediation of Trust In Government and Moderation of Cultural Values. *Journal of Cleaner Production*, *434*, 140012. https://doi.org/10.1016/j.jclepro.2023.140012

Xia, J., Wang, J., & Lai, Y. (2024). Development Strategy Based on Combination Typologies of Building Carbon Emissions and Urban Vibrancy—A Multi-Sourced Data-Driven Approach in Beijing, China. *Land*, *13*(7). https://doi.org/10.3390/land13071062

Yang, N., Li, J., Lu, B., Luo, M., & Li, L. (2019). Exploring The Spatial Pattern and Influencing Factors of Land Carrying Capacity In Wuhan. *Sustainability (Switzerland)*, *11*(10). https://doi.org/10.3390/su11102786