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Original Article

The Effect of Population Density and Forest Area on Regency/City GRDP in East Java Province in 2020–2024

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Abstract: *Gross Regional Domestic Product (GRDP) is a key indicator reflecting regional economic performance and a region's ability to manage its resources. Differences in demographic characteristics and environmental conditions across regions contribute to uneven development of GRDP in districts/cities, particularly in East Java Province, which has a highly diverse economic structure and land cover. Population density has the potential to drive economic activity through agglomeration effects, while the presence of forest land presents a dilemma between economic interests and environmental sustainability. Based on these conditions, this study aims to analyze the effect of population density and forest land area on GRDP in districts/cities in East Java Province during the 2020–2024 period. The study used balanced panel data covering 38 districts/cities with a total of 190 observations. The analytical method used was panel data regression using the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) approaches. The best model was selected using the Hausman test. The analysis results indicated that the Fixed Effect Model was the most appropriate. Partially, population density did not significantly affect GRDP after controlling for region-specific characteristics. Conversely, forest area has a negative and significant effect on the GRDP of regencies/cities in East Java Province. This finding confirms that differences in economic structure and regional characteristics play a dominant role in determining regional economic performance. The implications of this research demonstrate the importance of formulating regional economic development policies that are not solely oriented toward increasing output but also consider environmental sustainability and the specific advantages of each region.*

Keywords: *Forest Land, GRDP, Panel Data Regression, Population Density.*

I. INTRODUCTION

Regional economic development is a key pillar in supporting inclusive and sustainable national development. One of the most frequently used indicators to measure regional economic performance is Gross Regional Domestic Product (GRDP). GRDP not only reflects the level of economic output but also illustrates a region's capacity to manage its human and natural resources. East Java Province occupies a strategic position in the national economy as a major contributor to Indonesia's GDP. East Java's regional characteristics are highly heterogeneous, characterized by the presence of economic growth centers (such as Surabaya, Malang, and Sidoarjo) as well as natural resource and forestry-based regions (such as the Horseshoe and southern regions). This condition results in significant variation in GRDP performance between regencies/cities.

From a demographic perspective, population density is often viewed as a driving factor for economic growth through the mechanism of economic agglomeration. Agglomeration theory states that population concentration can increase productivity through transaction cost efficiencies, market expansion, and increased innovation. However, high population density can also lead to diseconomies of scale, such as congestion, environmental pressures, and a reduced quality of life, which can ultimately hinder economic growth.

In addition to demographic factors, the availability and utilization of forest land are crucial issues in regional development. Forest land serves a dual function: as an ecological support and as an economic resource. In regional development practices, a dilemma often arises between efforts to increase GRDP through economic expansion and efforts to preserve forests. The conversion of forest land to non-forest uses is often associated with short-term GRDP increases, but has the potential to cause long-term economic losses due to environmental degradation. The 2020–2024 period is an interesting time to study because the dynamics of economic recovery following the COVID-19 pandemic and the increasing attention to sustainable development issues shape it. Therefore, this research is crucial for understanding how population density and forest land area influence GRDP across districts/cities in East Java Province, while accounting for each region's specific characteristics.

II. LITERATURE REVIEW

A) Gross Regional Domestic Product (GRDP)

Gross Regional Domestic Product (GRDP) is the gross value added generated by all production units within a region during a specific period. In the context of regional economics, GRDP is used as a primary indicator to assess the level of economic progress and community welfare. Increases in GRDP are generally associated with greater employment opportunities, higher per capita income, and greater regional fiscal capacity.

B) Population Density From an Agglomeration

Agglomeration theory (Marshall, 1890; Fujita & Thisse, 2002) holds that the concentration of population and economic activity in a region can create economic benefits, including reduced production costs, increased labor productivity, and accelerated innovation diffusion. Within this framework, population density is seen as a driver of regional economic growth. However, urban economics theory also emphasizes the existence of an optimal limit to population density. When density exceeds a certain threshold, diseconomies of agglomeration arise, such as congestion, pollution, and limited infrastructure. These conditions can reduce economic efficiency and hinder GRDP growth.

C) Forest Land and Economic Growth

From a natural resource economics perspective, forest land is a natural capital that provides direct and indirect economic benefits. Sustainable development theory emphasizes that overexploitation of natural resources can increase economic output in the short term but reduce welfare in the long term. The Environmental Kuznets Curve (EKC) approach explains that in the early stages of development, increases in GRDP are often accompanied by environmental degradation, including a decrease in forest area. However, at certain income levels, communities and governments tend to increase conservation efforts. In a regional context such as East Java, differences in economic structures across regions lead to heterogeneous relationships between forest area and GRDP.

III. RESULTS AND DISCUSSION

A) Data Type and Source

This study uses secondary data in the form of panel data covering 38 regencies/cities in East Java Province during the 2020–2024 period. The variables used include:

- GRDP (LN_GRDP) as the dependent variable,
- Population Density (LN_DENSITY) as the independent variable,
- Forest Land Area (LN_LUAS_HUTAN) as the independent variable.

All variables are expressed in natural logarithmic form to reduce heteroscedasticity and facilitate the interpretation of elasticities.

B) Analysis Method

The analysis method used is panel data regression with three approaches: the Common Effect Model (CEM), the Fixed Effect Model (FEM), and the Random Effect Model (REM). The best model was selected using the Hausman Test.

The general model used in this study is:

$$LN\_GRDP\_it = \beta 0 + \beta 1\ LN\_DENSITY\_it + \beta 2\ LN\_FOREST\_AREA\_it + \varepsilon\_it$$

C) Descriptive Statistics

Table 1 presents descriptive statistics for the study variables for the 2020–2024 period. The average LN_GRDP value of 10.34 indicates a fairly high variation in the level of economic activity between districts/cities. LN_DENSITY has an average of 7.10 with a standard deviation of 0.89, indicating unequal population distribution between regions. LN_FOREST_AREA has the highest standard deviation, reflecting the differences in the characteristics of forest-based and non-forest areas in East Java Province.

Table 1. Descriptive Statistics of Research Variables

	LN_GDRP	LN_DENSITY	LN_FOREST_AREA
Mean	10.34308	7.104045	10.01262
Median	10.05824	6.806827	10.79094
Maximum	12.66915	9.074177	12.61471
Minimum	9.479871	5.686975	3.614964
Std. Dev.	0.678328	0.891783	2.216843
Skewness	1.359139	0.933629	-1.318094
Kurtosis	4.793238	2.550476	3.678415
Jarque-Bera	83.95417	29.20238	58.66036

Probability	0.000000	0.000000	0.000000
Sum	1965.186	1349.769	1902.397
Sum Sq. Dev.	86.96440	150.3073	928.8207
Observations	190	190	190

D) Model Estimation Result

Common Effect Model (CEM) The CEM estimation results show that population density and forest area have a positive and significant effect on GRDP. The LN_DENSITY coefficient of 0.668 indicates that a 1% increase in population density increases GRDP by 0.67%. Meanwhile, LN_FOREST AREA has a positive effect of 0.09%..

Table 2. Common Effect Model (CEM) Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.681496	1.107537	4.226945	0.0000
LN_DENSITY	0.668316	0.101718	6.570294	0.0000
LN_FOREST_AREA	0.091269	0.040919	2.230496	0.0269
R-squared	0.387248	Mean dependent var		10.34308
Adjusted R-squared	0.380695	S.D. dependent var		0.678328
S.E. of regression	0.533817	Akaike info criterion		1.598135
Sum squared resid	53.28758	Schwarz criterion		1.649404
Log likelihood	-148.8228	Hannan-Quinn criter.		1.618903

Fixed Effect Model (FEM): In the FEM model, LN_DENSITY has a negative coefficient (-0.027) and is not statistically significant. In contrast, FOREST AREA LN_DENSITY has a negative coefficient of -0.071 and is significant at the 5% level. This indicates that increasing forest area is correlated with decreasing GRDP, after controlling for the specific characteristics of each district/city.

Table 3. Fixed Effect Model (FEM) Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_DENSITY	-0.027436	0.051812	-0.529537	0.5972
LN_FOREST_AREA	-0.070817	0.007378	-9.598781	0.0000
KABKOTA="Kab. Bangkalan"	10.64428	0.366006	29.08226	0.0000
KABKOTA="Kab. Banyuwangi"	11.46682	0.326792	35.08905	0.0000
KABKOTA="Kab. Blitar"	10.98858	0.359361	30.57810	0.0000
KABKOTA="Kab. Bojonegoro"	11.78681	0.343141	34.34979	0.0000
KABKOTA="Kab. Bondowoso"	10.81555	0.336998	32.09379	0.0000
KABKOTA="Kab. Gresik"	12.21873	0.373038	32.75466	0.0000
KABKOTA="Kab. Jember"	11.07008	0.361181	30.64972	0.0000
KABKOTA="Kab. Jombang"	10.96744	0.378754	28.95660	0.0000
KABKOTA="Kab. Kediri"	10.79656	0.376211	28.69817	0.0000
KABKOTA="Kab. Lamongan"	10.90822	0.356029	30.63853	0.0000
KABKOTA="Kab. Lumajang"	10.95981	0.348265	31.46975	0.0000
KABKOTA="Kab. Madiun"	10.80053	0.351292	30.74517	0.0000
KABKOTA="Kab. Magetan"	10.84157	0.366829	29.55480	0.0000
KABKOTA="Kab. Malang"	11.26179	0.359727	31.30649	0.0000
KABKOTA="Kab. Mojokerto"	11.88230	0.382954	31.02799	0.0000
KABKOTA="Kab. Nganjuk"	10.73090	0.363588	29.51388	0.0000
KABKOTA="Kab. Ngawi"	10.65923	0.347905	30.63834	0.0000
KABKOTA="Kab. Pacitan"	10.89896	0.327224	33.30739	0.0000
KABKOTA="Kab. Pamekasan"	10.44572	0.372825	28.01777	0.0000
KABKOTA="Kab. Pasuruan"	12.13363	0.375018	32.35481	0.0000
KABKOTA="Kab. Ponorogo"	10.65636	0.352257	30.25165	0.0000
KABKOTA="Kab. Probolinggo"	10.96087	0.351738	31.16201	0.0000
KABKOTA="Kab. Sampang"	10.53288	0.359009	29.33872	0.0000
KABKOTA="Kab. Sidoarjo"	11.99209	0.423620	28.30863	0.0000
KABKOTA="Kab. Situbondo"	10.92053	0.327058	33.39017	0.0000
KABKOTA="Kab. Sumenep"	10.98633	0.341211	32.19807	0.0000
KABKOTA="Kab. Trenggalek"	10.81484	0.346174	31.24104	0.0000

KABKOTA="Kab. Tuban"	11.51902	0.346657	33.22885	0.0000
KABKOTA="Kab. Tulungagung"	11.14348	0.369703	30.14169	0.0000
KABKOTA="Kota Batu"	11.80171	0.380433	31.02178	0.0000
KABKOTA="Kota Blitar"	11.07582	0.441088	25.11020	0.0000
KABKOTA="Kota Kediri"	13.35550	0.440503	30.31874	0.0000
KABKOTA="Kota Madiun"	11.53245	0.450813	25.58145	0.0000
KABKOTA="Kota Malang"	11.87522	0.463819	25.60311	0.0000
KABKOTA="Kota Mojokerto"	11.16571	0.459573	24.29587	0.0000
KABKOTA="Kota Pasuruan"	10.95148	0.452311	24.21231	0.0000
KABKOTA="Kota Probolinggo"	11.11662	0.438512	25.35078	0.0000
KABKOTA="Kota Surabaya"	12.70982	0.474240	26.80037	0.0000
R-squared	0.996119	Mean dependent var		10.34308
Adjusted R-squared	0.995110	S.D. dependent var		0.678328
S.E. of regression	0.047436	Akaike info criterion		-3.074216
Sum squared resid	0.337523	Schwarz criterion		-2.390632
Log likelihood	332.0505	Hannan-Quinn criter.		-2.797306
Durbin-Watson stat	0.707885			

Random Effect Model (REM): The REM estimation results indicate that FOREST DENSITY has a positive but insignificant effect on GRDP. Meanwhile, FOREST AREA LN_DENSITY has a negative effect and is significant at the 5% level. The consistent direction of the forest area coefficient between the FEM and REM indicates a structural relationship between forested area characteristics and GRDP levels.

Table 4. Random Effect Model (REM) Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.76377	0.353717	30.43048	0.0000
LN_KEPADATAN	0.043293	0.046102	0.939055	0.3489
LN_LUAS_HUTAN	-0.072732	0.007293	-9.972532	0.0000
	Effects Specification			
			S.D.	Rho
Cross-section random			0.539426	0.9923
Idiosyncratic random			0.047436	0.0077
	Weighted Statistics			
R-squared	0.342583	Mean dependent var		0.406447
Adjusted R-squared	0.335552	S.D. dependent var		0.059914
S.E. of regression	0.048838	Sum squared resid		0.446024
F-statistic	48.72322	Durbin-Watson stat		0.543354
Prob(F-statistic)	0.000000			
	Unweighted Statistics			
R-squared	0.220826	Mean dependent var		10.34308
Sum squared resid	67.76038	Durbin-Watson stat		0.003577

Table 5. Summary of Panel Data Model Estimation Results

Variable	CEM	FEM	REM
LN_DENSITY	0,668***	-0,027	0,043
LN_FOREST_AREA	0,091**	-0,071***	-0,073***
R-squared	0,387	0,996	0,343

Note : *** significant at 1%, ** significant at 5%

E) Selecting the Best Model

Based on the Hausman Test, the Chi-Square probability value is 0.0013 (<0.05), so the most appropriate model to use is the Fixed Effect Model. This indicates that there are significant differences in characteristics between districts/cities that need to be controlled for in the model.

Table 6. Hausman Test Result

Correlated Random Effects - Hausman Test			
Equation: Untitled			
Test cross-section random effects			
Cross-section random	13.219435	2	0.0013

F) Discussion

The estimation results show that, after controlling for district- and city-specific characteristics using a fixed-effects model, population density has no significant effect on GRDP. This finding indicates that population growth alone does not automatically improve regional economic performance. Within the context of agglomeration theory, these results demonstrate that the benefits of agglomeration are highly dependent on the quality of the population and the structural capacity of the region. High population density, unmatched by quality human resources, adequate infrastructure, and a productive economic structure, has the potential to put pressure on the labor market and public services, thus preventing the positive effects of agglomeration from being optimally realized.

Empirically, this condition is relevant to the characteristics of several regions in East Java that have experienced increasing population density but remain dominated by sectors with relatively low productivity. This results in a greater share of the additional population being absorbed by the informal sector, whose contribution to GRDP is relatively limited. Therefore, the results of this study reinforce the view that population density will only have a positive impact on GRDP if accompanied by improvements in human resource quality, inclusive industrialization, and increased regional institutional capacity.

Conversely, forest area has been shown to have a negative and significant effect on GRDP. These findings indicate that districts/cities with a large proportion of forest land tend to have more limited economic space for expansion of the industrial and service sectors, which have historically been the primary drivers of GRDP growth. Within the development-environment trade-off framework, these results reflect the classic regional development dilemma, in which environmental conservation efforts often clash with demands for short-term increases in economic output.

However, the negative relationship between forest area and GRDP cannot be interpreted as justification for massive forest conversion. Forests play a strategic role in maintaining long-term economic sustainability through the provision of environmental services, ecosystem stability, and disaster risk reduction. Furthermore, environmental pressures resulting from forest degradation have the potential to incur high economic costs, which in the long term can actually reduce community welfare and regional economic performance.

In the context of East Java, these research results reflect differences in economic structure between regions. Districts/cities based on industry and services, particularly in metropolitan areas and key economic corridors, tend to have higher GRDP than regions that still rely on the primary sector and have extensive forest cover. Therefore, regional development strategies cannot be standardized; they must be tailored to each region's characteristics and potential. The policy implications of these findings emphasize the importance of a development approach oriented toward increasing added value, rather than solely focusing on the physical expansion of economic space. Green economic development, ecotourism, and the utilization of environmental services can be strategic alternatives for areas with extensive forest cover to drive economic growth without sacrificing ecological functions. Integrating economic and environmental policies is key to promoting inclusive and sustainable economic growth in East Java Province.

IV. CONCLUSION

This study provides a more comprehensive understanding of the relationship between population density, forest area, and regional economic performance, as represented by Gross Regional Domestic Product (GRDP) at the district/city level in East Java Province. Using a panel data approach and a Fixed Effect Model (FEM), this study captures the specific characteristics of each region that cannot be explained through simple cross-sectional or time series analysis. The results show that population density does not significantly influence GRDP after controlling for regional fixed effects. This finding indicates that population size or density alone are not the primary determinants of regional economic growth. The impact of population density on GRDP is highly dependent on the quality of human resources, infrastructure capacity, and the region's developing economic structure. In other words, population density can only become an economic driver if it is accompanied by high labor productivity and the region's ability to absorb labor into value-added sectors.

Conversely, forest area has been shown to have a negative and significant impact on GRDP. This result reflects a trade-off between short-term economic development and the availability of inherently conservative natural resources. Regions with a large proportion of forest have relatively limited space and activity in the industrial and service sectors, which have historically been the main contributors to GRDP. However, this finding cannot be interpreted as justification for the conversion or massive

exploitation of forests, given forests' role as natural capital that supports long-term economic and environmental sustainability. In the context of regional development in East Java, this study's results confirm the heterogeneity of economic structures across regencies/cities.

Regions with a base in industry and services tend to have higher GRDP levels than regions relying on primary sectors such as agriculture and forestry. Therefore, regional development strategies cannot be standardized; they must be tailored to each region's characteristics and resource potential. The policy implication of this research is the need for a shift in development paradigm from simply increasing GRDP to more inclusive and sustainable economic development. In regions with high population density, policies should focus on improving the quality of human resources, fostering innovation, and driving structural economic transformation. Meanwhile, in regions with large forest areas, development strategies should focus on increasing added value through a green economy, environmental services, and sustainable natural resource management, without sacrificing forests' ecological functions. Overall, this research enriches the regional economics literature by demonstrating that the relationship between demographic factors, land use, and economic performance is complex and contextual. These findings are expected to provide a basis for formulating more adaptive regional development policies that balance economic growth and environmental sustainability and are relevant to regional conditions.

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