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The Development Transformation Changes Of Urban-Rural Interaction Patterns

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ABSTRACT: This study examines how development transformation has reshaped interaction patterns between urban and rural areas in the Special Region of Yogyakarta, Indonesia. A mixed-methods approach is employed, utilizing Village Potential (PODES) data from 2000 and 2018. The Coefficient of Variation (CV) quantifies disparities in the provision of essential facilities and infrastructure across villages, while regression analysis is utilized to discern critical factors affecting population distribution and concentration at the village level, reflecting development dynamics. The results reveal a structural shift from service-based development toward an economy-driven transformation, in which income diversification, access to Rural Credit Banks (BPRs), and digital infrastructure via Base Transceiver Stations (BTS) are pivotal. Marginal analysis further demonstrates that changes in health infrastructure, traditional markets, and road quality are the primary factors influencing population change from 2000 to 2018. Primary education facilities are relatively evenly distributed across villages; nonetheless, disparities in access to secondary education persist. Overall, rural development in Yogyakarta has evolved toward a more inclusive, interconnected pattern, underscoring the need for policies that strengthen urban-rural linkages by improving health infrastructure, transportation, and financial inclusion in rural areas.
Keywords: Urban-Rural Development, Rural Transformation, Economic Factors, Disparity, Yogyakarta.

***ABSTRAK**: Penelitian ini mengkaji bagaimana transformasi pembangunan telah mengubah pola interaksi antara kawasan perkotaan dan perdesaan di Provinsi Daerah Istimewa Yogyakarta, Indonesia. Pendekatan mixed-methods digunakan dengan memanfaatkan data PODES tahun 2000 dan 2018. Koefisien variasi (CV) digunakan untuk mengukur ketimpangan dalam ketersediaan fasilitas dasar, sementara analisis regresi digunakan untuk mengidentifikasi faktor-faktor utama yang memengaruhi distribusi dan konsentrasi penduduk di tingkat desa sebagai cerminan dinamika pembangunan. Hasil penelitian menunjukkan adanya pergeseran struktural dari pembangunan berbasis layanan menuju transformasi ekonomi, di mana diversifikasi pendapatan, akses terhadap Bank Perkreditan Rakyat (BPR), dan infrastruktur digital (BTS) memainkan peran penting. Analisis marginal lebih lanjut menunjukkan bahwa perubahan infrastruktur kesehatan, pasar tradisional, dan kualitas jalan merupakan faktor penentu utama perubahan populasi selama periode 2000 hingga 2018. Secara keseluruhan, pembangunan perdesaan di Yogyakarta berkembang menuju pola yang lebih inklusif dan saling terhubung sehingga diperlukan kebijakan yang memperkuat keterkaitan urban-rural melalui peningkatan infrastruktur kesehatan, transportasi, dan inklusi keuangan di kawasan perdesaan.*
***Kata Kunci:** Pembangunan Perkotaan-Perdesaan, Transformasi Perdesaan, Faktor Ekonomi, Kesenjangan, Yogyakarta*

INTRODUCTION

The relationship between urban and rural areas has undergone significant transformation driven by urbanization and regional development dynamics. Urban centers function as primary hubs of economic activity, characterized by dense populations, advanced infrastructure, and efficient service delivery that generate employment, foster innovation, and attract migration. Nevertheless, cities also depend on their surrounding rural areas for natural resources, food production, and ecosystem services (Castillo et al., 2023). Over time, this relationship has evolved from a hierarchical structure where cities acted as growth poles and villages as resource suppliers toward a more integrated and interdependent system (Tacoli, 2003; Wu et al., 2017).

The interaction between rural and urban areas not only creates opportunities for rural economic growth but also highlights the continuing importance of rural areas in sustaining urban development (Gillen, 2016). Previous studies suggest that increasing flows of population, capital, information, and technology have narrowed the urban-rural gap and strengthened interconnectivity (Irwin et al., 2009;Castles, 2011) Consequently, the geographical and functional boundaries between urban and rural areas have become increasingly blurred (Dymitrow & Stenseke, 2016; Ye et al., 2022), encouraging scholars to conceptualize urban–rural relations as an integrated system rather than a binary division (He et al., 2025).

Despite this growing conceptual consensus, empirical assessments of urban–rural integration remain fragmented. Most existing studies emphasize single dimensions of change without examining how multiple development dimensions evolve simultaneously and reshape interaction patterns over time. As a result, there is limited longitudinal evidence on how transformations in education, health, and economic resources collectively alter spatial inequality and rural well-being within an integrated urban-rural system.

Globally, urbanization remains a defining trend in settlement formation. In 2022, 57% of the worlds population resided in urban areas, a figure projected to reach 68% by 2050, with Asia and Africa experiencing the most rapid growth (UN DESA, 2022). These demographic shifts profoundly affect rural regions through land-use change, increased commuting, and widening socioeconomic inequality between urban and rural populations (World Bank, 2021). In developing countries, urban expansion often coexists with continued reliance on agriculture, producing hybrid livelihood strategies that combine agricultural and non-agricultural income sources (Tacoli, 2018). This pattern is particularly evident in Southeast Asia, where intensifying rural-urban interactions have further eroded the traditional rural–urban dichotomy (Rigg, 1998; Delgado et al., 2022).

Indonesia, as one of the world's most populous countries, is facing the challenge of accelerating urbanization. According to the 2020 Population Census, the urbanization rate reached 56.7% and is projected to approach 70% by 2045 (BPS, 2023; World Bank, 2019). This process is driven by both rural–urban migration and the administrative reclassification of villages into "urban villages," influenced by population density, land use, and service availability (Katherina, 2023). While urbanization promotes economic growth and social mobility, persistent disparities remain, especially regarding access to education, healthcare, and infrastructure (Wahyuni et al., 2022;Naufal et al., 2023; Zakiyyah, 2023). At the regional level, these disparities are reflected in uneven welfare outcomes across cities in Java, where life expectancy, educational attainment, and per capita expenditure continue to serve as key determinants of spatial welfare differences (Wardani et al., 2023). These disparities raise critical questions about whether development transformation has reduced or reproduced spatial inequality within urban–rural systems.

The Special Region of Yogyakarta (DIY) exemplifies this dual transformation. As an agrarian region evolving into a tourism and education hub, Yogyakarta faces rapid urban expansion that converts agricultural lands particularly in peri-urban areas into residential and commercial spaces (Gunawan et al., 2023; Puspitasari et al., 2021). While spatial modeling studies have highlighted the pace of land conversion and its environmental implications (Sarastika et al., 2024; Sasongko et al., 2024), less attention has been given to how development transformation affects urban–rural

interaction patterns through changes in access to education, healthcare, and economic resources across villages over time.

Urban–rural development can be understood as a dynamic process consisting of coordination as a guiding concept, integration as a process, and equality as a development goal (Li et al., 2015). Within this framework, interactions between urban and rural areas occur through the movement of people, goods, services, and information across spatial and economic boundaries (Partridge et al., 2007; Shafiei & Azharianfar, 2017). Although these linkages are essential for inclusive and sustainable development (World Bank, 2006); Baffoe et al., 2021), national development strategies often continue to treat urban and rural economies separately, thereby overlooking their interdependencies (Akkoyunlu, 2015).

Against this background, the central research problem addressed in this study is the limited empirical understanding of how development transformation has reshaped urban–rural interaction patterns in Yogyakarta over time. Specifically, it remains unclear how changes between 2000 and 2018 have altered spatial disparities in education, health, and economic resources across urban and rural areas, and which socioeconomic and infrastructural factors are most strongly associated with rural well-being within an increasingly interconnected system.

Accordingly, this study analyzes longitudinal Village Potential (PODES) data from 2000 and 2018, using the Coefficient of Variation (CV) to measure changes in spatial disparities and regression analysis to identify key socioeconomic and infrastructural factors associated with village population size and density, which serve as proxies for rural demographic dynamics and development outcomes. By integrating disparity measurement and econometric analysis within a single empirical framework, this study provides evidence on how income diversification, access to Rural Credit Banks (BPRs), and digital infrastructure (BTS) are associated with shifts toward a more inclusive and interconnected urban-rural development pattern in Yogyakarta. This study contributes to the literature by providing longitudinal, village-level evidence on how multidimensional development transformation reshapes urban-rural interaction patterns, an aspect that has received limited empirical attention in previous studies.

METHODS

This study adopts a mixed-methods approach, in which quantitative analysis is conducted first, followed by qualitative inquiry to deepen the interpretation of results. The analysis of urban–rural interaction patterns is undertaken at the village level. Quantitatively, urban–rural linkages are examined through indicators of infrastructure availability, public investment, access to finance, and the diversity of local economic activities. Following Berdegué, et.al (2015) , urban–rural linkages are conceptualized through three mechanisms, such as income gap (delta), poverty, and inequality. Income and poverty gaps are treated as proxies for welfare accumulation, while interregional gaps reflect how welfare is distributed across space. Accordingly, this study applies two analytical perspectives: (i) income gaps (delta) and poverty as indicators of welfare accumulation in relation to population size (Berdegué et al., 2015), and (ii) disparities between regions.

Disparities between regions are analyzed using the Coefficient of Variation (CV), with maps visualizations to clearly illustrate how spatial locations differ. Gaps are observed in the availability of infrastructure at the village level across 438 villages in DIY, based on PODES data from 2000 and 2018. The number of PLN customers in 2000 and 2019 is used to assess basic infrastructure related to electricity availability. Although the electricity data for 2019 does not perfectly align with the 2018 PODES observation period, it represents the closest available data point and is used as a reasonable approximation of electricity access conditions in the post-reform period. Specifically for 2018, the number of BTS (Base Transceiver Station) units is used as a proxy for communication and information infrastructure, with this data being available only in PODES 2018.

The enactment of Law No. 6 of 2014 on Villages (*Undang-Undang Nomor 6 Tahun 2014 tentang Desa)* marked a fundamental shift in village governance, fiscal decentralization, and development authority in Indonesia. The law strengthened village autonomy, expanded fiscal

transfers, and mandated broader responsibilities in infrastructure provision and local economic development. This study positions PODES 2000 as a pre-reform baseline and PODES 2018 as a post-reform observation period in order to capture medium-term structural adjustments following the implementation of the Village Law. The selection of 2000 is also methodologically grounded in data comparability, as key indicators of education, health, economic facilities, and basic infrastructure are consistently defined and measured across the 2000 and 2018 waves. Ensuring variable consistency is essential for reliable longitudinal disparity analysis. While more recent PODES data are available, this study prioritizes structural comparability and reform-based periodization rather than the most recent cross-sectional condition.

The concept of urban centers (urban villages) and growth centers (KPY villages) represent urban areas, while purely rural non-KPY villages represent rural areas although at this stage this analysis has not distinguished between KPY and non-KPY village areas. This analysis also includes the spatial aspect of distance traveled (km). Three analytical models are estimated using OLS regression with robust standard errors. First, a cross-sectional model is estimated using PODES 2000 data to examine the determinants of village population and population density in the pre-reform period. Second, a parallel cross-sectional model is estimated using PODES 2018 data to capture the post-reform condition. Third, a marginal (delta) model is applied to examine changes between 2000 and 2018, where both dependent and independent variables represent the difference between the two periods, thereby capturing the association between infrastructure changes and population dynamics over time. Population and population density serve as dependent variables, while independent variables comprise interest variables representing public service and infrastructure availability, and control variables accounting for broader socio-economic characteristics. The general formula for urban-rural interaction patterns is modified from Berdegué, et.al (2015).

$$Y = F(X_i, Z_i)$$

Where:
X_i = interest variable
Z_i = control variable
Y = total population or population density

The transformation of urban-rural welfare at the village level is then analyzed by qualitative analysis of the KPY and non-KPY villages sample in this study. The study examines 8 villages, consisting of 4 KPY villages and 4 non-KPY villages in Sleman and Bantul. Non-KPY villages, categorized as pure villages, are villages whose economic activities are dominated by the agricultural sector. The KPY sample area consists of KPY and non-KPY villages in Sleman Regency on the north and west sides of Yogyakarta City and KPY and non-KPY villages in Bantul Regency on the south and east sides of Yogyakarta City. The selection of KPY and non-KPY village samples is based on village characteristics of Yogyakarta Province, in terms of geographic location, community characteristics and economic-social-cultural potential.

Comparisons between geographies at the village level can help analyze urban-rural transformations and interactions (Georgios et al., 2021). Qualitative data are obtained from in-depth interviews with village leaders and village officials in eight sample villages. The qualitative component employed purposive sampling based on spatial representation to capture variation in urban–rural interaction patterns surrounding Yogyakarta City. Sample villages were selected to represent the northern, southern, eastern, and western corridors of the urban core, reflecting differences in development intensity, accessibility, and dominant economic activities. Within each spatial direction, both KPY and non-KPY villages were included to capture contrasts between growth-oriented and predominantly rural contexts. This spatially structured sampling strategy allows the analysis to reflect heterogeneity in urban–rural transformation across the Yogyakarta region rather than focusing on a single locality.

A total of 32 village management participants were involved, with each village represented by four village managers (lurah, ulu-ulu, pangripto and village leaders). Additionally, participants included

local government officials (provincial/district/city levels) and representatives from related institutions and initiators of village development acceleration programs in Yogyakarta Province such as BUMDES, Tourism Village, Village Entrepreneurship model G2RT village and Kaspak. The total number of participants in this study was 46. Qualitative analysis was facilitated using NVivo 20 software to code participants' responses and organize emerging themes. Three main themes emerged in explaining rural transformation and urban–rural interaction: (1) access and connectivity; (2) labor mobility; and (3) rural income and capital. The analysis presented in this section is based on participants' perspectives.

RESULTS AND DISCUSSIONS

Urban-Rural Development Transformation Shapes Inter-regional Linkage Patterns

First, the analysis begins with 32 OLS models combining data from 2000 and 2018. In addition, six models using a marginal (delta) specification were estimated to examine population changes between 2000 and 2018. The dependent variables are village population and population density, which capture demographic concentration at the village level. To examine how public service facilities and infrastructure influence population distribution, the analysis includes two sets of explanatory variables. Interest variables represent the availability and accessibility of public facilities, including education (number of primary, junior secondary, and senior secondary schools, with corresponding distances), health (number of hospitals and public health centers/Puskesmas, and distances to these facilities), and economic infrastructure (number of markets and distance to markets). Control variables account for socio-economic and infrastructure characteristics, including household access to electricity, road type, main income source categories, presence of public banks, and presence of credit recipients. These variables control for variations in economic structure, financial access, and basic infrastructure conditions across villages.

Table 1. Estimation Results of the Urban-Rural Development Transformation Model, 2000

Variable	Variable Description	Coef Population 2000	Coef Population Density 2000
e1_2000	Number of primary schools (2000)	1096.03***	-179.9018
e2_2000	Number of junior secondary schools (2000)	43.67771	-141.7909
edist2_2000	Distance to junior secondary school (2000)	71.86708	-13.34457
e3_2000	Number of senior secondary schools (2000)	87.73969	-191.2518
edist3_2000	Distance to senior secondary school (2000)	24.14735	1.410735
h_2000	Number of hospitals (2000)	-334.2163	-2215.441**
hdist_2000	Distance to hospital (2000)	-29.2903*	-75.79349***
pus_2000	Number of public health centers (Puskesmas) (2000)	407.649	82.28235
pusdist_2000	Distance to public health center (2000)	-50.08404	-123.3494*
mkt_2000	Number of markets (2000)	-310.0235	-222.5038
mktdist_2000	Distance to market (2000)	-22.4986	-37.17944**
pln_2000	Percentage of households with access to electricity (PLN) (2000)	8.087273	-19.0139
road_2000 (2)	Road type (2000)	-456.5037*	-331.7871*
road_2000 (3)		-348.2554	-1412.507
inc_2000 (3)	Main income source (2000)	-36.18527	8160.38***
inc_2000 (4)		3634.612***	15435.33***
inc_2000 (5)		4308.494**	10127.44***
1.f1_2000	Presence of public bank (dummy variable) (2000)	482.42	881.3701
1.f2_2000	Presence of credit recipients (dummy variable) (2000)	-432.4371	-1210.454**

_cons	Constant (2000)	1247.164	4535.652***

Notes

*** Significant at 1% level; ** Significant at 5% level; *Significant at 10% level

Table 1 presents the results of the most complete OLS model for the year 2000. The results indicate that several factors influence village population and population density in DI Yogyakarta. The number of primary schools has a positive and statistically significant effect on total population, suggesting that villages with more primary school facilities tend to sustain larger populations. In contrast, the availability and distance of junior and senior secondary schools do not significantly affect population outcomes, reflecting the relatively widespread access to these education facilities across villages.

Health infrastructure shows a notable influence on population distribution. While the number of hospitals does not significantly affect total population, greater distance to hospitals is negatively associated with both population and population density, implying that villages farther from hospital centers tend to have lower demographic concentration. Similarly, proximity to public health centers slightly enhances population density, though the number of centers is not significant. Among economic variables, distance to traditional markets negatively affects population density, indicating that villages closer to markets exhibit higher concentration of residents. Other economic measures, such as the number of markets, show no significant effect.

Control variables reveal that non-agricultural income sources, particularly wholesale/retail trade and restaurants, positively influence population outcomes, highlighting the role of economic diversification in supporting local population. Road quality and the presence of credit recipients also show modest effects on population density, while access to electricity and presence of public banks do not yield statistically significant impacts.

Table 2. Summary the Results of Urban-Rural Development Transformation Model, 2000

Model Type	Variables	Results	Description
MODEL YEAR 2000_POPULATION (Y_2000)	E1_2000	+ significant in all models and has ; the largest coefficient	OK
	E2_2000	+ is not statistically significant in all models and the coefficient is small	Inconsistent results with dependent Yd_2000
	Edist2_2000	+ is not statistically significant in all models and the coefficient is small	Inconsistent results with dependent Yd_2000
	E3_2000	+, although not statistically significant, the coefficient of large	OK
	Edist3_2000	+ is not statistically significant in all models and the coefficient is small	Consistent results with Yd_2000 dependent
	H_2000	+ on independent all var.interest, var.interest is combined with pln, road and the presence or absence of credit people. - when the var.interest model is combined with inc, the presence or absence of commercial banks and combined with all var.controls. Small and statistically significant coefficients only occur in the model independent of var.interest combined with all var.controls	Consistent results with Yd_2000 dependent
	Hdist_2000	- and significant in all models	Ok
	Pus_2000	+ not statistically significant, large coefficient when var.interest is combined with pln and inc	Inconsistent with

Model Type	Variables	Results	Description
			Yd_2000 model
	Pusdist_2000	- and insignificant in all models, small coefficients	Inconsistent with Yd_2000 model
	MKT_2000	- not significant in all models but in some models the coefficients are large (var.interest, and if var.interest is combined with var.pln, presence/absence of credit people and presence/absence of commercial banks).	Inconsistent with Yd_2000 model
	MKTdist_2000	- significant in the independent model of var.interest and if var.interest is combined with the presence/absence of a credit person and if va.interest is combined with all var.controls	OK
	PLN_2000	+ and not significant	Inconsistent with Y_2000 model
	Road_2000	- relative to road 1 as a base (asphalt road) and a large coefficient on road type 2 (paved gravel, stone).	Inconsistent with Y_2000 model
	Inc_2000	+ and statistically significant	OK
	F1_2000	+ and not significant (presence/absence of commercial banks)	consistent in sign with the Yd_2000 model
	F2_2000	- and insignificant (presence/absence of credit people)	consistent in sign with the Yd_2000 model
MODEL YEAR 2000_Population Density (Yd_2000)	E1_2000	- not significant in all models	Inconsistent with Y_2000 model
	E2_2000	- not significant in all models	Inconsistent with Y_2000 model
	Edist2_2000	- not significant in all models	Inconsistent with Y_2000 model
	E3_2000	+ in the var.interest model and if var.interest is combined with pln, F2 and F1 and the coefficient is large. - in the var.interest model combined with road, inc and combined with all var.controls. Statistical significance only occurs in the model of var.interest combined with road and F2	OK
	Edist3_2000	+ almost in all models except var.interest combined with road. Statistical significance only occurs in the model of var.interest combined with F1 and pln. The coefficient is small	Consistent results with Y_2000 dependent
	H_2000	+ on independent all var.interest, var.interest combined with pln, road and the presence or absence of credit people. - when the var.interest model is combined with inc, the presence or absence of commercial banks and combined with all var.controls. Small and statistically significant	Consistent results with Yd_2000 dependent

Model Type	Variables	Results	Description
		coefficients only occur in the model independent of var.interest combined with all var.controls	
	Hdist_2000	- except the var.interest model combined with pln and significant in almost all models	OK
	Pus_2000	+ when the var.interest model is combined with var.inc and combined with all var.control. - in the var.interest model, combined with var. pln, road, F1, F2. Large coefficients occur only in the var.interest model combined with road and F1, F2. Not statistically significant	Inconsistent with Y_2000 model
	Pusdist_2000	- and significant in the var.interest, var.interest combined with pln, F1 and F2 models. Large coefficients in the var.interest, pln and F2 models	Inconsistent with Y_2000 model
	MKT_2000	- is not significant in all models except the var.interest model. And the large coefficient is only in the var.interest model combined with F1	Inconsistent with Y_2000 model
	MKTdist_2000	- significant in almost all models	OK
	PLN_2000	+ and - when all models are combined, are not significant	Inconsistent with Y_2000 model
	Road_2000	+ and - when all models are combined, are not significant	Inconsistent with Y_2000 model
	Inc_2000		OK
	F1_2000	+ and not significant (presence/absence of commercial banks)	sign consistent with the Y_2000 model
	F2_2000	- and significant (presence/absence of credit people)	sign consistent with the Y_2000 model

Based on Table 2, two interest variables consistently influence both population and population density in 2000. The first is the number of senior secondary (high) school facilities, which has a positive and statistically significant coefficient in most models. This indicates that villages with a higher number of high school facilities tend to have higher population concentrations, highlighting the role of educational infrastructure in supporting local demographic concentration and potential socio-economic development. In contrast, the number of primary and junior secondary schools does not show a significant impact, likely because most villages already possess these facilities, making distance and availability less of a differentiating factor.

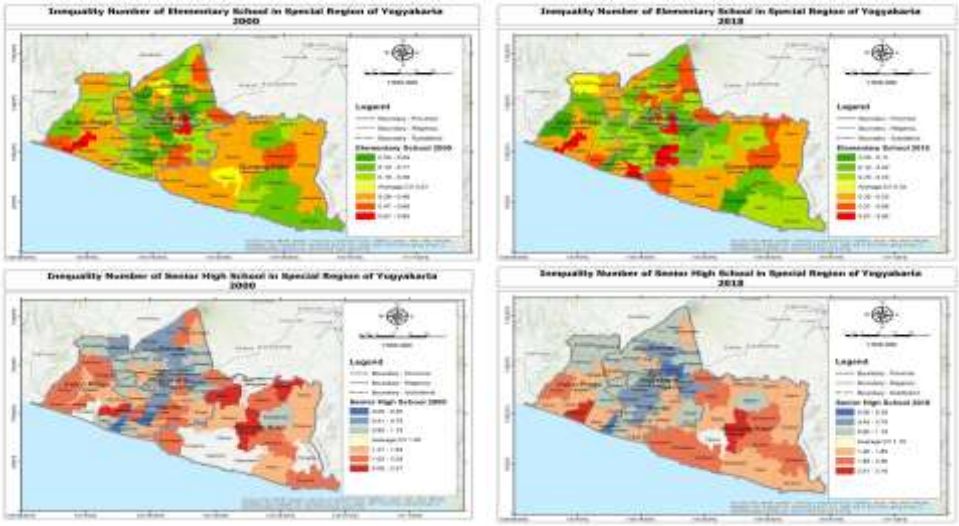

Figure 1. The Disparity of Primary and Secondary School Facilities, 2000 and 2018
Source: Podes 2000 & 2018

Disparities between regions can be seen from the coefficient of variation (CV) of the availability of several basic facilities. CV only describes the gap between villages in one sub-district and cannot be used as a comparison at the district/city or provincial level, but it can provide an idea of how much concentration of education facilities in an area by comparing the average CV in DI Yogyakarta Province in 2000 and 2018. The greater the CV value implies that the availability of facilities between regions is increasingly uneven or there is a concentration of facilities in the region. Figure 1 shows that primary school facilities are more evenly available than the senior high school facilities between 2000 and 2018, meaning that almost all village areas have primary school facilities but not all areas have senior high school facilities.

Secondly, the variable of village distance from hospital (km) denoted by Hdist_2000 has a negative sign. This indicates that villages located farther from hospital service centers tend to have lower population concentration. According to the BPS definition, a hospital health service center provides inpatient facilities and superior medical services compared to lower-tier health facilities like clinics and puskesmas (community health care). Hospitals are typically located in urban centers within districts or cities, while clinics and puskesmas are situated at the kecamatan or sub-district level, in 2000.

There is a disparity in hospital access between urban and rural populations in Indonesia, with urban populations having 1.49 times higher chances of obtaining outpatient services and 1.07 of using hospital inpatient facilities than rural populations (Wulandari et al., 2022). This finding is also consistent with several other study findings that distance to access health facilities is crucial (Bhangdia et al., 2022). Villages that are farther from health service centers tend to have higher health expenditures and poorer community health outcomes (Smith et al., 2013; Wasif et al., 2016). As an impact, rural communities have to travel longer to reach health facilities and obtain health services than urban communities (Andrilla et al., 2021) as was the case in Peru (Carrasco et al., 2022)

Third, the source of income as a control variable has a positive sign, indicating that the source of community income in the wholesale/retail trade and restaurant sectors has a statistically significant effect on the population. The majority of villagers' income sources were in the agricultural sector in 2000, while activities in the mining and quarrying sector in Yogyakarta Province were relatively few and only existed in the Kulon Progo and Sleman regions. In DI Yogyakarta Province, the proportion of village areas is larger than the urban areas, leading to urban characteristics (KPY) or urban villages (city) in urban areas, except in the City of Yogyakarta. Consequently, village income sources are predominantly from agriculture, followed by the manufacturing industry (factories and crafts), the wholesale/retail trade, restaurant, transportation, warehousing, and communication sectors.

Therefore, in 2000, income from agricultural sector was a crucial factor in determining the welfare of the community in the region.

For 2018, nine combination models were estimated using OLS regression, with population and population density as dependent variables. Among these, the ninth model represents the most complete specification, including all variables of interest and control variables. This model provides a comprehensive view of how public service facilities, economic infrastructure, and socio-economic characteristics relate to population distribution at the village level. Variables of interest include educational facilities (number of primary, junior secondary, and senior secondary schools, along with their respective distance measures), health facilities (number of hospitals and public health centers and distances to these facilities), and economic infrastructure (number of markets and distance to markets). These indicators aim to capture the role of accessibility and availability of services in shaping the spatial distribution of population. Control variables account for broader socio-economic and infrastructure characteristics, including access to electricity (percentage of households connected to PLN), road type, main income sources, and financial institutions (BTS, public banks, private banks, and rural credit banks/BPR). Inclusion of these controls allows for isolating the association between public service and economic infrastructure and population outcomes, while adjusting for structural differences among villages.

Table 3. Estimation Results of the Urban-Rural Development Transformation Model, 2018

Variable	Variable Description	Coef Population 2018	Coef Population Density 2018
e1_2018	Number of primary schools (2018)	1583.291***	-93.03529
e2_2018	Number of junior secondary schools (2018)	1179.847	252.9032
edist2_2018	Distance to junior secondary school (2018)	418.1058	-97.06225
e3_2018	Number of senior secondary schools (2018)	- 1242.562	-189.6944
edist3_2018	Distance to senior secondary school (2018)	- 262.1039	-51.97815
h_2018	Number of hospitals (2018)	1245.405	-474.0668
hdist_2018	Distance to hospital (2018)	- 15.3816	-40.0094***
pus_2018	Number of public health centers (Puskesmas) (2018)	1509.758	-902.8343*
pusdist_2018	Distance to public health center (2018)	- 72.20884	-147.7236***
mkt_2018	Number of markets (2018)	- 155.9074	-271.3614
mktdist_2018	Distance to market (2018)	- 11.33151	-124.0679**
pln_2018	Percentage of households with access to electricity (PLN) (2018)	- 77.93499	-10.72481**
road_2018	Road type (2018)	21.88285	775.626**
inc_2018 (3)	Main income source (2018)	2619.888	7812.444***
inc_2018 (4)		3134.187**	7471.017***
inc_2018 (6)		4358.593***	7452.189***
inc_2018 (7)		4850.465***	1461.209***
bts_2018	BTS (2018)	476.0118**	-59.16861
fjpublic_2018	Number of commercial banks (2018)	-668.8521*	-89.41.203
fjprivate_2018	Number of private banks (2018)	-512.5574*	797.3.164**
fjbpr_2018	Number of BPR Banks (2018)	2830.987	-136.1.347
_cons		2275.68	3588.834***

Notes

*** Significant at 1% level; ** Significant at 5% level; *Significant at 10% level

Based on Table 3, the most complete OLS regression examines the determinants of village population and population density using a set of public service and infrastructure variables. For population, the number of primary schools (E1_2018) remains positively significant, indicating a consistent association between the availability of primary education facilities and higher village population. In contrast, junior and senior secondary schools (E2_2018 and E3_2018), along with their respective distance measures, show largely insignificant coefficients, suggesting that at the village level, these educational facilities may have limited variation or accessibility is no longer a major determinant of population distribution.

Health facilities display mixed effects, the number of hospitals (H_2018) and public health centers (Pus_2018) have positive but mostly insignificant coefficients, whereas the distance to hospitals (Hdist_2018) and public health centers (Pusdist_2018) show negative associations, with Hdist_2018 statistically significant only for population density. These results imply that proximity to health services may still influence population concentration, although the magnitude is modest.

Economic infrastructure also exhibits differentiated impacts. Distance to markets (MKTdist_2018) is negatively associated with population density and statistically significant, indicating that villages located closer to traditional markets tend to exhibit higher population concentration. The number of markets (MKT_2018), however, remains insignificant, reflecting a shift in which proximity to economic facilities matters more than their sheer quantity in shaping population distribution.

Financial and communication infrastructure reveal further patterns. The number of BPR banks (FjBPR_2018) and BTS towers (BTS_2018) are positively associated with population and, in some models, significant, suggesting that microfinance availability and information-communication technology infrastructure may facilitate inter-village connectivity and influence settlement patterns. Meanwhile, the number of commercial and private banks (FjPublic_2018 and FjPrivate_2018) exhibits mixed or insignificant effects when combined with other controls, indicating their localized relevance. Access to electricity (PLN_2018) shows minimal influence, while improvements in road type (Road_2018) show a small positive effect on population density but are largely insignificant for total population.

Table 4. Summary the Results of Urban-Rural Development Transformation Model, 2018

Model Type	Variables	Results	Description
MODEL YEAR 2018_NUMBER OF POPULATION (Y_2018)	E1_2018	+ significant in all models and large coefficients	OK
	E2_2018	+ not Significant, large coefficients except in the model var.interest combined with var.inc and combined with all var.controls	Inconsistent results with dependent Yd_2018
	Edist2_2018	+ is not significant and the coefficient is small	Inconsistent results with dependent Yd_2018
	E3_2018	- insignificant and small coefficient	Inconsistent results with dependent Yd_2018
	Edist3_2018	- insignificant and small coefficient	Consistent results with dependent Yd_2018
	H_2018	+ significant in var.interest model combined with pln and road, large coefficients in road, pln, basic, Fj (public, private, BPR)	Relative OK
	Hdist_2018	- except for inc. Not significant and small coefficient	Inconsistent with model Yd_2018

Model Type	Variables	Results	Description
	Pus_2018	+ coefficient is large but not statistically significant	Inconsistent with model Yd_2018
	Pusdist_2018	- insignificant and small coefficient	Inconsistent with model Yd_2018
	MKT_2018	+ in almost all models except var.interest combined with var.BTS, FjBPR and combined with all var.controls	Inconsistent with model Yd_2018
	MKTdist_2018	+ in almost all models except var.interest combined with var.BTS, and combined with all var.control	OK
	PLN_2018	- and insignificant, small coefficient	Inconsistent with model Y_2018
	Road_2018	+ insignificant and small coefficient	
	Inc_2018	+ significant and large coefficient on inc_4,6 (wholesale/retail trade, restaurants and services sector)	OK
	BTS_2018	+ Significant and large coefficient on bts	OK, if on BTS itself
	FjPublic_2018	+ not significant and small coefficient	Inconsistent with model Yd_2018
	FjPrivate_2018	+ not significant and small coefficient	Inconsistent with model Yd_2018
	FjBPR_2018	+ Significant and large coefficient but becomes insignificant when var.interest is combined with all var.controls	OK, if fjBPR itself
MODEL YEAR 2018_Population density (Yd_2018)	E1_2018	- significant in all models except the var.interest model combined with all var.controls and small coefficients	Inconsistent results with dependent Y_2018
	E2_2018	+ not Significant, small coefficient	Inconsistent results with dependent Y_2018
	Edist2_2018	- insignificant and small coefficient	Inconsistent results with dependent Y_2018
	E3_2018	+ in the var.interest model, var.interest combined with pln, road and BTS while - in the inc, fjpublic, fjprivate and fjbpr models and if the var.interest model is combined with all var.controls, it is insignificant and the coefficient is small.	Inconsistent results with dependent Y_2018
	Edist3_2018	- insignificant and small coefficient	Consistent results with dependent Y_2018
	H_2018	+ in almost all models, except the var.interest model combined with inc, and combined with all var.controls. Not significant. The coefficients are almost all large except in the var.interest model combined with inc, fjprivate and with all var.controls.	Relative OK

Model Type	Variables	Results	Description
	Hdist_2018	- all models, significant all models despite small coefficients	OK
	Pus_2018	- significant except the combined var.interest and all var.control models, large coefficients in almost all models	Inconsistent with model Y_2018
	Pusdist_2018	- significant in all models, and small coefficients	OK but Inconsistent with model Y_2018
	MKT_2018	- significant although the coefficient is small	Inconsistent with model Yd_2018
	MKTdist_2018	+ in almost all models except var.interest combined with var.BTS, and combined with all var.control	OK
	PLN_2018	- and significant, small coefficient	OK but Inconsistent with model Y_2018
	Road_2018	+ is not significant on its own (large coefficient) but when combined with all var.control becomes significant (small coefficient)	but Inconsistent with model Y_2018
	Inc_2018	+ significant and large coefficient on inc_3,4,6,7 (processing industry, wholesale/retail trade, restaurants, services, and others)	OK
	BTS_2018	+ in bts model, - in combined model and not significant, small coefficient	OK, if bts itself is good
	FjPublic_2018	+ and the coefficient is large in the fjpublic model and significant, - in the combined model and the coefficient is small and insignificant.	OK, if in the combined model
	FjPrivate_2018	+ Significant and large coefficient	OK, but inconsistent
	FjBPR_2018	+ Significant in the fjBPR model, but - in the combined model and not significant.	OK, in the fjBPR model but not in the combined model

Based on table 4, nine combination models are analyzed using PODES 2018 data. sources of income were still primarily from the agricultural sector, although there was a downward trend compared to 2000. Other significant income sources included the manufacturing industry (factories, crafts), wholesale/retail trade and restaurants, services and others. This indicates that the source of income of a region in 2018 in DIY began to develop and diversify towards modern sectors such as the service sector.

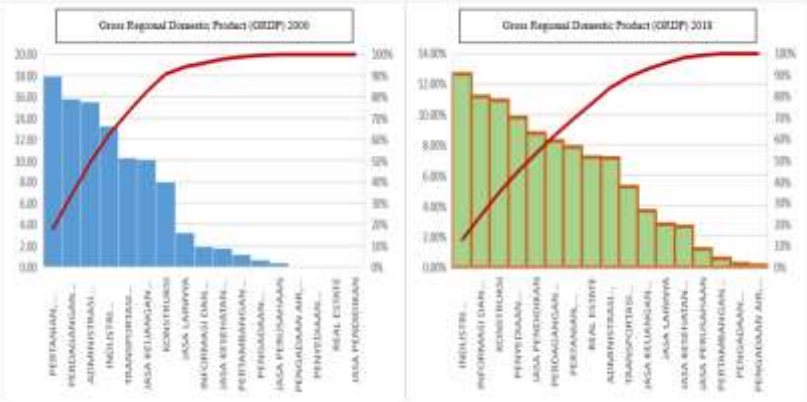

Figure 2. Contribution of DIY GRDP in 2000 and 2018
Source: BPS DI Yogyakarta

Based on Figure 2, the contribution of the agricultural sector has declined from 2000 to 2018, although it is still an important sector that contributes greatly to the GRDP of Yogyakarta Province. Other non-primary sectors such as manufacturing industry, information and communication, construction, provision of accommodation and food and beverages, and education services have significant contribution to the Yogyakarta GRDP in 2018.

At the village level, the difference in income sources between 2000 and 2018 is illustrated in Figure 3. Village areas that relied on the transportation, warehousing, and communication sector (5) in 2000 are no longer found in 2018. By 2018, some villages had shifted to relying on the services and other sectors. The transportation sector has relatively disappeared due to the establishment of the Trans Jogja consortium. The communication sector, which previously included public phone booths (*wartel*), had become non-existent by 2018. Other sectors have evolved and the transactions and activities within the sectors are undetectable by BPS, due to inability of BPS to capture high-tech activities.

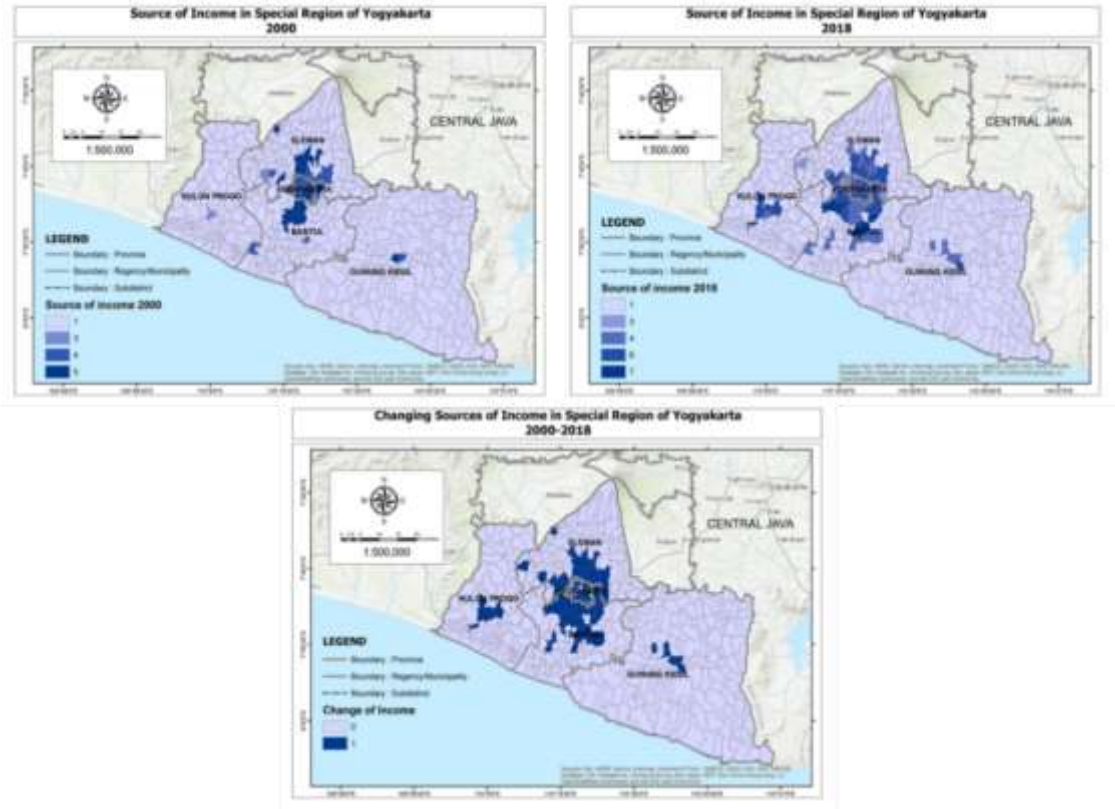

Figure 3. Regional Income Sources in 2000 and 2018
Source: Podes 2000 & 2018

Changes in the source of income from the primary sector to the secondary sector occurred in 2000 and 2018. It can be observed in the Figure 3. In 2018, almost all KPY village areas had secondary sectors as their source of income, as well as the urban in the city centers of Bantul, Sleman, Gunungkidul and Kulon Progo. However, other areas still relied on the primary sector.

Throughout the years, the distance between an area and the traditional market has become less relevant, as almost all villages already have a traditional market. The number of traditional markets, proxied by number of permanent buildings, was increasing during 2000 until 2018, as shown by the figure below. Rongkop, a sub-district in Gunungkidul has the largest gap in 2018, as it only has one traditional market with a permanent building in Pringombo village. In general, throughout the period of 2000 until 2018, the gap between regions is found to decrease.

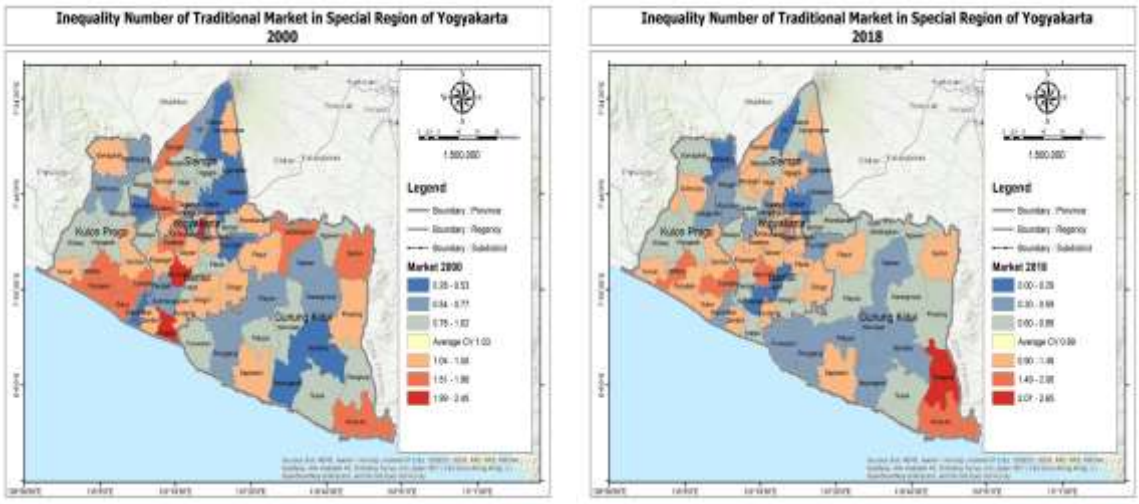

Figure 4. Gap in Traditional Market Facilities in 2000 and 2018
Source: Podes 2000 & 2018

An interesting finding is that the number of BPR banks is an important factor for the development of a region. The number of BPR banks is more than the number of commercial banks nationally from 2014-2021.

Table 5. Number of Commercial Banks and BPRs in Indonesia, 2014-2021

	Number of Banks							
Bank/Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Commercial Bank	119	118	116	115	115	110	109	107
BPR	1807	1799	1799	1786	1764	1709	1669	1632

Source: Financial Services Authority (OJK) cited by BPS

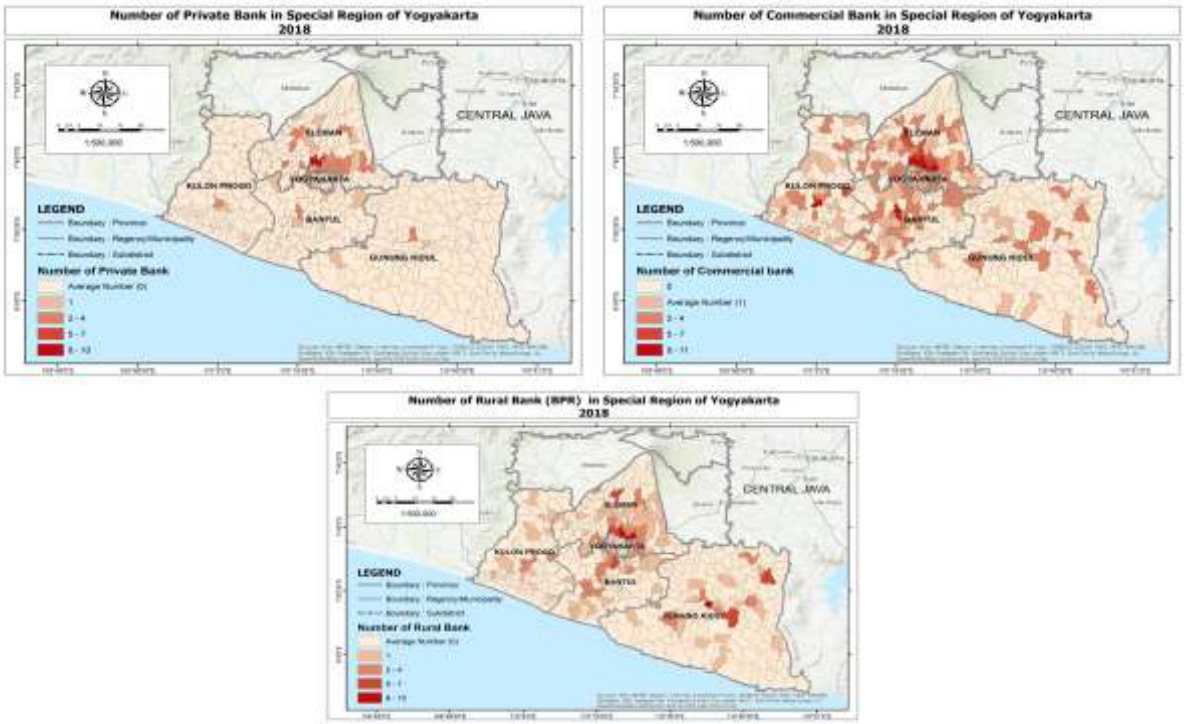

Figure 5. Distribution of Commercial, Private and BPR Banks in 2018
Source: Podes 2018

Private banks are predominantly located in the city center (Yogyakarta City) and Sleman, particularly in the south-central urban center and the northeastern areas bordering Yogyakarta City, such as KPY villages in Mlati sub-district (Sendangadi and Sinduadi) and Depok sub-district (Caturtunggal, Maguwoharjo, and Condong Catur). Other locations include Prambanan sub-district (Bokoharjo), Kalasan (Purwomartani) and, to a lesser extent, Ngemplak. In Kulon Progo, Bantul, and Gunung Kidul, private banks are concentrated in urban areas like Wates, Bantul, Banguntapan, and Wonosari.

The number of commercial banks in Yogyakarta Province surpasses that of private banks and BPRs. The data shown in Table 6 provides a clear depiction of the distribution and number of Commercial, Private, and BPR Banks in Yogyakarta Province. The concentration of Commercial Banks is highest in Yogyakarta City, Sleman, and Bantul, with Kulon Progo and Gunungkidul following suit. Private banks are primarily concentrated in Yogyakarta City and Sleman, whilst BPRs are found in Yogyakarta City, Sleman, and Gunungkidul.

Table 6. Number of Commercial, Private and BPR Banks in City Districts in 2018

	Yogyakarta	Sleman	Bantul	Kulon Progo	Gunungkidul
Commercial Bank	76	112	70	49	45
Private Bank	55	41	10	5	5
BPR	65	65	43	21	47

Source: PODES 2018

The presence of bank, including the commercial banks, BPRs, and private banks, plays a crucial role in promoting financial inclusion by fostering rural development and enhancing the economic well-being of individuals residing in rural regions, particularly those engaged in the agricultural sector (Cen et al., 2019) and MSMEs (Puspitasari et al., 2021). Enhancing financial inclusion in rural regions is crucial for mitigating the strain of poverty at the household level, particularly among farming households and those with limited access to non-agricultural employment opportunities (Dawood et al., 2019a).Enhancing financial access in rural areas has an impact in alleviating the extreme poverty experienced by households, addressing the scarcity of non-agricultural job prospects in rural areas, and

mitigating the poor educational attainment of household leaders. Furthermore, the inclusion of financial services will reduce the motivation for impoverished and unskilled individuals to relocate to metropolitan regions, looking for job opportunity outside of the agriculture sector (Dawood et al., 2019). Despite the presence of well-established banking infrastructure, it does not guarantee the poverty rates will be reduced in certain locations (Ismail, 2021).

Further, regarding the communication and information facilities, data on the number of BTS is only available in PODES 2018. Figure 6 illustrates the distributions of CV BTS, highlighting gaps in communication and information facilities at the sub-district level in Yogyakarta Province in 2018.

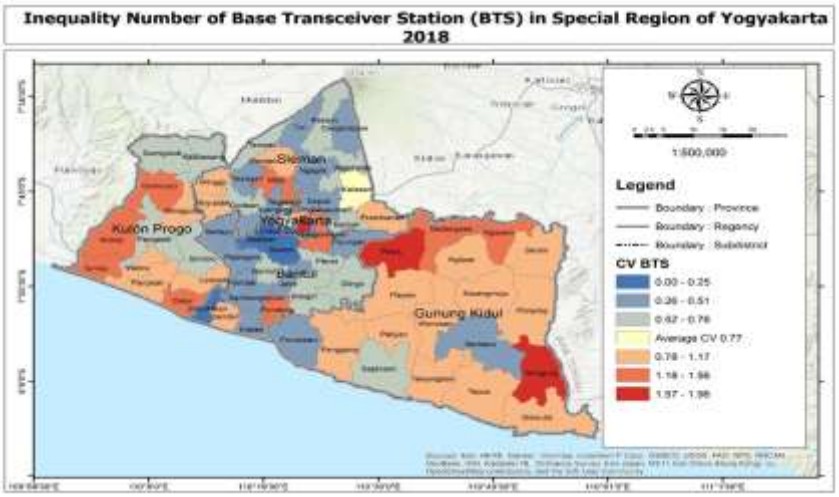

Figure 6. Gaps in Communication and Information Facilities in 2018
Source: Podes 2018

Based on Figure 6, Rongkop Sub-district, Gunungkidul, BTS units are concentrated in only three out of eight villages, such as Pringombo (6 units), Pucanganom (5 units), and Semugih (1 unit), while the remaining five villages have no BTS units. Pathuk Sub-district, also in Gunungkidul, shows a similar pattern, out of 11 villages, five have BTS units, including Beji (6 units), Ngoro Ngoro (1 unit), Putat (2 units), Salam (16 units), and Semoyo (1 unit). In Umbulharjo Sub-district, Yogyakarta City, BTS units are found in only two of seven villages, including Muja Muju (5 units) and Pandeyan (2 units).

According to the 2018 OLS model, the number of BTS units is positively associated with population size in certain models, indicating that areas with greater access to communication and information infrastructure tend to have higher population concentrations. This descriptive analysis shows that, while most sub-districts have some BTS coverage, the distribution remains uneven across villages, particularly in Gunungkidul, reflecting spatial variation in access to communication facilities within the province.

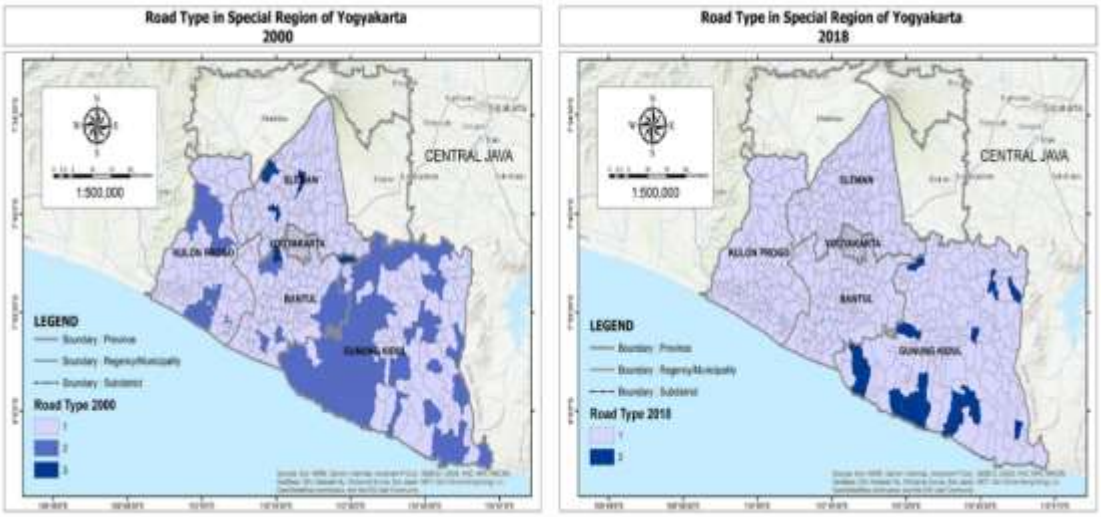

Figure 7. Changes in Road Quality in 2000 and 2018
Source: Podes 2000 & 2018

Based on Figure 7, distance is no longer a major constraint in Yogyakarta due to the province's relatively compact size compared to other provinces. Travel time has decreased as a result of improvements in both the availability and quality of road infrastructure. In 2000, some areas, particularly in Gunungkidul and Kulon Progo still had dirt roads. By 2018, the majority of roads were asphalt or concrete, with only a few locations in Gunungkidul retaining stone roads

By 2018, OLS results suggest that village population was less strongly associated with the availability of basic amenities, such as education, health, and traditional markets. Instead, economic factors, particularly sources of income and access to BPR (microfinance), along with infrastructure quality including roads and ICT, show more substantial associations with population patterns. Basic amenities now appear to influence population primarily through proximity rather than sheer quantity, as reflected in the distance-related coefficients. These shifts in determinant variables highlight the changing dynamics of rural-urban development in Yogyakarta and motivate further analysis using a marginal (delta) specification to capture temporal changes between 2000 and 2018.

Table 7. Estimation Results of the Urban-Rural Development Transformation Marginal Model

Variable	Variable Description	Population	Population Density
me1	Marginal Number of primary schools	70.81463	183.9957
me2	Marginal Number of junior secondary schools	68.15066	-193.8462
medist2	Marginal Distance to junior secondary school	65.23789	104.9003
me3	Marginal Number of senior secondary schools	214.7676*	26.70331
medist3	Marginal Distance to senior secondary school	-248.387**	-41.01409
mh	Marginal Number of hospitals	4509.635***	1326.523**
mhdist	Marginal Distance to hospital	42.78726	-14.04537
mpus	Marginal Number of public health centers (Puskesmas)	1434.879*	679.4032*
mpusdist	Marginal Distance to public health center	99.50091	44.60695**
mmkt	Marginal Number of markets	487.4126	448.9765***
mmktdist	Marginal Distance to market	16.08648	-19.60505
mpln	Marginal Percentage of households with access to electricity (PLN)	-95.29469	-9.885713
mroad (1)	Marginal Road type	144.8761	160.7825
mroad (2)		-1287.85	-450.2245
1.minc	Marginal Main income source	-236.2184	-1515.952
_cons		3323.815*	46.84026

Notes
*** Significant at 1% level; ** Significant at 5% level; *Significant at 10% level

Based on Table 7, the marginal model provides a comprehensive examination of the determinants of changes in village population and population density using a set of public service and infrastructure variables. The results indicate that several key facilities, particularly in the health and education sectors are significantly associated with demographic changes over the observation period.

In the education sector, the marginal increase in the number of senior secondary schools (me3) has a positive and statistically significant effect on population change at the 10% level, suggesting that the expansion of higher-level educational facilities is associated with population growth. Conversely, the marginal increase in the distance to senior secondary schools (medist3) shows a negative and statistically significant effect (5%) on population change, indicating that reduced accessibility to advanced education facilities is associated with lower population growth. These findings imply that both the availability and accessibility of upper-level education play a role in shaping demographic dynamics. Other education variables, such as primary and junior secondary schools, do not show statistically significant effects.

In the health sector, the marginal increase in the number of hospitals (mh) demonstrates a strong positive and highly significant association with both population change (1%) and population density (5%). This suggests that the expansion of hospital infrastructure is closely linked to increases in both the size and concentration of the population. Similarly, the marginal increase in the number of public health centers (mpus) has a positive and statistically significant effect on both population and population density at the 10% level, indicating that primary healthcare facilities also contribute to demographic change. Meanwhile, the marginal increase in distance to public health centers (mpusdist) shows a positive and significant association with population density (5%), suggesting the presence of more complex spatial dynamics that may reflect patterns of settlement concentration rather than straightforward accessibility effects.

From an economic perspective, the marginal increase in the number of markets (mmkt) is positively and significantly associated with changes in population density (1%), indicating that local economic facilities are linked to greater population concentration. Other variables, including access to electricity (mpln), road type (mroad), and main income source (minc), do not exhibit statistically significant effects in this specification, implying that there is insufficient statistical evidence to conclude a systematic relationship with population change during the study period. Overall, the results of the delta (marginal) regression model indicate that four variables consistently influence population change, both in terms of total population and population density, between 2000 and 2018, as summarized in Table 8.

Table 8. Summary from the Marginal (Delta) Regression Model

Variable	Direction	Description
ΔMH (Delta Number of Hospitals)	Positive	Increase in hospital facilities is associated with higher population growth and concentration
ΔMpus (Delta Number of Public Health Centers)	Positive	Expansion of primary healthcare facilities is positively associated with demographic change
ΔMMKT (Delta Number of Traditional Markets)	Positive	Growth in local market facilities is linked to greater population concentration
ΔMroad (Delta Road Quality Improvement)	Positive	Improvements in road infrastructure are associated with increased population mobility and settlement
Note: The table summarizes variables that show significance across all six model specifications of the marginal (delta) regression model.		

Table 8 summarizes variables that demonstrate significance across all six specifications of the marginal regression model, indicating that these findings are not solely reflected in the final model presented in Table 7. In general, the results consistently demonstrate that changes in health, economic, and transportation infrastructure are important determinants of population size and population density during the period 2000 to 2018.

In the health sector, the increase in the number of hospitals shows a strong positive association with population change. This indicates that areas experiencing an expansion of hospital facilities tend

to record higher population growth alongside greater population concentration. This finding consistently confirms that the availability of hospital infrastructure serves as a strong regional pull factor. This is consistent with empirical evidence that disparities in hospital service access between urban and rural areas in Indonesia remain considerable, whereby urban populations have a higher likelihood of utilizing both outpatient and inpatient hospital services compared to their rural counterparts (Wulandari et al., 2022). This condition indicates that the presence of and proximity to hospital facilities influences the pattern of population distribution and concentration across regions. Similarly, the increase in the number of public health centers also demonstrates a significant positive association, reinforcing the role of primary healthcare facilities in supporting demographic dynamics. Therefore, improvements in health infrastructure at both the secondary and primary levels are found to significantly influence population mobility and settlement patterns.

From an economic perspective, the increase in the number of traditional markets positively influences changes in population density. This result indicates that the availability of local economic facilities contributes to the attractiveness of an area and encourages population concentration. This finding is consistent with the argument that local economic opportunities and structural shifts in community livelihoods stimulate migration and population concentration within a given area. Evidence from Yogyakarta further supports this pattern, as population agglomeration has been found to exert a significant positive effect on regional economic growth, particularly in areas with higher concentrations of economic activity (Artaningtyas et al., 2019). This suggests that the growth of local market facilities not only reflects increased economic activity at the village level but also contributes to broader agglomeration dynamics that drive regional development in DIY.

The significant improvement in road quality in the marginal model further underscores the importance of transportation infrastructure in facilitating mobility and supporting demographic transformation. Empirical evidence at the village level in Indonesia demonstrates that improvements in road surface type and accessibility for four-wheeled vehicles significantly increase the probability of rural economic transformation, with paved or concrete roads in the Java-Bali region exhibiting a higher marginal effect compared to other regions (Kamaludin & Qibthiyyah, 2022). This finding is particularly relevant to the context of the Special Region of Yogyakarta as part of the Java region, where improvements in road quality not only enhance population mobility but also promote broader rural economic transformation. Furthermore, evidence from Central Java similarly suggests that infrastructure quality and interregional connectivity, rather than mere physical expansion, are more decisive determinants of regional economic outcomes, indicating that the productivity effects of infrastructure depend on operational efficiency and strategic integration within regional production systems (Suripto et al., 2025).

This is further supported by international evidence indicating that improvements in market access through road network expansion are positively associated with regional population and economic growth, whereby a 1% increase in market access raises population by an average of 0.6% and GDP by 0.2% (Adler et al., 2020). Overall, improvements in road infrastructure have been shown to not only facilitate population mobility but also expand the economic reach of a region, thereby promoting more equitable population growth and concentration, including in rural areas.

Compared to the cross-sectional regressions conducted separately for 2000 and 2018, the delta (marginal) model provides stronger evidence that changes in infrastructure are central to explaining population dynamics. The implication of these findings is that sustained improvements in the availability, accessibility, and quality of health, economic, and transportation infrastructure play a crucial role in shaping population mobility and migration processes, as reflected in changes in population size and density over the 18-year observation period.

CONCLUSIONS

The transformation of development in the Special Region of Yogyakarta Province has fundamentally changed the pattern of interaction between urban and rural areas. At the beginning of

the observation period, the welfare of rural communities was still highly dependent on the availability of basic services, such as secondary education and health facilities. However, with the increasing process of urbanization and regional economic dynamics, the role of economic factors, financial access, and digital connectivity has become increasingly dominant. This shift marks the emergence of a more interdependent urban–rural relationship, in which the exchange of capital, labor, and information takes place intensively and mutually influences each other.

The results of the study show that, in 2018, economic variables such as diversification of income sources, access to Rural Credit Banks (BPR), and the existence of digital infrastructure (BTS) had a greater influence on community welfare than the availability of education and health facilities. Basic educational facilities are relatively evenly distributed, but the gap in access to secondary education is still evident. This condition indicates that the success of development is not only measured by the equitable distribution of basic services, but also by the extent to which the community has access to economic resources and digital networks that expand opportunities for welfare.

These findings reveal that spatial disparities in Yogyakarta are multidimensional. Inequality arises not only from social and public service aspects, but also from differences in access to capital, financial networks, and information technology. Villages with strong economic and digital connectivity tend to develop more rapidly, while isolated villages are prone to new marginalization. Therefore, the direction of development policy needs to transform from an approach of equal distribution of facilities to strengthening economic and technological inclusion, among others, through the expansion of microfinance access, the development of communication infrastructure, and the improvement of digital literacy among communities at the village level.

The government should adopt integrated rural–urban planning that promotes digital and financial inclusion while safeguarding environmental capacity. Prioritizing spatial planning enforcement, equitable education access, and local institutional capacity building will help achieve sustainable regional transformation. Future research may expand the analysis by incorporating ecological and socio-cultural dimensions to provide a more comprehensive understanding of rural–urban interdependence in Indonesia's regional development.

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