Multidisciplinary Output Research For Actual and International Issue (MORFAI Journal) ISSN (e): 2808-6635
Volume 6 No. 2 (2026)

ANALYSIS OF REGIONAL GROWTH CENTERS THROUGH THE INTEGRATION OF SCALOGRAM, MARSHALL CENTRALITY INDEX, AND GRAVITY ANALYSIS (A CASE STUDY OF SOUTH BURU REGENCY)

Astuty N. DB[1], Teddy Ch.Leasiwal[2*], Hendri D. Hahury[3]
Postgraduate Program in Economics, Pattimura University, Jl. Ir. M. Putuhena,
Postgraduate Building, Poka, Ambon
E-mail: astutidaengbarang6@gmail.com, t.leasiwal@gmail.com, hahury31@gmail.com

Received	: 01 October 2025	Published	: 01 January 2026
Revised	: 10 October 2025	DOI	: https://doi.org/10.54443/morfai.v6i2.4581
Accepted	: 15 November 2025	Publish Link	: https://radjapublika.com/index.php/MORFAI/article/view/4581

Abstract

This study aims to identify and verify growth centers in South Buru Regency through the integration of three analytical methods: scalogram, Marshall Centrality Index, and gravity analysis. Using secondary data from 2023, this study examines the completeness of facilities, the weight of supporting infrastructure, and the spatial interactions occur between districts. The results indicate that Namrole District stands out as the primary growth center with the most complete facilities (30), the highest infrastructure weight (888.90), and the strongest interaction with Leksula District (510,712.95). This study also higlights Kepala Madan District and Leksula District as secondary growth centers. The multi-method integration provides a more solid and comprehensive basis for identifying growth centers, especially in island regions such as South Buru Regency. The results suggest several policy implications, including strengthening infrastructure in Namrole District, improving economic corridors, and developing local potential-based economic clusters.

Keywords: Growth center, Scalogram, Marshall Centrality Index, Gravity analysis, Regional planning

INTRODUCTION

South Buru Regency, as a relatively new administrative region, continues to face a range of challenges as it works to strengthen its regional development efforts. Its archipelagic geography creates its own complexities, especially in terms of the distribution of resources and the inter-island accessibility. Population distribution is also uneven, with densities varying widely from 7.51 to 68.63 people per square kilometre (km), which highlights significant demographic disparities. This phenomenon suggests that residents tend to cluster in areas with better access to bacis public facilities and services. As a result, the development and public services across districts often progress at uneven pace.

Harahap (2025) and Suhardi & Panjaitan (2025), Identifying growth centers accurately is therefore essential for fostering inclusive and equitable growth. Growth centers often serves as engines of regional economic activity because of the multiplier effects they generate. For this reason, determining growth centers is not only a technical process, but also a strategic one, with the aim of accelerating development in lagging areas. The development gaps between subdistricts in South Buru Regency are manifested through the uneven distribution of infrastructure. Existing data show that Namrole District, which holds the status of regency capital, has a far more complete set of facilities compared to other districts. The infrastructure gap under discussion spans several key sectors, including health, education, transportation, and access to economic activity centers.

Table 1. Number of Facilities in South Buru Regency, 2025

No.	Facility	District					
		Kepala Madan	**Leksula**	**Fena Fafan**	**Namrole**	**Waesama**	**Ambalau**
1.	*Education Sector*						
	Elementary School	18	24	12	29	19	9
	Junior High School	11	13	14	10	10	5
	Vocational / Senior High School	7	6	1	7	6	4
2.	*Healthcare Sector*						
	Hospital	1	0	0	1	0	0
	Sub-Public Health Center	8	13	4	11	11	6
3.	*Tourism Sector*						
	Tourist Attraction	6	5	3	6	2	3
4.	*Place of Worship*						
	Mosque	17	5	0	23	19	17
	Church	3	26	12	22	1	0
5.	*Telecommunication Sector*						
	Village Information System	11	6	1	13	9	7
	Internet Café	7	12	2	5	5	1
	Wi-Fi	3	5	5	6	7	4
6.	*Electricity*						
	Electrification Ratio	96.47.00	80.34.00	97.77	97.01.00	83.02.00	93.53.00

Source: BPS of South Buru Regency, various years of publication

These disparities can slow down regional economic integration and ultimately weaken the overall pace of development. Gaps in accessibility are also visible in the transportation network connecting the districts. In several areas, limited connecting infrastructure has led to isolation. Such conditions tend to widen existing inequalities in public services and restrict the mobility of people and goods between regions. As a conseuquence, the benefits of development are unevenly distributed and many communities have limited access to economic growth centers. This perspective indicates that determining the growth centers in South Buru Regency requires a broader, more comprehensive approach that considers multiple factors relevant to regional development. Key aspects that must be considered include natural resource potential, the availability of infrastructure, demographic conditions, and the patterns of spatial interaction between districts (Amane et al., 2023; Nurhikmah et al., 2025; Ridwan & Hajiali, 2022). The region's economic prospects are supported by its varied natural resources, such as fisheries, plantations, mining, and tourism. For instance, the fisheries sector alone has a sustainable potential of 788,939 tons per year, and various leading plantation commodities offer additional opportunities for growth. However, capitalizing on these strengths depends on improving infrastructure and adopting an integrated development strategy that connects these assets to broader economic activities.

Furthermore, the spatial interaction patterns between districts are also a determining factor in shaping mutually beneficial economic networks. Gravity analysis helps reveal the strength of these interactions, using population size and distance as its main variables. Consequently, growth center-based development policies in South Buru Regency must be carefully designed and carried out in a sustainable way. This strategy should encourage collaboration between districts by improving connectivity and making better use of each area's local potential. Developing economic corridors that link the main growth centers with nearby regions can help accelerate the process of development diffusion. Furthermore, adequate transportation infrastructure is also essential for maintaining strong connections between growth centers and their buffer zones. In addition, strengthening local government capacity is crucial to ensure that policies are well coordinated and implemented effectively. Community participation and engagement from local stakeholders are equally important so that the development reflects local needs and aspirations (Latifah et al., 2024; Suryaman, 2025). To ensure the efficacy of the policy, continuous monitoring and evaluation are necessary to identify issues early and make timely adjustments.

The concept of growth centers was proposed by François Perroux and later expanded spatially by John Friedmann through the Core-Periphery Theory, which continues to serve as the primary reference in regional development planning. The objective of this study is to identify areas capable of generating strong spread effects that can stimulate growth in surrounding regions. A study by Saputra & Suryanto (2022) employed Klassen's Typology Analysis and Location Quotient (LQ) to identify base sectors and classify regional growth patterns in Central Java, though their study lacked a spatial perspective. In contrast, Sari, et al., (2023) incorporated economic, social, infrastructure, and accessibility indicators through a scoring method to determine potential growth centers in South Sumatra, offering flexibility that allows the analysis to match local conditions more closely.

Further contributions to the field include Nugroho, et al (2021), who applied Hot Spot Analysis to map concentrations of economic activity in East Java and examined how these clusters relate to transportation infrastructure. A similar approach was adopted by Pratiwi & Dharma (2020) in their study of Kalimantan, wherein they employed the same model to establish the hierarchy of service centers and identify regions with the strongest attraction. A more recent work by Yuniar & Setiawan (2024) illustrated a growing trend toward integrating multiple indicators into a single composite index. In their study, they integrated the Human Development Index (HDI), regional competitiveness, and digital access to formulate a more comprehensive measure of regional growth. These studies demonstrate that growth center analysis can be carried out through a variety of methods, such as Klassen's Typology Analysis and LQ, Scoring Analysis (Multi-Criteria Analysis), GIS Integration and Spatial Analysis, Hierarchy and Attraction Analysis (Gravity Model), and Composite Index and Multidimensional Approach. However, many of these works rely on only one analytical approach at a time. Although some use a scalogram or gravity analysis, these tool are often applied independently rather than in combination.

In reality, research on regional growth centers benefits greatly from a more integrated framework that integrates diverse methodological approaches. Furthermore, studies related to growth centers in archipelagic regions, such as Maluku, that simultaneously integrate the scalogram, Marshall Centrality Index, and gravity analysis are still limited. For this reason, the purpose of this study is to identify and verify growth centers in South Buru Regency through the integration of three analytical methods: scalogram, Marshall Centrality Index, and Gravity Analysis. This raises several key research questions, including: How well are potential resources and infrastructure distributed across South Buru Regency? Which districts have the capacity to sserve as growth centers in South Buru Regency? In what ways do the districts within South Buru Regency interact with one another? The results of this study are expected to offer scientific contributions by developing a more comprehensive model for identifying growth centers, especially in regions with archipelagic characteristics.

LITERATURE REVIEW

Regional Growth Centers

Economic growth does not occur uniformly across all regions but tends to concentrate around "growth poles" that possess high leverage to spread positive impacts to their surrounding areas (spread effect). Referring to François Perroux's growth pole theory, which states that economic growth tends to concentrate in specific regions with high leverage, the research findings in South Buru Regency empirically validate this theory in a contemporary archipelago context. The study reveals that Namrole District functions as the primary growth pole with the most complete facilities and the highest infrastructure weight, creating a characteristic polarization of development, as identified in the study by Sari, et al (2023) in South Sumatra.

Furthermore, the evolution of growth pole theory, integrated with a spatial dimension by Friedmann, finds its relevance in the gravitational interaction patterns between regions. The strength of interaction between regions is driven not only by population factors but also by complementary functions as administrative centers and maritime logistics hubs. This is corroborated by the research of Wicaksono, & Hidayat (2019) on the influence of connectivity on shifts in growth centers. Additionally, this dynamic forms a de facto economic corridor that has the potential to become the backbone of regional economic integration, although it risks exacerbating disparities with regions exhibiting low levels of interaction. The study by Pratiwi & Dharma (2020) in Kalimantan confirms that the strength of spatial interaction is positively correlated with centrality index values.

The importance of an adaptive growth pole development strategy, as recommended by Yuniar & Setiawan (2024) in the context of the digital economy, is paramount. Strengthening the role of a region as a primary growth center must be balanced with the development of secondary centers in other areas through complementary economic cluster specialization. This is crucial to prevent excessive dominance and to facilitate a more equitable trickle-down effect. Moreover, investment in physical and digital connectivity infrastructure along the core regional corridor can

be a prerequisite for expanding the reach of the spread effect, while simultaneously addressing the dual isolation faced by remote regions.

Core Periphery Theory

Economically and infrastructurally advanced core regions tend to dominate less developed peripheral areas. The interaction between the two can either reduce or widen the development gap. The core-periphery theory, developed by John Friedmann from the foundational ideas of François Perroux, explains the structurally imbalanced relationship between advanced core regions and lagging peripheral territories. Core regions are characterized by the concentration of capital, advanced infrastructure, access to power, and innovation. In contrast, the periphery often functions as a provider of raw materials and labor, maintaining a high dependency on the core. According to Friedmann, this interaction is not without conflict, as the development process frequently reinforces polarization rather than spreading prosperity, unless there is active policy intervention to encourage diffusion. A recent study by Sari, et al, (2023) in archipelagic regions of Indonesia confirms that without planned intervention, market mechanisms tend to deepen the core-periphery disparity, where productive resources are continuously siphoned towards the center.

Research findings from various other regions provide clear empirical evidence for the core-periphery theory. The core region excels not only in the completeness of facilities and infrastructure weight but also serves as the strongest node of interaction. This structure creates a relationship of dependency, where peripheral areas with limited facilities and low centrality indices experience dual isolation—both geographical and functional. This perspective aligns with the study by (Nugroho, et al, (2021) in East Java, which concluded that infrastructure concentration in a single center accelerates the growth of the core but slows convergence with the periphery. Further gravity analysis reveals that the strongest interactions occur between the core and secondary centers, whereas interactions with even the nearest peripheral regions remain very weak. This indicates a feeble spread effect and a strong backwash effect, which transfers resources from the periphery to the core.

The implications of this identified core-periphery structure demand a transformative policy approach. As critiqued by Pratiwi & Dharma (2020), a development model that solely spurts the growth of the core without strengthening the connectivity and capacity of the periphery will lead to permanent inequality. The study by Wicaksono & Hidayat (2019) demonstrates that investment in core-periphery connecting corridors can transform a dependency relationship into one of interdependence. Furthermore, as highlighted by Yuniar & Setiawan (2024) the integration of digital infrastructure is crucial to transcend geographical barriers and reduce information disparities for peripheral regions.

Multi-Criteria Approach and Method Integration

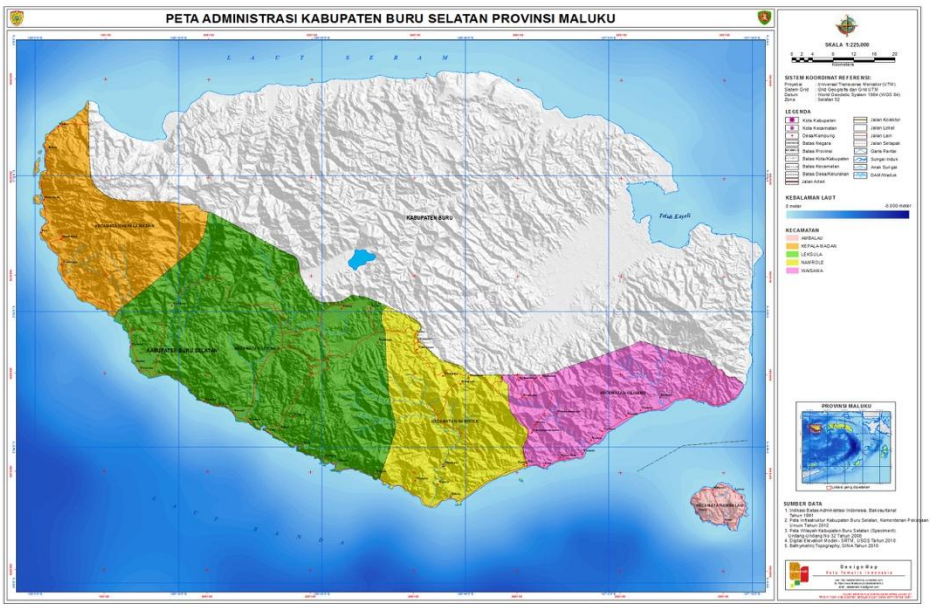
The integration of multiple analytical methods—such as scalogram, gravity model, and centrality index—enables more comprehensive and valid results in identifying regional growth centers. This integrated approach allows for the identification of growth centers not merely based on facilities, but also incorporating service quality and spatial interactions. As an analytical framework, the multi-criteria approach combines various dimensions and indicators to produce comprehensive assessments in regional planning. Unlike single-method approaches that often fail to capture the complexity of spatial realities, multi-method integration facilitates evidence convergence from complementary perspectives. In growth pole studies, this approach accommodates not only quantitative aspects like facility quantity but also qualitative factors such as service weighting and spatial interaction dynamics. Sari, e al (2023) confirm that multidimensional scoring analysis reveals service center hierarchies more accurately than conventional methods. Current trends identified by Yuniar & Setiawan (2024) demonstrate a paradigm shift toward integrating digital economy and sustainability variables in regional analysis, enriching the assessment dimensions for modern growth centers.

The scalogram functions to identify structural hierarchies based on facility completeness, while the Marshal Centrality Index advances further by applying differential weighting to various facilities, evaluating not only quantity but also quality and infrastructure significance, ultimately generating composite scores. Meanwhile, Gravity Analysis reveals relational dimensions by mapping the strength of spatial interactions, demonstrating how the strongest connections can form between specific regions. As Nugroho, et al (2021) established, integrating these structural, functional, and relational dimensions enables identification of growth hotspots and network patterns that remain invisible through single-method approaches. The convergence of results from these three methods not only confirms a region's position as a primary growth center with high confidence levels but also reveals nuanced roles of each district within the regional system. Pratiwi & Dharma (2020) emphasize that inter-method inconsistencies

actually reveal the functional complexity of a region. Therefore, this multi-method integration not only answers "where" growth centers are located, but also explains "why" and "how" they function within the spatial system, providing a more robust foundation for formulating targeted and sustainable development policies.

METHOD

This study employed a quantitative-descriptive method to picturize existing economic and social conditions in the research location, particulary those related to the availability of infrastructure (Nur, 2024). This study was carried out over a three-month period and conducted in South Buru Regency, Maluku Province, particularly in 6 districts, including Kepala Madan District, Leksula District, Fena Fafan District, Namrole District, Waesama District, and Ambalau District. The following Figure 1 presents the map of research location:



This study utilized secondary data obtained from several relevant government institutions, such as Statistics Indonesia (*Badan Pusat Statistik,* BPS) of Maluku Province and South Buru Regency, along with other pertinent agencies. The data set comprised various indicators related to infrastructure, along with supporting social and economic data from each district. After the data was collected, they were processed and analyzed through several stages, including the following:

Scalogram Analysis

Scalogram analysis was employed to help identify potential growth centers in a region by examining the range and availability of existing facilities (Rohmah & Fitrianto, 2024). This method facilitates the identification of the hierarchy of growth centers and service activities within the research location, with the objective of supporting efforts to improve the access to public facilities (economic, social, and governmental). Areas with the most complete set of facilities are typically regarded as the growth centers with fewer facilities generally fall into the category of hinterland areas.

$$COR = 1 - \frac{(\Sigma e)}{(N \times K)}$$

Note:
Criteria: COR ≥ 0.7 (acceptable)
Number of Order = 1 + 3.3 log N

Marshall Centrality Index

In this study, the Weighted Centrality Index (WCI) was employed as an analytical tool to determine the hierarichal structure of regions. This method was used to identify which areas function as the central region and which serve as their hinterlands (Putra, 2019).

$$C = t/T$$

Note:
C = Weight
t = Centrality score
T = Total infrastructure

Gravity Analysis

Gravity analysis was employed to measure how attractive one region is in comparison to others. In principle, the interaction between two centers becomes stronger when both have larger populations, but gradually weakens as the distance separating them increases. In other words, stronger interaction is expected when both regions have substantial populations and are located relatively close to each other (Hanifah, 2025).

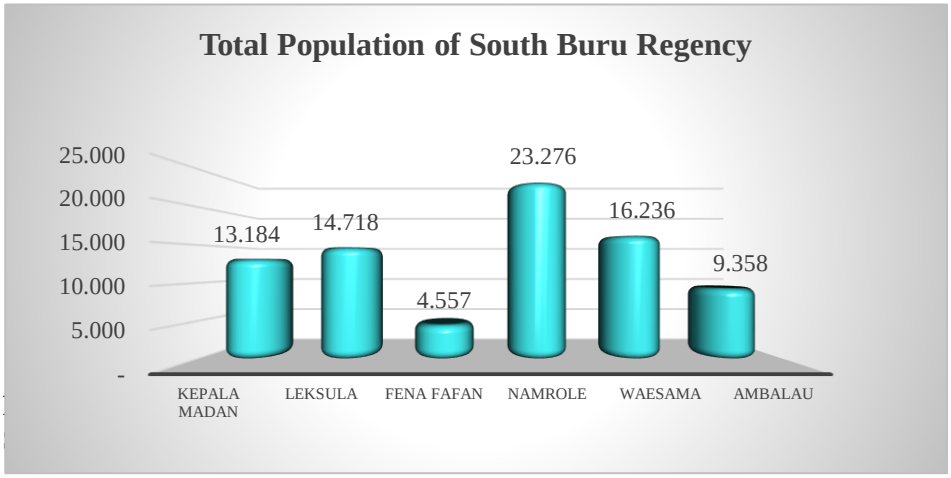
$$Iij = \frac{(Pi \times Pj)}{(Dij^2)}$$

Note:
Aij : Magnitude of interaction between region I and region J
Pi : Population of region I (in thousands of people)
Pj : Population of region J (in thousands of people)
dij : Distance between region I and region J (in kilometers)
k : Constant value based on empirical experience
b : Exponent of dy, commonly set at b = 2

RESULTS AND DISCUSSION

Demographic Profile and Physical Characteristics of South Buru Regency

An analysis of the population data reveals substantial variations in distribution across the districts of South Buru Regency. Several districts have comparatively large populations, for example around 23,276 people, while others record lower populations, such as 4,557 people. These contrasts suggest that settlement tends to cluster in particular regions, a pattern likely shaped by geographical factors and infrastructure availability. The physical characteristics of the islands in South Buru Regency contribute to the population distribution pattern. Regions with gentler terrain and better accessibility generally support higher population densities. Conversely, regions characterized by challenging geographical conditions, such as hills or remote areas, typically have lower population densities. As a result, a noticeable demographic gap emerges between more accessible regions and those with challenging geographic constraints.



From a demographic perspective, the wide gap in population sizes, from only a few thousand residents to well over ten thousand, indicates that human resources were unevenly distributed across the regency. Districts with larger populations might benefit from a broader labor force; however, they also faced greater demands for public services. On the other hand, regions with smaller populations often struggled to deliver basic services efficiently.

Scalogram and Service Order Analysis in South Buru Regency

Scalogram analysis, a quantitative method in regional planning, helped identify the hierarchy of service centers based on the completeness and variety of facilities available. The method functioned through the classification of

service facilities according to their degree of specialization, with highly specialized facilities exclusively present in high-order service centers. In the case of South Buru Regency, this analysis reveals a clear hierarchical pattern. Namrole District was designated as the primary growth center (Order I) with a total of 30 facilities, followed by other districts classified under Order II and Order III. The COR value of 0.91 indicates a very high data reliability in describing the service structure in the study area. A research by Sari, et al, (2023)) in South Sumatra applied a similar approach with multidimensional scoring analysis and noted that the scalogram analysis provided a more rigid functional hierarchy. Meanwhile, the study by Nugroho, et al (2021) in East Java combined spatial analysis with hot spot mapping, thereby complementing the scalogram findings with a more dynamic spatial dimension. The findings of both studies indicated that the polarization of service facilities toward specific centers was a common pattern in the context of regional development. In a similar vein, the research conducted by Pratiwi & Dharma (2020) in Kalimantan found a clear alignment between the hierarchical structure of the scalogram and the intensity of spatial interactions. Their analysis revealed that higher-order centers tended to function as the main interaction nodes within the regional network. This finding is consistent with the findings in South Buru Regency, where Namrole District, identified as an Order I center, emerges as the strongest interaction node in the gravity analysis.

Table 2. Results of Scalogram Analysis and Service Order

No.	District	Number of Facilities	Order	Range
1.	Namrole	30	I	29-20
2.	Kepala Madan	28	II	27-28
3.	Leksula	28	II	27-28
4.	Waesama	27	II	27-28
5.	Fena Fafan	26	III	25-26
6.	Ambalau	26	III	25-26

Source: Research results, 2025

The COR value of 0.91 reflects a very strong level of data reliability. Namrole District has historically occupied at the highest position in the regional hierarchy, and its identification in this study as the primary growth center aligns well with the foundational theory of growth poles (Perroux, 1955a) within a contemporary framework. The consistency of results from all three analytical methods (scalogram, Marshall Centrality Index, and gravity analysis) strengthens the validity of these findings, which echoes recent research trends that emphasize multi-method convergence. As demonstrated by Sari, et al (2023), flexible multi-criteria frameworks are better suited to capturing the complexity of regional development, a method that has proven relevant for the case in South Buru Regency. Using multiple approaches also helped address the limitations of relying on a single approach, which frequently overlooked spatial dynamics or disparities in the infrastructure availability, as previously observed by Saputra & Suryanto (2022). Therefore, the assertion of Namrole District's designation as the primary growth center was supported not only by its completeness of facilities, but also by its stronger economic interactions, providing a more comprehensive foundation for policy planning.

Further, the scalogram analysis, a method that generated a hierarchical structure of service orders ranging from Order I to Order III, offers a clear representation of the infrastructure gaps present within the districts. The fact that Namrole District is the sole district classified as Order I, while two others are designated as Order II and three as Order III, underscored a substantial disparity in developmental progress among the regions. This pattern aligns with the findings of Nugroho, et al (2021) in East Java, which determined a strong correlation between economic growth and the availability of transportation infrastructure. In an archipelagic context, such as South Buru Regency, this disparity became even more pronounced. Remote districts, such as Fena Fafan District and Ambalau District, faced a double isolation, both geographically and infrastructurally. This finding suggests that existing equity policies have not yet fully trickled down to more remote areas, making it necessary to implement more specific and targeted interventions. Furthermore, the gravity analysis discloses pivotal spatial dynamics within the region. The strongest interaction occrs between Namrole District – Leksula District. This finding aligns with the Law of Gravity by Reilly (1931), which remains relevant today in explaining how population size and distance shape spatial interaction. The strength of the Namrole-Leksula District interaction stands ut markedly compared to other district pairs, suggesting the presence of a potential economic corridor that could serve as the foundation for regional development. Evidence from Wicaksono & Hidayat (2019) on the Trans Java Toll Road demonstrated that enhanced connectivity could shift

growth centers and reinforce emerging economic corridors. In this light, the proposed Namrole-Leksula-Waesama corridor was not strategically important, but was also supported by strong empirical evidence of the robustness of existing interactions. While this present study focuses primarily on physical and demographic factors, the evidence supporting Namrole District's centrality offered a strong foundation for integrating contemporary variables, as highlighted by Yuniar & Setiawan (2024). The integration of digital economy indicators into growth-center analysis was emphasized, with the objective being the creation of a more comprehensive assessment. In this context, Namrole District's position as the main regional hub made it a strategic candidate for future digital infrastructure development, such as data centers, large-scale internet cafés, and digital literacy programs. This strategic positioning would not only strengthen the district's role as a central node, but also extend digital benefits to surrounding secondary regions. Adopting this composite approach would enhance future models by including aspects of digital competitiveness and innovation capacity. Consequently, growth centers would excel within both traditional frameworks and the demands of a modern economy.

Analysis of Marshall Centrality Index

The Marshall Centrality Index is an extension of the breaking point theory proposed by Marshall to measure the level of centrality of an area based on the weight and distribution of service facilities. In contrast to the scalogram analysis, which exclusively calculates the quantity of facilities, this index assigns different weights to each facility type based on its relative importance in the regional service structure. In the context of South Buru Regency, the application of this index results in a more detailed hierarchy. Namrole District occupies the highest position (888.90), followed by Kepala Madan (612.39) and Leksula (497.93). These results reflect the variation in service quality between districts in South Buru Regency.

Table 3. Results of Marshall Centrality Index Calculation

No.	District	Number of Facilities	Order	Range
1.	Namrole	888.90	I	690-892
2.	Kepala Madan	612.39	II	487-689
3.	Leksula	497.93	II	487-689
4.	Waesama	491.19	III	284-486
5.	Fena Fafan	292.77	III	284-486
6.	Ambalau	284.62	III	284-486

Source: Research results, 2025

A similar approach was implemented by Sari et al. (2023) in determining growth centers in South Sumatra. They found that assigning weights to different types of infrastructure resulted in a more accurate hierarchical pattern than the usual quantitative analysis. They emphasized the particularly strong influence of health and education facilities in determining an area's level of centrality. This finding aligns with the findings from South Buru Regency, where districts equipped with more complete health and education facilities tended to exhibit higher centrality indices. Nugroho et al. (2021) further developed the index in their study in East Java by incorporating digital accessibility variables, demonstrating that in the modern era, telecommunication infrastructure played an increasingly important role in shaping the centrality value of a region. This innovation was highly relevant to South Buru Regency, where variables of village information systems and Wi-Fi had been included in the calculation. However, their utilization could be further optimized to provide a more comprehensive perspective of the local conditions. Similarly, a study by Pratiwi and Dharma (2020) in Kalimantan found a positive correlation between the centrality index and the intensity of spatial interaction. They explained that regions with higher index values tended to serve as primary destinations for population and goods movement. This finding aligns with the research results in South Buru Regency, where Namrole District, which has the highest centrality index, is also the strongest interaction node in the gravity analysis.

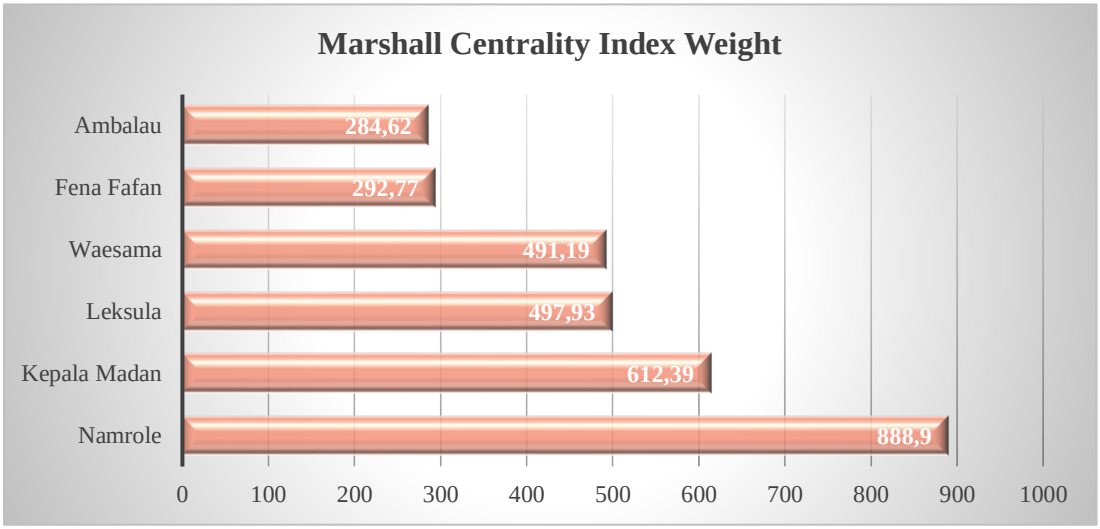


Figure 3. Marshall Centrality Index Weight
Source: Research results, 2025

The calculation of the Marshall Centrality Index, which places Namrole District significantly higher (888.90) than other districts, reinforces the findings of recent studies on the clustering of infrastructure in government centers. A research by Sari et al. (2023) in South Sumatra found that district capitals tended to accumulate disproportionate service weights, creating a significant "centrality gap" with surrounding regions. This situation in South Buru Regency reflected this pattern. Namrole District's index value, which is almost twice that of the lowest sub-district (Ambalau, 284.62), showed how strongly infrastructure development remained concentrated in the core. As suggested by Nugroho et al. (2021), this stype of imbalance often reinforced the core-periphery structure, where resources and services accumulated in the center, thus slowing down the diffusion of development to the buffer zones.

The wide gaps between Namrole District, Kepala Madan District (612.39) and Leksula District (497.93) indicated a clear hierarchy within the service network in South Buru Regency. This finding aligns with the research conducted by Pratiwi & Dharma (2020) in Kalimantan, which showed that the hierarchical structure of service centers significantly influenced the intensity of regional economic interactions and flows. In this context, Kepala Madan District and Leksula District functioned as secondary centers with relatively high index values, suggesting that both hold considerable potential as "sub-growth centers" that could bridge the gap between the capital city and remote areas of South Buru Regency. In terms of regional planning, this hierarchical structure highlighted the need for differentiated policy directions, where secondary centers must be strengthened so that they could help balance the dominance of primary centers.

The Marshall Centrality Index value obtained reflected not only the quantity, but also the quality and variety of facilities, offering a more holistic picture of the weight of infrastructure. In accordance with the trend initiated by Yuniar & Setiawan (2024), this approach incorporated modern elements, including digital infrastructure and connectivity. Despite the inclusion of variables, such as village information system and Wi-Fi, Namrole District's leading score indicates that it might offer broader or more reliable quality and coverage of digital infrastructure, an increasingling critical factor for supporting inclusive development in today's digital era. This finding also reinforced the growing view that the evaluations of growth centers in the 21st century must extend beyond traditional physical infrastructure and also consider readiness for digital economic activity.

From a policy perspective, the wide disparities in index scores between districts underscored the need for a more strategic approach. As posited by Wicaksono & Hidayat (2019), investments in transportation infrastructure that facilitated connections between primary and secondary centers had the potential to optimize the dispersion effect, thereby reducing disparities. Strengthening the connectivity between Namrole District and Kepala Madan District and Leksula District should be considered as a key priority, especially given their relatively high centrality values. Improved connectivity among these regions would allow them to function as a more synergistic growth network. Furthermore, additional research should adopt the approach used by Sari & Juanda (2023), who included sustainability and environmental impact variables in assessing the weight of infrastructure. This would ensure that

development resulting from the identification of these growth centers remain aligned with the region's carrying capacity of the environment.

Gravity Analysis

Gravity analysis is a quantitative method in regional planning that adapts Newton's law of gravity to estimate the strength of spatial interaction between two or more regions. The model assumes that the strength of interaction (Iij) increases with the combined "mass" (typically population or economic scale) of the regions, while decreasing as the distance (Dij^2) between them grows. In the context of South Buru Regency, this analysis successfully identified the strongest interaction between Namrole District and Leksula District (510,712.95). This result reflected more than population size alone; it also captured the functional roles and relative economic attractiveness of the two districts, forming a potential economic corridor, as presented in Table 4:

Table 4. Matrix of Inter-District Distance (in kilometers)

No.	District	Kepala Madan	Leksula	Fen Fafan	Namrole	Waesama	Ambalau
1.	Namrole	0	97	109	122	151	175
2.	Kepala Madan	97	0	26	25	51	86
3.	Leksula	109	26	0	65	94	126
4.	Waesama	122	25	65	0	30	61
5.	Fena Fafan	151	51	94	30	0	25
6.	Ambalau	175	86	126	61	25	0

Source: Research results, 2025

Table 5. Top Five Interactions Between Districts

No.	Origin District	Destination District	Interaction Value
1.	Namrole	Leksula	510.712,95
2.	Namrole	Waesama	394.063,11
3.	Waesama	Ambalau	233.975,52
4.	Leksula	Fena Fafan	90.942,57
5.	Leksula	Waesama	86.951,36

Source: Research results, 2025

The gravitational interaction between Namrole District and Leksula District (510,712.95) is of significant value, as it not only validates the classical law of gravity by Reilly (1931), but also mirrors contemporary spatial patterns within the archipelago. The strength of this interaction, which is significantly higher than that observed among other pairs of districts, could be attributed to the combination of the substantial population mass of both areas and their relative proximity, although not the closest. This finding aligns with the research conducted by Nugroho, et al (2021), which demonstrated that the strongest spatial interactions frequently occurred between two nodes with complementary service functions, rather than solely between areas located closes to each other. In this context, Namrole District's role as the administrative center and Leksula District's strength in maritime activities created substantial economic synergies, thereby establishing a de facto economic corridor that served as the pivotal conduit for resource mobility in South Buru Regency.

The large interaction value between Namrole District and Leksula District reflected a strong flow of people, goods, and services moving between the two districts. This finding aligns with the conclusions of Wicaksono & Hidayat (2019), who demonstrated that stronger connectivity, as measured by the strength of interaction, tended to be associated with faster regional economic growth. The Namrole-Leksula District corridor had the potential to serve as a catalyst for the economic integration of the district, generating the multiplier effect of economic activity for surrounding areas. However, this value also presented a challenge, namely the potential for "reverse flows" that could further concentrate economic resources into these two nodes and weaken the attractiveness of other districts, such as Fena Fafan District and Ambalau District, both of which show much lower interaction values.

A comparison with other pairs, namely Namrole-Waesama (394,063.11) and Waesama-Ambalau (233,975.52), reveals that the interaction pattern in South Buru Regency is not solely linear with respect to the distance. The relatively low interaction of Leksula District with Fena Fafan District (90,942.57), despite its proximity to the Namrole-Leksula District corridor, suggested that the "mass" factor or economic attractiveness of a region played a more crucial role. This pattern reinforces the findings of Sari & Juanda, (2023) Sari et al. (2023) that the quality and diversity of economic facilities (as reflected in the Namrole District's high Marshall Centrality Index)

frequently served as stronger drivers of spatial interaction than mere geographical proximity. This suggested that development policies that focused only on reducing physical distances, without simultaneously strengthening the economic attractiveness of the region, were unlikely to generate meaningful interactions. Spatial planning and infrastructure investment were crucial for optimizing and maintaining the Namrole-Leksula District corridor. As Pratiwi & Dharma (2020) have suggested, improving the service center connectivity should be prioritized after their hierarchical structure was clearly established. In the case of South Buru Regency, this means that the government must prioritize upgrading and maintaining both maritime and land transportation routes connecting these two districts to ensure the efficient flow of logistics. Furthermore, in light of the digital economic integration trend highlighted by Yuniar & Setiawan, (2024), there was a need to extend digital infrastructure along this corridor. Strengthening internet connectivity would support the exchange of information and digital transactions, thereby fostering enhanced economic integration and allowing the benefits of development to reach a wider set of communities.

Analysis of Regional Growth Centers through the Integration of Scalogram, Marshall Centrality Index, and Gravity Analysis Methods

This study employed a multi-layered analytical approach that combines scalogram, Marshall Centrality Index, and gravity analysis methods to identify regional growth centers (Fadrullah, 2022; Sari, 2021; Sulistya, 2025). The integration of these three methods allows the assessment to capture structural, functional, and relational dimensions of the regional systems. In practice, the growth centers were evaluated not only by the completeness of facilities, but also by the quality of services and the strength of spatial interactions. In the context of South Buru Regency, this integrated approach offers more valid confirmation than the use of a single method. It has been determined through the application of three distinct analytical perspectives that Namrole District is consistently identified as the primary growth center.

Table 6. Results of Integration of Three Analysis Methods

No.	Origin District	Scalogram	Marshall Centrality Index	Gravity Analysis	Conclusion
1.	Namrole	I	I	Strong interaction	Primary growth center
2.	Kepala Madan	II	II	Moderate interaction	Secondary growth center
3.	Leksula	II	II	Strong interaction	Secondary growth center
4.	Waesama	II	III	Strong interaction	Buffer zone
5.	Fena Fafan	III	III	Weak interaction	Remote zone
6.	Ambalau	III	III	Moderate interaction	Buffer zone

Source: Research results, 2025

Table 6 indicates that Namrole District holds the top position in the Order I of scalogram, records the highest score in the Marshall Centrality Index, and forms the strongest interaction pair in the gravity analysis. This validates its established status as the uncontested primary growth center. This finding aligns with the growth pole theory by Perroux (1955b), which posited that economic growth was often concentrated in locations with superior characteristics. A similar pattern was identified in the study conducted by Sari et al. (2023) in South Sumatra, wherein the district capital consistently occupied the highest hierarchical position in the multi-method analysis. The comprehensive range of facilities available in Namrole District (30 facilities) and its exceptionally high infrastructure weight (888.90) designate the area as a major engine of regional growth. Furthermore, its status as the strongest interaction node further reinforced this role, indicating that Namrole District functioned not merely as an administrative center, but as a genuine driver of economic activity across South Buru Regency. These findings provide a strong foundation for the prioritization of infrastructure development in Namrole District, recognizing it as a pivotal catalyst for the region's engine of growth. Furthermore, Kepala Madan District and Leksula District exhibit consistency as secondary growth centers, as evidenced by the Order II of scalogram and the Marshall Centrality Index II. However, it should be noted that these centers manifested divergent interaction patterns. The study by Nugroho, et al (2021) found that secondary centers typically developed complementary functional specializations. Leksula District, which exhibits the strongest interaction with Namrole District, demonstrated considerable potential as a strategic partner within the economic corridor. Conversely, Kepala Madan District, with its moderate interaction, played a stabilizing position in the western region. These differences signaled the need for differentiated policy requirements for each secondary center. Specifically, Leksula District would require further development as a regional logistics node, while Kepala Madan District would have the potential to function as a service center for the hinterland. This strategy aligns with the clustering approach proposed by Pratiwi & Dharma

(2020). Meanwhile, Waesama District's position, classified as Order II of scalogram, Marshall Centrality Index III, and the strongest interaction, suggests that it occupies a transitional role between secondary centers and buffer zones. This inconsistency mirrored a phenomenon identified, wherein regions with decent accessibility yet insufficient infrastructure frequently assumed multiple roles. In the case of Waesama District, its status as a buffer zone with the strongest interaction indicated its potential to absorb the development impact of the main growth center. However, its lower infrastructure weight (Marshall Centrality Index III) limited its ability to fully capitalize on this role, highlighting the need for special investment to increase its service capacity.

Fena Fafan District consistently appears at the lowest tier across all three analyses, as indicated by its position in Order III of scalogram, Marshall Centrality Index III, and weak interaction. This observation highlighted the significant challenges associated with the development of remote areas. This finding is consistent with the conclusions of a study by Yuniar & Setiawan (2024), which identified a digital divide and multiple forms of isolation in areas exhibiting similar characteristics. Limited access to higher-order centers, combined with low level of spatial interaction, reinforced the cycle of underdevelopment. For this reason, Fena Fafan District would require affirmative policy interventions that would prioritize not only the development of fundamental infrastructure, but also the enhancement of digital connectivity and the implementation of specific empowerment programs. When the core-periphery theory was visualized on a growth center zoning map, the context of South Buru Regency would be clear. The formation of a hierarchical structure with Namrole District as a relatively centrally located primary growth centre, surrounded by secondary growth centres (Kepala Madan District and Leksula District), suggested a polarized pattern of development. This phenomenon aligns with the observations reported by Nugroho, et al, (2021), who noted a tendency for economic growth to concentrate in locations with stronger accessibility and more compelte infrastructure. Namrole District's strategic position would enable it to function as the growth engine of regional development. However, this concentration also had the potential to widen the gap with remote areas if it was not matched by effective redistributive policies to ensure the diffusion process of development was optimized.

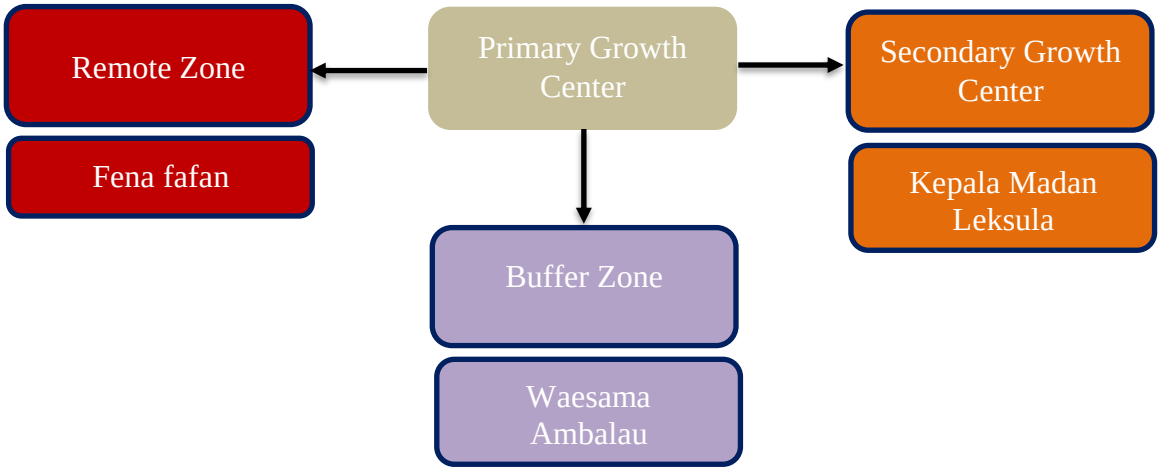


Figure 4. Growth Center Zoning Map
Source: Research results, 2025

Figure 4 above presents the growth center zoning map. The zoning map above illustrates that the presence of two secondary growth centers, namely Kepala Madan District and Leksula District, created a more resilient spatial structure than the monocentric model. Both secondary growth centers functioned as intermediary centers or gateways that helpd channel interaction between the primary growth center (Namrole District) and the buffer and remote zones. This finding aligns with the research conducted by Pratiwi & Dharma (2020), which underscored the significance of establishing a hierarchical structure for service centers to strengthen the regional economic networks. In this regard, Leksula District, with its maritime potential, and Kepala Madan District, could develop specific economic clusters that complemented each other, thus creating multiple engines of growth. This strategy would have the potential to prevent overburdening Namrole District and strengthen the internal economic integration of the district through the creation of multiple development corridors. The zoning of buffer zones (Waesama Distract and Ambalau District) and remote zones (Fena Fafan District) identified areas that further required specialized policy approaches. Waesama District and Ambalau District, positioned as buffer zones, hold the potential to function as labor-absorbing areas and

raw material providers for the growth centers. Meanwhile, Fena Fafan District's status as a remote area implied considerable accessibility and isolation challenges. Without effective intervention, these challenges could risk permanent development lag. A study by Sari, et al, (2023) had identified the need for affirmative interventions in the form of basic infrastructure development and targeted community empowerment programs in these areas. In line with these findings, future policy directions in South Buru Regency should prioritize enhancing both physical and digital connectivity between the designated growth centers and the more isolated regions. Such improvements must be coupled with efforts to cultivate each area's superior local potential, thereby reducing structural dependency while improving functional connectivity within a more integrated regional system.

CONCLUSION

The integration of scalogram, Marshall Centrality Index, and gravity analysis provides a clear and polarized hierarchy of regional growth in the spatial structure of development in South Buru Regency. Taken together, these three methods consistently point to Namrole District as the primary growth center, supported by its complete set of facilities (30), strong infrastructure weight (888.90), and its role as the strongest interaction node, particularly with Leksula District (510,712.95). Further, this study finds that Kepala Madan District and Leksula District function as secondary growth centers that help connect Namrole District with the surrounding areas. Meawhile, Waesama District and Ambalau District function as buffer zones, while Fena Fafan District is categorized as a remote zone due to its limited access and facilities. This pattern is consistent with the classical growth center theory and spatial interaction models, as well as recent research findings emphasizing the unique challenges of development in archipelagic regions. These findings suggest that future policy planning should prioritize strengthening the connectivity within the Namrole-Leksula District corridor while simultaneously fostering economic clusters that reflect the strengths and potential of each tier within the hierarchy to ensure a more inclusive and sustainable regional growth

REFERENCES

Amane, A. P. O., Fatimah, I. A., Fadjarajani, S., Ramadhani, B. S., Destanto, K., Rangkuti, B. A. F., Wurarah, R. N., Arida, V., Wijaya, M., & Mailendra, M. (2023). *Pengembangan wilayah dan perkotaan di Indonesia*. PT Mafy Media Literasi Indonesia.

Badan Pusat Statistik (BPS) Kabupaten Buru Selatan. (2025). *Buru Selatan Dalam Angka*.

Fadrullah, M. (2022). *Analisis Penentuan Pusat-Pusat Pertumbuhan Di Kecamatan Pangkaln Kuras Kabupaten Pelalawan*. Universitas Islam Riau.

Hanifah, J. (2025). *Analisis Pusat Pertumbuhan Wilayah dan Hinterland di Kabupaten Kulon Progo*. Universitas Islam Indonesia.

Harahap, A. A. (2025). Analisis Pertumbuhan Ekonomi Inklusif di Kawasan Tertinggal. *Circle Archive*, *1*(7).

Latifah, N., Ningsih, Y., & Assyahri, W. (2024). Partisipasi Masyarakat dalam Perencanaan Pembangunan Nagari di Sumatera Barat. *Journal of Public Administration and Management Studies*, *2*(2), 47–54.

Nugroho, A. D., Prasetyo, B., & Hadi, S. P. (2021). Identifying regional growth poles: A spatial analysis of economic development in East Java, Indonesia. *Journal of Regional and City Planning*, *32*(2), 145–162.

Nur, A. A. (2024). Analisis dampak pembangunan infrastruktur terhadap kesejahteraan masyarakat pedesaan di Kabupaten Bulungan. *Jurnal Ekonomi Pembangunan Dan Manajemen*, *3*(1), 1–12.

Nurhikmah, Z., Manaf, M., & Aksa, K. (2025). Penilaian Kesesuaian Kegiatan Pembangunan Infrastruktur Terhadap Pemanfaatan Ruang Kota Sofifi Provinsi Maluku Utara. *Urban and Regional Studies Journal*, *7*(2), 146–156.

Perroux, F. (1955a). Note sur la notion de pôle de croissance. *Économie Appliquée*, *8*(2), 307–320.

Perroux, F. (1955b). Note sur la notion de pôle de croissance. *Économie Appliquée*, *8*(2), 307–320.

Pratiwi, R., & Dharma, A. G. (2020). Analyzing urban hierarchy and spatial interaction for regional development planning in Kalimantan. *Indonesian Journal of Geography*, *52*(1), 88–105.

Putra, M. E. (2019). *Analisis Pusat-Pusat Pertumbuhan Wilayah Pesisir Di Kabupaten Indragiri Hilir*. Universitas Islam Riau.

Reilly, W. J. (1931). *The Law of Retail Gravitation*. Knickerbocker Press.

Ridwan, R., & Hajiali, I. (2022). *Analisis Potensi Wilayah (ANPOTWIL)*. Pustaka Pelajar.

Rohmah, N. A., & Fitrianto, A. R. (2024). Analisis Interaksi Spasial Antarwilayah di Kabupaten Sidoarjo: Identifikasi Pusat Pertumbuhan Ekonomi dan Dampaknya terhadap Ketimpangan. *Desa-Kota: Jurnal Perencanaan Wilayah, Kota, Dan Permukiman*, *6*(1), 1–13.

Saputra, K. A., & Suryanto, S. (2022). Sektor Basis dan Tipologi Pertumbuhan Ekonomi sebagai Dasar Penetapan Pusat Pertumbuhan Wilayah di Jawa Tengah. *Jurnal Ekonomi Dan Pembangunan Daerah*, *17*(1), 55–70.

Sari, D. P., Fauzi, A., & Juanda, B. (2023). Multi-criteria analysis for determining regional growth centers in South Sumatra: A spatial approach. *Regional Science Policy & Practice*, *15*(1), 88–105.

Sari, M. (2021). *Kajian pusat pertumbuhan dan wilayah hinterland di kabupaten Siak*. Universitas Islam Riau.

Suhardi, S., & Panjaitan, P. (2025). Analisis Strategi dan Kebijakan Pemerintah Daerah dalam Perencanaan Pembangunan Ekonomi Nasional. *Jurnal Ilmu Manajemen, Bisnis Dan Ekonomi (JIMBE)*, *3*(1), 42–55.

Sulistya, I. E. (2025). Penentuan Pusat Pertumbuhan Ekonomi dan Analisis Interaksi Spasial Antarwilayah Di Provinsi Daerah Istimewa Yogyakarta. *JDEP (Jurnal Dinamika Ekonomi Pembangunan)*, *8*(1), 63–78.

Suryaman, M. (2025). Keterlibatan Stakeholder dalam Perencanaan Pembiayaan untuk Meningkatkan Mutu Kualitas Pendidikan. *Jurnal Penelitian Tarbawi: Pendidikan Islam Dan Isu-Isu Sosial*, *10*(1), 121–132.

Wicaksono, A., & Hidayat, K. (2019). The impact of transportation infrastructure on shifting regional growth centers: Evidence from the Trans-Java Toll Road. *Journal of Infrastructure, Policy and Development*, *3*(2), 210–225.

Yuniar, R., & Setiawan, I. (2024). Integrating digital economy indicators into regional growth pole analysis: A case study of Metropolitan Bandung. *Journal of Urban Management*, *13*(1), 112–128.