SERVICE CENTER HIERARCHY IN GORONTALO: EMPIRICAL ANALYSIS THROUGH SCALOGRAM AND CENTRALITY

Kalzum R. Jumiyanti[1]*, Joachimu Stanley Machimu[2], Dewi Walahe[3]

[1]Faculty of Economics and Business, Gorontalo University, Indonesia

[2]Tanzania Institute of Accountancy, Tanzania

[3]Faculty of Social Politics, Gorontalo University, Indonesia

*Corresponding author: yanti.kalzum@gmail.com

ARTICLE INFO	ABSTRACT
	Regional disparities in service infrastructure persist across Indonesia despite spatial planning efforts. This study addresses the critical gap between normative planning (RTRW 2012) and empirical service center hierarchy in Gorontalo Regency. Using an integrated approach combining Guttman scalogram analysis and Marshall centrality index—a methodological innovation in regional analysis—we identified five hierarchical levels of service centers based on facility distribution across 19 sub-districts. The key finding reveals a serious asynchronization between planned hierarchy (RTRW) and empirical reality: while Tibawa is designated as the regional activity center (PKW), scalogram analysis demonstrates that Limboto and Telaga represent the functionally dominant centers with significantly higher service capacity and facility diversity. Conversely, several peripheral zones designated as PPL (environmental service centers) show higher potential than planned estimates. These findings demonstrate that spatial planning in Gorontalo Regency has not effectively aligned with actual economic and infrastructure development patterns. We recommend RTRW revision based on empirical evidence to optimize infrastructure investment allocation and support more equitable regional development. This research contributes theoretically by demonstrating the applicability of integrated spatial analysis methods to Indonesian regional contexts and provides practical policy guidance for responsive spatial planning in decentralized governance systems.

1. INTRODUCTION

Indonesia is experiencing rapid urbanization, with approximately 67.5% of the population projected to live in urban areas by 2025 (Bappenas, 2015). This urban transformation reveals a fundamental spatial reality: regional economic growth concentrates at specific geographic points rather than distributing evenly across territory.

Gorontalo Regency, comprising 2,125.47 km² and 19 sub-districts, exemplifies this pattern, where development opportunities and service infrastructure remain concentrated in a few major administrative and economic centers. This spatial concentration creates persistent inequities in regional development, raising critical questions about the effectiveness of spatial planning in directing more balanced and inclusive growth.

Understanding regional spatial concentration requires integrating multiple theoretical perspectives. Growth Pole Theory Perroux, (1995), explains that economic development manifests at specific centers or "poles" with varying intensities, subsequently spreading through different economic channels with differential impacts on surrounding regions. This theory predicts that growth concentrates rather than disperses naturally. Central Place Theory Christaller, (1933), complements this perspective by demonstrating that settlements organize hierarchically based on the functions they provide and the geographic extent they serve—larger centers offer more specialized services with broader spatial reach. Together, these theories explain why without deliberate intervention, development gaps between primary centers and peripheral areas tend to widen. Myrdal, (1957) concept of backwash effects describes this dynamic precisely: capital, labor, and investment flow from poor regions to rich regions, reinforcing spatial inequality through cumulative causation. However, these classical theories emerged in developed economies with established infrastructure networks. Their application to developing regions with uneven infrastructure, complex topography, and decentralized governance—as in Indonesia—requires empirical validation and potential theoretical refinement. This research applies these integrated theoretical lenses to examine whether Gorontalo Regency's actual spatial structure aligns with these theoretical predictions.

Gorontalo Regency confronts two critical, interrelated challenges. First, systematic regional inequality: public infrastructure and service facilities are concentrated in specific administrative centers (particularly Limboto and Tibawa), leaving peripheral areas with severely limited access to education, health, and economic services. This concentration creates bottlenecks in major centers while peripheral regions experience persistent underdevelopment, driving migration pressure and reinforcing spatial disparities. Second, and more critically, a significant planning-implementation gap: The Regional Spatial Plan (RTRW 2012) designates specific centers for development based on aspirational planning, yet empirical conditions on the ground often diverge substantially from these designations. Research by Muliana et al., (2018) confirms that RTRW classifications frequently misalign with actual service center functionality based on facility availability and accessibility analysis. Gorontalo Regency's new urban development plan designating Telaga District as a primary center lacks comprehensive empirical validation, raising concerns about resource allocation efficiency and regional equity outcomes.

Scalogram analysis and centrality index approaches have been applied in various Indonesian regions with varying methodological rigor. Single-method approaches: Srinivasu, (2013) identified five-tier hierarchies in Medan using scalogram analysis, while Jufri & Nonce, (2016) documented significant variations in socio-economic infrastructure completeness across West Halmahera sub-districts. These studies confirmed that facilities distribute unevenly but provided limited insight into which facilities most significantly determine center hierarchy. Integrated approaches show greater analytical power: Sutikno & Maryunani, (2007) demonstrated that combining scalogram analysis with Marshall centrality index—which weights facilities by their relative importance and spatial rarity—produces more nuanced hierarchy classifications. Muliana et al., (2018) confirmed this advantage across multiple Indonesian districts: integrated application resulted in more accurate identification of actual service centers compared to single-method approaches. However, a critical research gap persists: No study has systematically compared RTRW-designated hierarchies with empirically-derived hierarchies, meaning the accuracy and current relevance of spatial plans remain unevaluated. Moreover, applications remain concentrated in Java and Sumatra; Sulawesi regions remain understudied. This represents both geographic and methodological gaps requiring urgent attention.

This research addresses four distinct, reinforced research gaps: (1) Geographic Gap—Understudied Region: While scalogram-centrality index studies exist for Java and Sumatra, comprehensive, integrated analysis in Sulawesi, specifically Gorontalo Regency, is absent from literature. This geographic gap is significant because Sulawesi's distinct topography,

|infrastructure constraints, and decentralized governance patterns differ substantially from Java/Sumatra, requiring region-specific analysis. (2) Methodological-Comparative Gap—Missing Validation: No prior study has systematically compared RTRW-designated center hierarchies with empirically-derived hierarchies using integrated scalogram-centrality index analysis. This comparative gap is critical because RTRW accuracy and relevance to actual ground conditions remain unevaluated; planners cannot determine whether spatial plan designations reflect empirical reality or aspirational thinking; resource allocation decisions continue without evidence regarding actual center functionality. (3) Policy-Validation Gap—Unvalidated Development Plans: Gorontalo Regency's new urban development plan designating Telaga District as a primary growth center lacks empirical evidence regarding its feasibility, capacity, and equity implications. Implementing major development investment without evidence-based validation of the designated center's actual service capacity and hierarchical position creates high risk of resource misallocation and exacerbated inequality. (4) Integration-Application Gap—Limited Theoretical Application: While theory predicts that spatial concentration reinforces through backwash effects, empirical validation of these mechanisms in the Indonesian context and assessment of whether RTRW planning effectively counteracts these effects remains limited. Integration of Growth Pole Theory, Central Place Theory, and Myrdal's backwash concept with empirical facility-based analysis has not been systematically attempted in Gorontalo Regency. These four gaps create a compelling research imperative combining geographic, methodological, policy, and theoretical dimensions.

This research addresses three primary research questions designed to fill these gaps: (1) What is the structure of service centers in Gorontalo Regency based on the current RTRW? (2) What is the hierarchical structure of service centers in Gorontalo Regency based on empirical analysis using the scalogram method and centrality index? (3) What are the optimal recommendations for the structure of service centers in Gorontalo Regency based on the results of a comprehensive analysis? In general, this study aims to: (a) identify and analyze the structure of service centers based on RTRW to understand the direction and policy of space development that has been set; (b) conduct mapping and empirical analysis of the hierarchy of service centers using scalogram analysis and Marshall centrality index; (c) conduct a comparative evaluation between the structure of the service center in the RTRW and the results of empirical analysis; and (d) formulate comprehensive, empirical evidence-based recommendations for optimal service center structures to support more equitable regional development.

This research has significant implications on three dimensions. Theoretically, this research contributes to the development of an understanding of how scalogram analysis and centrality indices can be integrated to provide a more comprehensive understanding of the hierarchy of growth centers in heterogeneous regions outside Java, as well as make an academic contribution to the relevance of Central Place Theory (CPT) in the context of developing regions in Indonesia (Asoka et al., 2013; Faradila et al., 2022; Christaller, 1933 in Pane, 2013; Srinivasu, 2013). Practically, the results of this research will be valuable input for decision-makers in Gorontalo Regency in designing regional development strategies that are more effective and based on actual empirical conditions. The results of the analysis can be used to optimize the allocation of investment in infrastructure and public service facilities to encourage the development of alternative growth centers that are more equitable throughout the district. In terms of policy, this research provides a strong empirical basis for the evaluation and revision of the Gorontalo Regency RTRW to be more responsive to the dynamics of local economic development. The results of the research can be a guide for decision-makers in evaluating the feasibility and impact of the new city development plan with Telaga District as the center so that decisions can be more informed and based on in-depth spatial analysis. Broadly, the methodology and findings of this research can be replicated for other regions in Indonesia to support more inclusive and sustainable regional development planning in the modern decentralized era.

2. RESEARCH METHODS

This research employed a mixed-methods approach combining scalogram analysis with Marshall centrality index analysis to identify and classify service center hierarchies in Gorontalo Regency. The study was conducted across 19 sub-districts and 206 villages covering an area of 2,125.47 km² with a total population of 405,690 people (BPS Kabupaten Gorontalo, 2024). Primary data were collected through field observation to systematically inventory public facilities including education (kindergarten, primary school, junior high school, senior high school, and university), health (hospitals, health centers, and posyandu), worship facilities, economic facilities (supermarkets, restaurants, banks, and shops), and government facilities. Secondary data were obtained from the Central Statistics Agency (BPS) Gorontalo Regency regarding population statistics and administrative boundaries. Both data types were analyzed using scalogram analysis and Marshall centrality index to establish the empirical hierarchy of service centers.

Scalogram or Guttman scale analysis is a quantitative method to group sub-districts based on the level of complexity of their service functions (Utari, 2015). According to Riyadi & Bratakusumah, (2005), this method requires three data components: (1) a comprehensive inventory of settlements within the study area, (2) population data for each settlement, and (3) a complete list of service facilities and functions present in each settlement. The Guttman scale method operates under two fundamental requirements: first, variables must be homogeneous and single-dimensional, meaning the scale measures only one underlying dimension of service center complexity; second, the variables must be cumulative and hierarchical, indicating that if a settlement possesses a higher-order service facility, it will necessarily possess all lower-order facilities. This cumulative property ensures logical consistency in the hierarchy and increases interpretability of results.

The procedure for compiling the scalogram followed five sequential stages to ensure systematic and replicable analysis Muzahar, (2000) : (1) all 19 sub-districts were arranged by population size, from largest to smallest, using 2024 BPS population data, (2) sub-districts were re-ordered based on the total count of distinct facility types present in each location, reflecting functional complexity, (3) each facility type was independently arranged to identify which sub-districts possessed that specific facility, creating a binary matrix (1 = facility present; 0 = facility absent), (4) facilities were organized by their frequency of occurrence across all sub-districts, ranging from most common to rarest, and (5) the final hierarchy classification was determined based on the cumulative count of facility types and total facility units in each sub-district (Muzahar, 2000). This five-stage procedure ensured that the resulting hierarchy maintained logical coherence where higher-order centers necessarily contained the service functions of lower-order centers.

Hierarchy classification thresholds were established using the value interval formula: Value Interval = (Highest Value – Lowest Value) / Number of Hierarchy Levels, with hierarchy levels predetermined at five tiers based on the Guttman cumulative property and precedent from comparable studies (Srinivasu, 2013; Jufri & Nonce, 2016). This mathematical approach ensured objective, reproducible threshold determination rather than subjective categorization. The rationale for selecting five hierarchy tiers was grounded in several factors: first, scalogram analysis of comparable regional studies (Medan, West Halmahera) consistently produced five distinct functional tiers; second, five tiers align with the normative planning categories in Indonesia's spatial planning framework (PKW, PKL, PKLp, PPK, PPL) and provide sufficient granularity to distinguish functional differences while maintaining analytical clarity; third, preliminary data exploration of Gorontalo's 19 sub-districts revealed natural clustering patterns that corresponded to approximately five functional groupings. The quality of the resulting scalogram was measured using the Reproducibility Coefficient (COR), calculated as COR = [(Frequency – Error) / Frequency] × 100%, with values above 0.90 indicating a scale with acceptably low error rates. All scalogram analyses achieved COR values exceeding 0.92, confirming high-quality hierarchical classification.

The level of each sub-district is divided into three categories (high, medium, low) using the value interval formula in equation (1). The value of the reproducibility coefficient (COR) indicates the quality of the resulting Guttman scale. According to Riyadi & Bratakusumah, (2005), the COR ranges from 0–1, and the > value of 0.9 is considered to indicate a scale that applies with a low error rate.

The COR is calculated by equation (2) which compares the total frequency with the number of errors in the scale (Riyadi & Bratakusumah, 2005).

$$Value\ Interval = \frac{(Highest\ Value - Lowest\ Value)}{Order\ Quantity/Hierarchy}$$ .... (1)

$$COR = \frac{(Frequency - Error)}{Frequency} \times 100\%$$ .... (2)

Marshall centrality index analysis is used to give weight to existing facilities and determine the hierarchy of growth centers (Faradila et al., 2022). Marshall centrality index analysis was employed as a complementary weighting method to account for the differential importance of facility types in determining service center hierarchy. Unlike scalogram analysis which treats all facilities equally, the centrality index recognizes that certain rare and strategically important facilities contribute more significantly to a center's hierarchical status than ubiquitous, basic facilities. The weighting system operated as follows: each facility type was assigned a weight inversely proportional to its frequency of occurrence across all sub-districts, calculated using the formula: Weight = (Total Sub-districts – Frequency of Specific Facility) / Frequency of Specific Facility. This weighting mechanism ensured that rare facilities such as universities (appearing in only 3 of 19 sub-districts, weight = 6.33), hospitals (appearing in 1 sub-district, weight = 19.00), and people's credit banks (appearing in 1 sub-district, weight = 19.00) received the highest weights, reflecting their greater rarity and strategic importance in determining centrality. Conversely, ubiquitous facilities such as primary schools, health centers, and posyandu (appearing in all 19 sub-districts, weight = 1.00) received minimal weights, as their universal presence provides limited discriminatory power for hierarchy determination.

The centrality value of each facility is calculated using equation *(3)*, where C is the weight of the facility attribute, t is the combined centrality value, and T is the total number of facility attributes in the study area (Faradila et al., 2022). Centrality Index = Σ (Facility Count × Facility Weight). This weighted approach produced a centrality value that ranged from 8 (for the lowest-ranked sub-district) to 21 (for the highest-ranked sub-district), creating a more nuanced differentiation than simple facility counting. The resulting index values directly determined classification thresholds for hierarchy levels: Primary Level (Index ≥ 19), Secondary Level (Index 13-18), Tertiary Level (Index < 13). These thresholds were established post-hoc from the distribution of calculated centrality indices, ensuring that threshold selection reflected actual data distribution rather than arbitrary assumptions. The mathematical logic underlying this weighting system enhances replicability: future researchers applying this methodology to other regions would generate comparable weights based on facility frequencies in their respective study areas, making the method transferable and transparent.

$$C = \frac{t}{T}$$ .... (3)

where C is weights of facility attributes, t is combined centrality value, and T is total number of facility attributes.

The integration of scalogram and centrality index analysis addressed complementary analytical objectives: scalogram analysis identified which combinations of facilities appear together in service centers and provided a cumulative classification of facility completeness; centrality index analysis weighted facilities by strategic importance and identified which specific facility profiles create the most influential service centers. The combined approach revealed that some sub-districts with high facility counts (like Limboto, with numerous basic facilities) achieved moderate centrality indices, while other sub-districts with fewer but rarer facilities (like Telaga) achieved higher centrality indices. This integration revealed that service center hierarchy is determined not merely by facility quantity but by the strategic composition of facilities present.

Data limitations were explicitly acknowledged and managed throughout the analysis. First, this analysis counted facility presence (binary: present/absent) and facility quantity but did not evaluate facility quality, capacity, or actual service delivery effectiveness. A sub-district with five low-quality health centers was counted identically to a sub-district with one high-quality, well-equipped health center. Future analysis should incorporate quality assessments (equipment status, staffing levels, service hours) to provide more realistic functionality measures. Second, the facility inventory was limited to major facility categories and did not account for informal service providers (private clinics, private schools, informal markets) that may be numerically significant in some areas. Third, the analysis did not measure actual accessibility or service reach from facilities to populations; geographic distance, transportation networks, and travel time barriers were not incorporated.

A sub-district with 10 health centers might still have populations with limited practical access if facilities were concentrated in specific geographic areas. Fourth, the analysis reflected the situation at a single point in time (2024) and did not capture temporal dynamics in facility development or depreciation. Sub-districts that recently gained facilities or experienced facility closures would not show these transitions. Fifth, facility classification categories may have inadequately captured specialized facilities or services unique to certain sub-districts that do not fit standard categories. Sixth, population mobility and actual service-seeking behavior patterns were not empirically measured; the analysis assumed populations used nearest facilities rather than investigating where services were actually utilized.

These methodological limitations suggest that while the scalogram and centrality index provide valuable comparative rankings of service center hierarchy, they should be interpreted as one component of comprehensive service assessment rather than absolute measures of center functionality. The results identify relative differences in service center development that are suitable for strategic planning guidance but should be supplemented with accessibility analysis, quality evaluation, and longitudinal monitoring for operational decision-making. Subsequent research should address these limitations through integration with geographic information systems (GIS) to model accessibility, inclusion of facility quality metrics, and time-series analysis to capture facility development dynamics.

To enhance replicability and transparency, the complete facility inventory matrix, centrality weight calculations, and hierarchy classification decisions have been documented and made available in supplementary materials. Researchers seeking to replicate this analysis in other regions can follow the identical five-stage scalogram procedure, apply the inverse-frequency weighting formula to their local facility distributions, and employ the same threshold formulas and procedures. The methodology is independent of specific facility categories, allowing adaptation to different regional facility classifications while maintaining analytical rigor and transparency. This systematic documentation supports the research objective of developing transferable, transparent methods for service center analysis applicable across Indonesia's diverse regions.

3. RESULTS AND DISCUSSION
Analysis of Supporting Factors for Determining the Growth of Local Activity Centers in Gorontalo Regency

Along with the passage of time, population growth in Gorontalo Regency from time to time has always undergone changes. This condition is also triggered by the natural development pattern of population distribution carried out by the residents themselves in the process of choosing a less directed place to live, which means that there is a tendency for uniform motivation from the population in choosing a place to live, both the motivation of the strategic location to facilitate the fulfillment of daily needs and other motivations which in the end this phenomenon results in an uneven distribution of the population. The distribution of the population in Gorontalo Regency can be seen in the Table 1.

Gorontalo Regency has a total population of 405,690 people spread across 19 sub-districts and 206 villages/sub-districts in an area of 2,125.47 km². The population distribution in these districts shows a very uneven pattern, where the population is concentrated in a few specific sub-districts while other sub-districts have much lower populations. This non-homogeneous distribution pattern reflects the dynamics of economic development, regional accessibility, and the availability of public service

facilities that vary in each sub-district. This inequality is the result of a complex process of interaction between geographical, infrastructure, economic opportunities, and development policies that has taken place over a long period of time.

The highest population concentration occurred in Limboto District with a total of 51,676 people, representing 12.73% of the total district population. Limoto, which is the capital of the district, is the main administrative and commercial center, which is why it attracts population migration from various other regions. After Limboto, a significant population concentration is also found in Tibawa District with 41,933 people (10.34%), Telaga Biru with 31,173 people (7.68%), and Pulubala with 27,334 people (6.74%). These four sub-districts alone accommodate 37.4% or more than a third of the total population of Gorontalo Regency, showing a very extreme level of concentration. This phenomenon shows that development and economic growth are still largely concentrated in a few major growth centers, while other regions are still lagging behind in their development.

The sub-district category with a moderate population concentration includes areas such as Tolangohula with 23,163 people (5.71%), Mootilango with 19,380 people (4.78%), Bongomeme with 20,111 people (4.96%), Tabongo with 18,670 people (4.60%), Dungaliyo with 17,872 people (4.40%), Boliyohuto with 17,673 people (4.36%), and Tilango with 16,162 people (3.99%). These sub-districts have populations ranging from 16,000 to 23,000 people, with each representing between 3.99% to 5.71% of the total population of the district. These areas serve as secondary growth centers with a medium level of development, have several service facilities but are not as complete as those in the main center. These sub-districts show the potential to be further developed as part of the equitable regional development strategy.

Table 1. Number of Population in Gorontalo Regency in 2024

District	Population
Batudaa Pantai	12.377
Biluhu	8.570
Batudaa	14.920
Bongomeme	20.111
Tabongo	18.670
Dungaliyo	17.872
Tibawa	41.933
Pulubala	27.334
Boliyohuto	17.673
Mootilango	19.380
Tolangohula	23.163
Asparaga	13.829
Bilato	10.547
Limboto	51.676
Limboto Barat	25.343
Telaga	22.229
Telaga Biru	31.173
Tilango	16.162
Talaga Jaya	12.728
Gorontalo Regency	405.690

Source: Badan Pusat Statistik Kabupaten Gorontalo (2024)

Structure of Growth Centers in Gorontalo Regency Based on the RTRW of Gorontalo Regency
The spatial structure of the district area is a spatial layout of the district area which is composed of a constellation of activity centers that are hierarchical with each other connected by the district area infrastructure network system, especially the transportation network. The structure of service centers in Gorontalo Regency based on the Gorontalo Regency RTRW is on the Table 2.

Table 2. Structure of Service Centers in Gorontalo Regency Based on the Gorontalo Regency RTRW

District Capital	Hierarchy of Functions	Main Functions
Batudaa Pantai	PPL	Development Center
		Marine transportation; Rural settlement allocation areas; Strategic Development Area, Cultural Tourism and Historical Buildings
Biluhu	PPL	Development Center
		Marine transportation; Rural settlement allocation area
Batudaa	PPK	Urban settlement, trade and service areas; Strategic Development Area, Cultural Tourism and Historical Buildings
Bongomeme	PPL	Rural settlement allocation areas; Strategic Development Area, Cultural Tourism and Historical Buildings
Tabongo	PPL	Urban & rural settlement allocation areas; Strategic Development Area, Cultural Tourism and Historical Buildings
Dungaliyo	PPL	Kawasan strategi pengembangan agro industri, perdagangan dan jasa; peruntukan permukiman perkotaan&Perdesaan
Tibawa	PKW	Your Urban Area Plan; Development of Land, Rail, Bus and Air Transportation Centers; Development of the Center for Agro-Industry and Agro-Business; Facility Development and
		Accommodation and Tourism Infrastructure; Development of Trade and Service Centers; Urban & Rural Settlement Allocation Area
Pulubala	PPK	Processing industrial estates; Rural settlement allocation area
Boliyohuto	PPK	Processing industrial estates; Urban & rural settlement allocation area
Mootilango	PPL	Processing industrial estates; Rural settlement allocation area
Tolangohula	PPL	Irrigation Areas; production forest areas; Rural settlement allocation area
Asparaga	PPL	Irrigation Areas; production forest areas; Rural settlement allocation area
Bilato	PPL	Development of Marine Transportation Centers; Rural settlement allocation area
Limboto	PKL	Preparation of Limboto Urban Spatial Plan; Strengthening the Gorontalo Regency Government Center; Development of Education and Research Centers; Development of trade and service centers; development of land transportation; infrastructure improvement; Urban & Rural Settlement Allocation Area
Limboto Barat	PKLp	Development of Education and Research Centers; Urban & Rural Settlement Allocation Area
Telaga	PKLp	Development of Education and Research Centers; Facilities strategy areas and
		Land transportation infrastructure; Urban & rural settlements, trade and services areas;
Telaga Biru	PPL	Land transportation facilities and infrastructure strategic areas; Urban & rural settlements, trade and services;
Tilango	PPL	Wetland and dry land agricultural allocation areas; plantation areas; livestock areas; Mineral mining allocation area; Urban settlement, trade and service areas;
Talaga Jaya	PPL	Wetland and dry land agricultural allocation areas; plantation areas; Urban settlement, trade and service areas;

Based on the Table 2, the structure of the RTRW growth centers shows that there is a clear differentiation between centers that have complete urban functions (PKL and PKLp) and centers that have local service functions and local resource-based development (PPL and PPK). Pulubala, Boliyohuto, Asparaga, and Batudaa Districts were designated as Regional Development Centers (PPK) with a focus on development in the processing industry, agriculture, and settlements, reflecting the economic potential of these areas. RTRW also recognizes that the development of these growth centers must be supported by adequate infrastructure, especially in terms of land transportation, accessibility, and connectivity between centers. The hierarchical structure pattern set out in the RTRW reflects efforts to create a more balanced and equitable development system across districts, driving economic growth not only in the main centers but also in secondary centers and developing areas. However, the implementation of this structure requires significant investment commitments, strong coordination between government agencies, and careful planning to ensure that each growth center can function in accordance with the roles that have been set in the RTRW, so that regional development can run effectively and sustainably in achieving the goal of equitable development in Gorontalo Regency.

Structure of Service Centers in Gorontalo Regency based on Scalogram Analysis and Centralist Index

Scalogram *analysis* is used to analyze the completeness of the function of facilities in an area by writing the method of writing the existence or absence of (socio-economic facilities), namely by filling in the number 1 if the facility is located in an area and filling in the number 0 if the facility is not located in an area. Furthermore, *scalogram* analysis can be developed to determine the *weighted centrality index*. The *centrality index* analysis is used to see the level of centralization of service facilities, in an area, this analysis is not only based on the number of functions or facilities, but also based on the frequency of the existence of functions or service facilities, the higher the centrality value, the higher the hierarchy of the region. The types of facilities used in the analysis of the scalogram and centrality index are as follows on the Table 3.

Table 3. Types of Facilities for Scalogram Analysis and Centrality Index in Gorontalo Regency

Facility Functions	Facility Name
Educational Facilities	- Kindergarten
	- Elementary School
	- Junior High School
	- High School
	- College/TP
Health Facilities	- Posyandu
	- Polyclinic
	- Health Center
	- Auxiliary Health Center/Pustu
	- Practicing Physician
	- Hospitals
	- Pharmacy
Worship Facilities	- Prayer room
	- Mosque
	- Church
Economic Facilities	- Traditional Market
	- Shop
	- Supermarket/minimarket
	- KUD
	- Banks
Other Facilities	- Terminal
	- Processing Industry
	- Hotel
	- Restaurants/food stalls

Identification of service centers for Gorontalo Regency scale activities using scalogram analysis and Centrality Index. Scalogram and Centrality Index analysis were used to identify service centers based on the distribution of facilities owned by each village. Furthermore, the calculation of the Centrality Index is used using the number of existing facilities and then the weight of each of these facilities is determined. The calculation of the scalogram and centrality analysis will produce values that will later determine the hierarchy of each village in identifying the service center of Gorontalo Regency activities. The calculation data of the scalogram analysis and the Centrality Index in identifying the service center of Gorontalo Regency can be seen in the following calculation. But first, it is necessary to identify public facilities that support each sub-district in Gorontalo Regency.

Table 4 shows the factual distribution of the number of each public facility in 19 sub-districts/sub-districts in Gorontalo Regency. This data shows significant variations in the availability of facilities between regions. Based on the analysis of the distribution matrix, some important findings are: First, Limboto District shows the highest concentration of facilities with a total of 11 types of facilities (Kindergarten/RA: 32 units, SD: 35 units, Junior High School: 13 units, High School: 6 units, Higher Education: 1 unit, Hospital: 2 units, Health Center: 1 unit, Posyandu: 31 units, Supermarket: 11 units, Restaurants: 30 units, Shops: 20 units, Hotel: 6 units, Bank: 6 units). This reflects Limboto as the main service center of the Regency. Second, Tibawa District occupies the second position with a total of 19 types of facilities that include a wide distribution in the fields of education (kindergarten: 21, SD: 32, junior high school: 17), health (Posyandu: 32), and economy (Supermarkets: 3, Restaurants: 5, Banks: 3). Third, suburban areas such as Biluhu, Asparaga, and Bilato show a high dependence on basic facilities (education and lower-level health), with a limited number of economic and worship facilities. Fourth, special attention was seen in the presence of universities which were only found in 3 regions (Limboto, West Limboto, and Telaga Biru), showing the concentration of higher education services in the main centers. Fifth, the Hospital, which is a critical facility only available in Limboto, indicates that people in other regions have to do long mobility to get referral health services. This distribution pattern confirms the existence of spatial disparities in the provision of public facilities, with Limboto and Tibawa as primary service centers, while other areas function as secondary or tertiary service centers.

Table 5 presents the results of the calculation of the weighted centrality index which is a transformation of the data distribution matrix by taking into account the level of availability of facilities across districts. The methodology used is the calculation of the index value for each facility using the formula: Index = (f/n) / SD, where f is the frequency of facility attendance, n is the total area, and SD is the standard deviation. The results of this calculation produce a weight value for each type of facility that shows its relative significance. Facilities that are rarely found such as Universities (n=3, weight=6,333), Hospitals (n=1, weight=19), and People's Credit Banks (n=1, weight=19) have the highest weight, indicating that the presence of these facilities is very significant in determining the status of a region's service center. On the other hand, facilities available in almost all areas such as Puskesmas (n=19, weight=1), Posyandu (n=19, weight=1), and Elementary Schools (n=19, weight=1) have lower weights because they are evenly distributed. Using this weight, the final centrality index is calculated for each sub-district by adding the result of multiplying the number of facilities by their weight.

The centrality index reveals a clear hierarchy of service centers. Telaga ranks highest (21), followed by Limboto and Tibawa (19), Tolangohula and Telaga Biru (17), and West Limboto (16). The middle group includes Batudaa (16), Boliyohuto (14), Tabongo, Bongomeme, and Talaga Jaya (13), while Asparaga and Biluhu rank lowest (8). These differences reflect not just the number of facilities, but their composition and quality. Telaga leads due to a balanced mix of facilities, including high-weight ones such as banks, minimarkets, and large industries. In contrast, Limboto—despite having the most facilities—scores lower because they are concentrated in low-weight categories like basic education and health services. This confirms that the weighted centrality index more accurately identifies true service centers than simple facility counts.

Table 4. Matrix of Facility Distribution in Gorontalo Regency

District	Number of Kindergarten/RA	Number of primary schools	Number of Junior High Schools/MTs	Number of High School Graduates/SMK/MA/SMK	College	Number of Hospitals/maternity hospitals (units)	Number of Puskesmas (units)	Posyandu	Number of Auxiliary Posts (units)	Clinics / health centers	Physician Practice	Number of Pharmacies (units)	Number of passenger terminals for 4-wheeled motor vehicles	Agricultural production facilities kiosk	Large Industrial Number(≥100 workers) (units)	Medium industrial number (20-99 workers) (units)	Supermarkets, supermarkets, minimarkets (indomart/alfmart)	Restaurants, restaurants	Grocery Store/Stalls	Hotel	Commercial bank (branch headquarters/capem) (unit)	People's Credit Bank (BPR) (unit)	Number of Cooperatives	Total
Batudaa pantai	12	12	6	4	0	0	1	17	3	0	0	0	1	0	0	1	0	0	0	0	2	0	2	2
Biluhu	7	13	5	1	0	0	1	14	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Batudaa	9	12	3	2	0	0	1	16	6	0	1	3	1	1	0	0	1	1	0	0	3	0	1	2
Bongomeme	18	20	10	3	0	0	1	27	3	0	1	1	1	4	0	0	0	3	0	0	1	0	0	0
Tabongo	15	13	3	1	0	0	1	21	3	0	1	1	0	3	1	0	1	2	4	0	0	0	0	0
Dungaliyo	16	15	4	2	0	0	1	22	2	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Tibawa	21	32	17	3	0	0	2	32	8	0	4	5	1	4	1	1	3	5	1	3	3	0	0	5
Pulubala	10	26	17	2	0	0	1	28	5	0	1	0	0	0	0	3	0	0	1	0	1	0	0	1
Boliyohuto	20	17	8	3	0	0	1	30	2	1	1	0	0	4	0	1	1	0	0	0	5	0	1	0
Mootilango	20	20	11	2	0	0	1	30	2	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0
Tolangohula	21	20	12	2	0	0	1	33	6	0	1	1	0	2	1	0	3	0	4	1	2	0	1	1
Asparaga	11	12	7	1	0	0	1	21	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Bilato	7	10	5	2	0	0	1	22	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Limboto	32	35	13	6	1	2	1	31	4	3	6	11	1	5	0	4	11	30	20	6	6	0	3	11
Limboto Barat	20	19	7	3	1	0	1	20	3	1	4	2	0	4	0	1	0	1	4	0	0	0	0	1
Telaga	11	13	7	4	0	0	2	18	4	1	4	5	1	2	1	6	3	9	5	1	5	2	1	8
Telaga Biru	21	22	10	2	1	0	1	21	6	0	0	2	0	3	0	3	6	9	5	4	2	0	0	2
Tilango	16	11	2	1	0	0	1	14	2	0	3	2	0	0	0	1	0	0	1	0	0	0	0	0
Talaga Jaya	11	8	2	1	0	0	1	10	2	0	1	0	0	0	0	0	2	1	3	0	0	0	1	2

Source : Processed Data 2025

Table 5. Centrality Index Calculation Based on Facility Type

Districts	Kindergarten/RA	SD/MI	Junior High School/MTs	SLTA/SMK/MA/SMK	College	Hospitals/maternity hospitals (units)	Health Center (unit)	Posyandu	Auxiliary Posts (units)	Clinics / health centers	Physician Practice	Pharmacy (unit)	Passenger Terminal kenderaan bermotor	Production facilities kiosk pertanian	Large industry(>100 workers) (units)	medium industry (20-99 workers) (units)	Supermarket, supermarket, minimarket	Restaurants, restaurants	Grocery Store/Stalls	hotel	Commercial Bank (Branch Head Office/CAPEM)	Number of People's Credit (BPR) (unit)	Cooperatives	KUD	Total Index
Batudaa pantai	0,970	0,970	0,485	0,323	0	0	0,081	1,374	0,242	0	0	0	0,081	0	0	0,081	0	0	0	0	0,162	0	0,162	0,162	12
Biluhu	0,817	1,517	0,583	0,117	0	0	0,117	1,634	0,117	0	0,350	0	0	0,067	0	0	0	0	0	0	0	0	0	0	8
Batudaa	0,603	0,804	0,201	0,134	0	0	0,067	1,072	0,402	0	0,067	0,201	0,067	0,067	0	0	0,067	0,067	0	0	0,201	0	0,067	0,134	16
Bongomeme	0,895	0,994	0,497	0,149	0	0	0,050	1,343	0,149	0	0,050	0,050	0,050	0,199	0	0	0	0,149	0	0	0,050	0	0	0	13
Tabongo	0,803	0,696	0,161	0,054	0	0	0,054	1,125	0,161	0	0,054	0,054	0	0,161	0,054	0	0,054	0,107	0,214	0	0	0	0	0	13
Dungaliyo	0,895	0,839	0,224	0,112	0	0	0,056	1,231	0,112	0	0,056	0	0	0,056	0	0,056	0	0	0	0	0	0	0	0	10
Tibawa	0,501	0,763	0,405	0,072	0	0	0,048	0,763	0,191	0	0,095	0,119	0,024	0,095	0,024	0,024	0,072	0,119	0,024	0,072	0,072	0	0,119	0	19
Pulubala	0,366	0,951	0,622	0,073	0	0	0,037	1,024	0,183	0	0,037	0	0	0	0	0,110	0	0	0,037	0	0,037	0	0	0,037	11
Boliyohuto	1,132	0,962	0,453	0,170	0	0	0,057	1,698	0,113	0,057	0,057	0	0	0,226	0	0,057	0,057	0	0	0	0,283	0	0,057	0	14
Mootilango	1,032	1,032	0,568	0,103	0	0	0,052	1,548	0,103	0	0,103	0	0	0,052	0	0	0	0	0	0	0	0	0	0	9
Tolangohula	0,907	0,863	0,518	0,086	0	0	0,043	1,425	0,259	0	0,043	0,043	0	0,086	0,043	0	0,130	0	0,173	0,043	0,086	0	0,043	0,043	17
Asparaga	0,795	0,868	0,506	0,072	0	0	0,072	1,519	0,145	0	0	0	0	0	0	0	0	0	0,072	0	0	0	0	0	8
Bilato	0,664	0,948	0,474	0,190	0	0	0,095	2,086	0,095	0	0	0	0	0,095	0	0	0	0,095	0	0	0	0	0	0	9
Limboto	0,619	0,677	0,252	0,116	0,019	0,039	0,019	0,600	0,077	0,058	0,116	0,213	0,019	0,097	0	0,077	0,213	0,581	0,387	0,116	0,116	0	0,058	0,213	19
Limboto Barat	0,789	0,750	0,276	0,118	0,039	0	0,039	0,789	0,118	0,039	0,158	0,079	0	0,158	0	0,039	0	0,039	0,158	0	0	0	0	0,039	16
Telaga	0,495	0,585	0,315	0,180	0	0	0,090	0,810	0,180	0,045	0,180	0,225	0,045	0,090	0,045	0,270	0,135	0,405	0,225	0,045	0,225	0,090	0,045	0,360	21
Telaga Biru	0,674	0,706	0,321	0,064	0,032	0	0,032	0,674	0,192	0	0	0,064	0	0,096	0	0,096	0,192	0,289	0,160	0,128	0,064	0	0	0,064	17
Tilango	0,990	0,681	0,124	0,062	0	0	0,062	0,866	0,124	0	0,186	0,124	0	0	0	0,062	0	0	0,062	0	0	0	0	0	10
Talaga Jaya	0,864	0,629	0,157	0,079	0	0	0,079	0,786	0,157	0	0,079	0	0	0	0	0	0,157	0,079	0,236	0	0	0	0,079	0,157	13
Number of Regions (n)	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	
Number of Regions that have facilities (f)	19	19	19	19	3	1	19	19	19	4	15	10	6	13	4	10	9	10	11	5	10	1	7	10	
Minimum	0,366	0,585	0,124	0,054	0	0	0,019	0,600	0,077	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Maximum	1,132	1,517	0,622	0,323	0,039	0,039	0,117	2,086	0,402	0,058	0,350	0,225	0,081	0,226	0,054	0,270	0,213	0,581	0,387	0,128	0,283	0,090	0,162	0,360	
Standard deviation	0,202	0,209	0,161	0,064	0,012	0,009	0,024	0,410	0,075	0,021	0,086	0,079	0,026	0,070	0,018	0,066	0,073	0,159	0,114	0,041	0,089	0,021	0,043	0,098	
Total (n/f)	1	1	1	1	6,333	19	1	1	1	4,75	1,267	1,9	3,167	1,462	4,75	1,9	2,111	1,9	1,727	3,8	1,9	19	2,714	1,9	

Source : Processed Data 2025

Structure of Service Centers in Gorontalo Regency Based on Scalogram Analysis and Centrality Index

The provision of accessible and quality public service infrastructure is a fundamental prerequisite for human development development and equitable distribution of community welfare at the regional level. However, in reality, the distribution of service facilities in many regions shows an uneven pattern of concentration, with administrative centers or economic centers receiving much larger allocations of infrastructure investment than peripheral areas, creating persistent inequities in access to quality education, health, and economic services. Gorontalo Regency, like many districts in Indonesia, faces similar challenges in the provision of equitable service infrastructure, where the concentration of facilities in a few specific centers creates a service desert in peripheral areas. To overcome this problem, the analysis of the structure of service centers through the Scalogram and Centrality Index approaches is crucial to identify existing gaps, understand the drivers of spatial concentration, and design a more balanced infrastructure development strategy. The following is the data on the results of regionally weighted centralization to determine settlement centers based on Gorontalo Regency service facilities can be seen in the following table:

Table 6. Hierarchy of Gorontalo Regency Service Centers Based on Scalogram Analysis and Centrality Index

Districts	Number of Types/Functions of Facilities	GPA (District Development Index)	Hierarchy
Batudaa Pantai	12	29,54	4
Biluhu	8	21,80	5
Batudaa	16	25,13	2
Bongomeme	13	20,21	3
Tabongo	13	17,13	3
Dungaliyo	10	11,43	5
Tibawa	19	19,42	1
Pulubala	11	11,77	4
Boliyohuto	14	26,87	3
Mootilango	9	14,94	5
Tolangohula	17	23,85	2
Asparaga	8	12,13	5
Bilato	9	16,49	5
Limboto	19	46,04	1
Limboto Barat	16	20,94	2
Telaga	21	45,18	1
Telaga Biru	17	23,59	2
Tilango	10	12,46	5
Talaga Jaya	13	16,90	4

Source: Processed data, 2025

Based on Table 6, the structure of service centers in Gorontalo Regency which is built from a combination of Scalogram and Centrality Index analysis shows a clear hierarchical pattern and a fairly strong spatial ineval. Limboto, Telaga, and Tibawa sub-districts occupy the first hierarchy with the most diverse number of facilities and the highest GPA score (around 36.9 on average). This condition confirms the role of the three as the main service center that functions as a node of economic and administrative activities while serving the needs of residents from other sub-districts. The concentration of infrastructure and public services in these three sub-districts makes it a "magnet" for district-scale services.

Below him, Batudaa, Tolangohula, West Limboto, and Telaga Biru are in hierarchy II. These sub-districts have a fairly large number of facilities with an average GPA of around 23.4, so they can be categorized as secondary service centers. Its function is to expand the service coverage from the main centers while reducing the pressure on the service load in Limboto and Telaga.

In regional planning, this group has great potential to be developed as a sub-center of growth so that access to services for people in the central and suburban parts of the district becomes more even.

Hierarchy III, consisting of Bongomeme, Tabongo, and Boliyohuto, shows the character as a local center with more limited roles. The number of facilities of about 13 types and an average GPA of about 21.4 illustrates that these sub-districts are able to provide basic facilities such as education, first-level health, and local markets, but for more specialized services the population still has to rely on hierarchical sub-districts I and II. Meanwhile, sub-districts in hierarchy IV (Batudaa Pantai, Pulubala, Talaga Jaya) and hierarchy V (Biluhu, Dungaliyo, Mootilango, Asparaga, Bilato, Tilango) can be categorized as suburban areas and pockets of service deficit. Low GPA scores (around 19.4 in hierarchy IV and 14.5 in hierarchy V) with a limited number of facilities indicate limited service functions and low spatial connectivity with the network of major service centers. The case of Batudaa Pantai is interesting, because it has a relatively high GPA compared to other peripherals but remains in hierarchy IV, which indicates that in addition to the number of facilities, position and connectivity factors also determine the level of centrality of a sub-district.

Thus this pattern describes a strong central-peripheral structure: public services are concentrated in administrative/economic centers, while the periphery experiences limited access. The Scalogram analysis highlights the diversity of service functions of each sub-district, while the Centrality Index emphasizes its strategic position in the spatial network. The combination of the two shows that the gap is not only affected by the number of facilities, but also by the connectivity and reach of services. The planning implication is the need to strengthen the role of hierarchical sub-districts II and III as sub-centers of growth and the implementation of affirmative policies in hierarchical sub-districts IV and V, both through the addition of basic facilities and the improvement of transportation connectivity. Therefore, it can be said that the results of this analysis can be the basis for local governments in designing spatial planning and infrastructure investment strategies that are more balanced and equitable between sub-districts in Gorontalo Regency.

Recommendations for the Structure of Service Centers in Gorontalo Regency

Through the RTRW plan that has been determined by the Gorontalo Regency Regional Government, 5 groups of settlement centers in Gorontalo Regency have been determined, namely: PKW (Regional Activity Center); street vendors (local activity centers); PKLp (Local Activity Center promotion); PPK (Regional Service Center); PPL (Environmental Service Center). At the same time, in the analysis of the scalogram there are 5 orders of class division. From the results of the comparison of table 7, it can be seen that the regional spatial planning that has been determined by the Gorontalo Regency Regional Government in 2013 has not undergone changes in accordance with expectations. In Tibawa sub-district is projected as the center of the city according to the RTRW in 2013 it is inconsistent with the results of the scalogram analysis, it was obtained that precisely from Tibawa sub-district the projection of the sub-district has a number of facilities that do not meet public services even though it is in the highest class. This statement is supported by the findings in the Table 7.

The results of the comparison between the structure of the service center based on the 2012 RTRW and the results of the scalogram-centrality index analysis show that there is a serious insynchronization between normative planning and the empirical condition of public services in Gorontalo Regency. The RTRW determines five classes of settlement centers (PKW, PKL, PKLp, PPK, PPL), while the scalogram analysis yields five hierarchical orders based on the number and diversity of facilities. In particular, Tibawa, which is planned as a PKW/city center, actually appears as a sub-district with a relatively inadequate number of facilities compared to other centers, although according to the scalogram analysis it is still in the top class. This indicates that the designation of Tibawa as the center of the region is more projective and political than based on the actual readiness of infrastructure and services, thus creating a gap between the "planned center" and the "really functioning center".

Table 7. Comparison of the Two Analyses

Districts	Hierarchical grouping of RTRW	Hierarchy
Batudaa Pantai	PPL	4
Biluhu	PPL	5
Batudaa	PPK	2
Bongomeme	PPL	3
Tabongo	PPL	3
Dungaliyo	PPL	5
Tibawa	PKW	1
Pulubala	PPK	4
Boliyohuto	PPK	3
Mootilango	PPL	5
Tolangohula	PPL	2
Asparaga	PPL	5
Bilato	PPL	5
Limboto	PKL	1
Limboto Barat	PKLp	2
Telaga	PKLp	1
Telaga Biru	PPL	2
Tilango	PPL	5
Talaga Jaya	PPL	4

Source: Processed data 2025

Notes: *PKW (Pusat Kegiatan Wilayah); PKL (Pusat Kegiatan Lokal); PKLp (Pusat Kegiatan Lokal promosi); PPK (Pusat Pelayanan Kawasan); PPL (Pusat Pelayanan Lingkungan)*

The results of the comparison between the structure of the service center based on the 2012 RTRW and the results of the scalogram-centrality index analysis show that there is a serious insynchronization between normative planning and the empirical condition of public services in Gorontalo Regency. The RTRW determines five classes of settlement centers (PKW, PKL, PKLp, PPK, PPL), while the scalogram analysis yields five hierarchical orders based on the number and diversity of facilities. In particular, Tibawa, which is planned as a PKW/city center, actually appears as a sub-district with a relatively inadequate number of facilities compared to other centers, although according to the scalogram analysis it is still in the top class. This indicates that the designation of Tibawa as the center of the region is more projective and political than based on the actual readiness of infrastructure and services, thus creating a gap between the "planned center" and the "really functioning center".
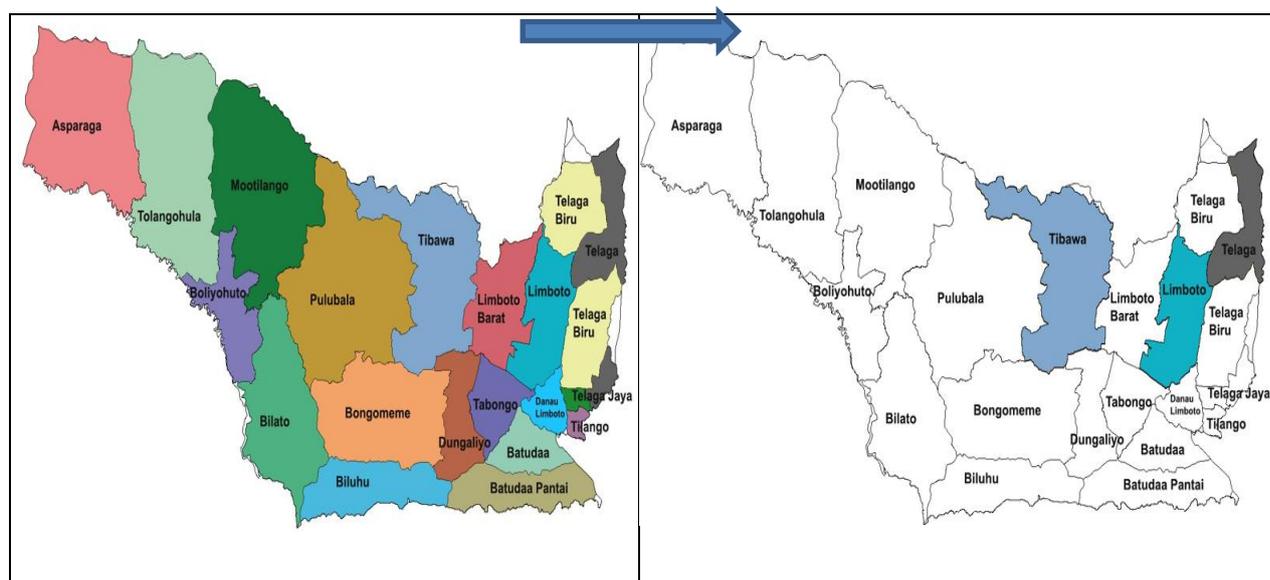

Figure 1. Map of Gorontalo Regency Sub-districts and Sub-district Group Maps - Hierarchy 1

In the hierarchy 1 (see Figure 1) of the service centers are divided into three sub-districts, namely: Tibawa District with the status of a regional activity center, Limboto District as a center of local activities while Telaga district is a center for local promotional activities, this is because each service center has limited ability to serve a certain number of residents with certain areas as well. Based on table 7 above, hierarchy 2, hierarchy 3, hierarchy 4 and hierarchy 5 are each sub-district that is included in the hierarchy categorization. If you look at each sub-district, there are also symptoms that some areas that are only given PPL status in the RTRW actually empirically play a higher role. Telaga Biru and Tolangohula, for example, are classified as PPL but by scalogram analysis are placed in hierarchy 2 alongside other PPKs such as Batudaa and West Limoto, meaning both have developed into important regional service sub-centres. On the other hand, sub-districts with PPK status such as Pulubala and Boliyohuto did not all jump to the upper hierarchy; Boliyohuto is in hierarchy 3 and Pulubala in hierarchy 4, indicating that the service role expected by the RTRW has not been fully realized. This pattern shows two things: first, there is an "under-estimation" of the potential of the new center (Telaga Biru, Tolangohula) in the plan document; Second, there is an "over-estimation" of sub-districts that factually do not have the capacity of facilities according to the status of the plan.

On the other hand, there are also parts of the region where the RTRW and scalogram results are relatively consistent, especially in peripheral PPL sub-districts such as Biluhu, Dungaliyo, Mootilango, Asparaga, Bilato, Tilango, Batudaa Pantai, and Talaga Jaya which are in the hierarchy 4–5. This consistency shows that the spatial plan is quite appropriate in recognizing areas that function as environmental service centers with limited facilities. However, precisely because of this consistency, the contrast between "really strong centers" (Limboto, Telaga) and "centers that are only planned strong" (Tibawa) becomes sharper. As a result, the spatial structure that is formed tends to remain center-peripheral around the Limboto-Telaga corridor, while the scenario of decentralization of service centers through the strengthening of Tibawa as a PKW has not been achieved.

Critically, these findings suggest that the revision of the RTRW is urgent by including empirical evidence of the scalogram and the centrality index as the objective basis for the review of the hierarchy of settlement centers. Without adjustments, there is a risk that infrastructure and public service investment policies continue to refer to the status of the plan that does not reflect the actual pattern of space use: the government can continue to allocate the budget to support Tibawa as a PKW, while the real need is actually greater in the centers that have factually grown (Limboto, Telaga, Telaga Biru, Tolangohula). On the other hand, the scalogram analysis itself has limitations—for example, it emphasizes the quantity of facilities rather than quality, capacity, and accessibility—so it needs to be combined with the analysis of population mobility, transportation networks, and economic dynamics. Thus, the main criticism of this result is not only the inconsistency of the RTRW with the facts, but also the need to use a multi-indicator approach so that the structuring of service center structures really supports the equal distribution of access and efficiency of public services in Gorontalo Regency.

Spatial Inequality as Structural Phenomenon: Disaggregating the Service Gap

The empirical results expose a deeply entrenched spatial concentration of public service infrastructure that transcends simple quantitative disparity. Limboto, Telaga, and Tibawa—classified as Hierarchy I with centrality indices of 19, 21, and 19 and GPA scores of 46.04, 45.18, and 19.42 respectively—collectively monopolize higher-order service functions across the regency. The concentration is most pronounced in critical facilities: hospitals exist solely in Limboto, universities in only three sub-districts (Limboto, Limboto Barat, and Telaga Biru), and commercial banks are heavily skewed toward the Limboto–Telaga corridor. This pattern constitutes what the OECD, (2023) terms a "service provision gradient," where access quality deteriorates sharply with distance from the administrative core, creating compounding disadvantages for peripheral populations.

The weighted centrality index illuminates a crucial qualitative dimension often missed by raw facility counts. By assigning inverse-frequency weights—hospitals and People's Credit Banks each receiving a weight of 19, universities 6.333, while ubiquitous facilities such as elementary schools and posyandu receive only 1—the methodology captures Christaller, (1933) foundational insight that settlement hierarchy is determined not by the provision of common lower-order goods but by the

concentration of specialized, high-threshold services with extensive market ranges. Telaga's achievement of the highest centrality index (21) despite not having the most facilities in absolute terms exemplifies this principle: its diversified portfolio spanning large industries, commercial banks, minimarkets, and restaurants represents a functionally complex service center in the Rondinellian sense (Rondinelli, 1985), one whose centrality derives from the breadth and rarity of its service offerings rather than their volume.

The socio-spatial consequences of this concentration are severe. Hierarchy V sub-districts—Biluhu (index: 8), Asparaga (8), Bilato (9), Mootilango (9), Dungaliyo (10), and Tilango (10)—constitute "service deserts" where residents must undertake substantial travel to access referral health care, tertiary education, or financial services. Their average GPA score of 14.5 represents less than one-third of the Hierarchy I average (36.9), signaling not a mere gap but a structural chasm. This finding aligns with recent evidence from Pakistan (Ahmed et al., 2024), Chile (Contreras et al., 2023), and Iran (Dadashpoor et al., 2016), which collectively demonstrate that spatial inequality in public services operates as a self-reinforcing mechanism: areas lacking higher-order facilities fail to attract investment, skilled labor, and population, which in turn reduces their political leverage for securing future infrastructure allocations. In the Gorontalo context, this mechanism has produced a persistent condition of cumulative disadvantage that Myrdal, (1957) characterized as "backwash effects"—where the growth of core areas actively drains peripheral regions of productive resources.

Core–Periphery Dynamics: The Limboto–Telaga Corridor as a Self-Reinforcing Growth Axis

The spatial structure revealed by the analysis conforms closely to Friedmann, (1966) core–periphery model, with the Limboto–Telaga corridor functioning as an unambiguous core region. The population data reinforce this interpretation: Limboto (51,676 inhabitants, 12.73%) and Tibawa (41,933, 10.34%) represent the two largest concentrations, and the four most populous sub-districts collectively account for 37.4% of the regency's 405,690 total population. This demographic clustering reflects the agglomeration dynamics theorized by Krugman, (1991) and empirically validated by Fang et al., (2023), where the interaction between increasing returns, transportation costs, and labor mobility generates self-reinforcing tendencies for economic activities to concentrate spatially. Limboto's concentration of 30 restaurants, 20 grocery stores, 11 supermarkets, and 6 hotels demonstrates the commercial agglomeration economies that simultaneously attract and sustain population growth—a virtuous cycle for the core that simultaneously starves peripheral areas of economic dynamism.

The peripheral sub-districts exhibit characteristics consistent with what Friedmann, (1966) termed "downward-transitional areas": limited economic diversification, dependence on basic-level facilities, and weak integration into the broader regional economy. The absence of banks, supermarkets, and processing industries in areas like Biluhu, Asparaga, and Bilato suggests not merely underdevelopment but functional disconnection from the commercial networks centered on Limboto–Telaga. This resonates with recent findings by Nguyen et al., (2024), who demonstrated through large-scale settlement pattern analysis that peripheral settlements in developing countries often exhibit truncated functional hierarchies—possessing only the lowest-order services while remaining dependent on distant higher-order centers for specialized needs.

A notable anomaly is Batudaa Pantai, which occupies Hierarchy IV despite a relatively high GPA of 29.54. Its coastal location provides specialized functions (marine transportation, fishing) that the centrality index methodology does not fully capture, illustrating a limitation that Rondinelli, (1985) anticipated: standard hierarchical analyses may undervalue settlements with specialized economic roles that do not conform to the typical service-center typology. This finding suggests that future analyses should integrate functional specialization indices alongside the traditional centrality approach to achieve a more comprehensive spatial assessment.

Planning–Reality Divergence: Structural Inconsistencies Between the RTRW and Empirical Hierarchy

The most policy-critical finding is the systematic misalignment between the RTRW's normative hierarchy and the empirical service structure. The RTRW designates Tibawa as PKW (Regional Activity Center)—the highest tier—while classifying Limboto as PKL (Local Activity Center) and Telaga as PKLp (promoted Local Activity Center). Empirically, however, Telaga achieves the highest centrality index (21), and Limboto's GPA of 46.04 dramatically exceeds Tibawa's 19.42. This inversion reveals what can be termed a "planning–reality divergence": a condition where plan designations reflect projective aspirations and politico-administrative considerations rather than evidence-based assessments of actual service capacity. Such divergences have been documented across Indonesian regional planning contexts (Husna et al., 2025; Luthfiah et al., 2023), suggesting a systemic governance challenge rather than a Gorontalo-specific anomaly.

The comparison in Table 7 reveals two distinct patterns of misalignment. The first is under-estimation, where sub-districts designated as PPL (the lowest planning tier) have organically developed into significant secondary centers. Telaga Biru and Tolangohula, both classified as PPL, empirically function at Hierarchy II alongside sub-districts with higher planning designations (Batudaa as PPK, Limboto Barat as PKLp). This pattern indicates that spontaneous economic growth and facility agglomeration have outpaced planning assumptions, generating emergent growth nodes that the RTRW neither recognizes nor actively supports. Ye et al., (2021) observed analogous phenomena in Chinese rural–urban transitions, where bottom-up settlement development frequently outstripped top-down spatial designations, necessitating adaptive planning frameworks capable of responding to emergent spatial realities.

The second pattern is over-estimation, where designated service centers have failed to materialize their planned roles. Pulubala (PPK designation) occupies Hierarchy IV with only 11 facility types and a GPA of 11.77—markedly inferior to PPL-designated Tolangohula (Hierarchy II, GPA: 23.85). Similarly, Boliyohuto (PPK) stagnates at Hierarchy III. These cases demonstrate that planning designations without corresponding investment commitments and institutional capacity-building produce hollow hierarchies: formal classifications that lack substantive content. This gap between de jure status and de facto function represents a form of institutional decoupling that undermines the allocative efficiency of public investment, as resources may continue flowing to designated centers that lack the absorptive capacity to deploy them productively.

Importantly, the RTRW demonstrates reasonable accuracy at the lowest tier: peripheral PPL sub-districts (Biluhu, Dungaliyo, Mootilango, Asparaga, Bilato, Tilango) consistently appear in Hierarchy IV–V. This consistency paradoxically intensifies the critique: the plan correctly identifies areas of deprivation but fails to prescribe effective interventions to address them. The spatial structure consequently remains locked in a monocentric configuration around the Limboto–Telaga corridor, while the planned decentralization through Tibawa's PKW status remains aspirational rather than operational.

Toward Evidence-Based Spatial Restructuring: Policy Directions and Methodological Considerations

These findings carry three policy implications of considerable significance. First, Hierarchy II sub-districts (Batudaa, Tolangohula, Limboto Barat, Telaga Biru), with their existing facility diversity (average GPA: 23.4), represent the most cost-effective targets for investment aimed at creating viable sub-centers of growth. Targeted provision of higher-order facilities—particularly health, financial, and commercial services—in these areas could effectively distribute service loads and reduce the excessive gravitational pull of the Limboto–Telaga core. Second, Hierarchy IV–V sub-districts require integrated interventions that combine facility provision with transportation connectivity improvements. The extremely low GPA scores (average: 14.5 for Hierarchy V) indicate that facilities alone, without accessibility, will remain underutilized—a conclusion supported by OECD, (2023) evidence showing that travel times to healthcare facilities in remote rural areas are five times higher than in urban cores.

Third, and most fundamentally, the RTRW revision process must institutionalize empirical spatial analysis as a mandatory input, moving away from purely projective designations toward adaptive frameworks informed by periodically updated scalogram and centrality data.

Methodologically, this study demonstrates that the weighted centrality index offers a more diagnostically powerful tool than raw facility counts, capturing the functional complexity that Christaller, (1933) theory identifies as the true determinant of settlement hierarchy. However, the approach has acknowledged limitations: it measures facility presence without assessing quality, capacity, or utilization, and does not incorporate accessibility metrics such as travel time or road network density (Rustiadi et al., 2018). Future research should adopt multi-indicator frameworks integrating scalogram analysis with gravity models, transportation network analysis, and population mobility data—an approach that C. Li et al., (2024) have demonstrated can reveal service hierarchies more accurately than any single method employed in isolation. The Gorontalo case ultimately illustrates a persistent challenge in developing-country regional planning: the tension between normative spatial frameworks and emergent development patterns. Bridging this gap requires not the imposition of predetermined hierarchies but the development of adaptive, evidence-responsive planning systems capable of guiding organic growth trajectories toward equitable spatial outcomes.

In the broader context of Indonesian decentralization, the Gorontalo findings contribute to a growing body of evidence that spatial planning instruments, when disconnected from empirical monitoring, risk perpetuating rather than correcting the very inequalities they are designed to address. The designation of growth centers without sustained investment and institutional support creates a paradox of planned centrality without functional substance—a condition that diverts scarce public resources toward aspirational categories while neglecting areas of demonstrated need and organic potential. As Wei, (2015) argued, spatial inequality is not merely an outcome of market forces but is actively produced through institutional decisions about where to invest, what to designate, and how to allocate. The Gorontalo case offers a compelling illustration of this insight, demonstrating that the path toward spatial equity requires not only better analytical tools but also the political will to let empirical evidence reshape entrenched planning assumptions.

4. CONCLUSION

This study examined the hierarchy of service centers in Gorontalo Regency through Scalogram analysis and the weighted Centrality Index, encompassing 24 types of public facilities across 19 sub-districts. Three principal findings emerge. First, the spatial distribution of public services exhibits a pronounced structural inequality, with Limboto, Telaga, and Tibawa constituting Hierarchy I centers that collectively monopolize higher-order functions—hospitals, universities, commercial banks, and large-scale industries—while six sub-districts (Biluhu, Asparaga, Bilato, Mootilango, Dungaliyo, and Tilango) remain in Hierarchy V as service deserts, recording average GPA scores of 14.5 compared to 36.9 for the primary centers. Second, a distinct core–periphery structure has crystallized around the Limboto–Telaga corridor, where agglomeration economies and population concentration (37.4% of the regency total in only four sub-districts) generate self-reinforcing growth dynamics that further marginalize peripheral areas. Third, and most critically, the study reveals a systematic planning–reality divergence between the RTRW-designated hierarchy and the empirically observed spatial structure: Tibawa, designated as PKW (Regional Activity Center), underperforms empirically relative to Telaga (PKLp) and Limboto (PKL), while several PPL-designated sub-districts—notably Telaga Biru and Tolangohula—have organically developed into Hierarchy II centers that the spatial plan fails to recognize.

Based on these findings, four policy recommendations are proposed. First, the Gorontalo Regency Government should undertake an evidence-based revision of the RTRW that recalibrates settlement center designations in accordance with empirical scalogram and centrality data, particularly by upgrading the formal status of Telaga Biru and Tolangohula to reflect their demonstrated service capacity. Second, Hierarchy II sub-districts (Batudaa, Tolangohula, Limboto Barat, Telaga Biru) should be prioritized for targeted investment in higher-order facilities—specifically referral health services, branch banking, and secondary commercial infrastructure—

to function as effective growth sub-centers that relieve pressure on the Limboto–Telaga core. Third, for Hierarchy IV–V sub-districts, the government should implement integrated accessibility programs that pair facility provision with transportation network improvements, as infrastructure alone without connectivity will remain underutilized in geographically isolated areas. Fourth, the RTRW revision process should institutionalize periodic empirical monitoring through scalogram updates at five-year intervals, ensuring that planning designations remain responsive to evolving spatial realities rather than static projections.

Several methodological limitations should be acknowledged. The Scalogram and Centrality Index employed in this study measure facility presence and diversity but do not capture service quality, institutional capacity, or actual utilization rates. A sub-district possessing a health center (puskesmas) that is understaffed receives the same score as a fully operational one. Furthermore, the analysis does not incorporate spatial accessibility metrics—road quality, travel time, public transport availability—that critically mediate the relationship between facility existence and effective service delivery. The case of Batudaa Pantai, whose specialized coastal functions are undervalued by the standard centrality approach, further illustrates the method's difficulty in accommodating settlements with non-typical economic roles.

Future research should address these limitations through multi-method designs that integrate the scalogram–centrality framework with gravity model analysis, transportation network assessment, and population mobility data derived from mobile phone records or travel surveys. Incorporating qualitative indicators of service quality and community satisfaction would further enrich the hierarchical classification. Longitudinal studies comparing service center hierarchies across multiple time points would also be valuable for assessing whether planned interventions are effectively restructuring spatial patterns or merely reinforcing existing inequalities. Extending the comparative scope to include neighboring regencies in Gorontalo Province would additionally enable a broader understanding of inter-regional service dependencies and cross-boundary accessibility dynamics.

5. REFERENCES

Ahmed, S. H., Zahid, M., Waseem, S., Zafar, A., Shaikh, T. G., Sabri, T., & Arshad, A. (2024). The current state of primary healthcare in Pakistan: A way forward for low-to-middle income countries. *Primary Health Care Research & Development*, *25*, e59. https://doi.org/https://doi.org/10.1017/S1463423624000379

Asoka, G. W., Thuo, A. D., & Bunyasi, M. M. (2013). Effects of Population Growth on Urban Infrastructure and Services: A Case ofEastleigh Neighborhood Nairobi, Kenya. *Journal of Anthopology & Archaeology*, *1*(1), 41–56.

Badan Pusat Statistik Kabupaten Gorontalo. (2022). Kabupaten Gorontalo Dalam Angka. In *BPS Kabupaten Gorontalo*. Badan Pusat Statistik Kabupaten Gorontalo.

Bappenas. (2015). *Strategi pengembangan pusat-pusat pertumbuhan di Indonesia*. Badan Perencanaan Pembangunan Nasional.

BPS Kabupaten Gorontalo. (2024). *Kabupaten Gorontalo dalam angka 2024*. BPS Kabupaten Gorontalo.

Christaller, W. (1933). *Die zentralen Orte in Süddeutschland*. Gustav Fischer, Jena.

Contreras, D., Bhamidipati, S., & Wilkinson, S. (2023). Social vulnerability and spatial inequality in access to healthcare facilities: The case of the Santiago metropolitan region. *Socio-Economic Planning Sciences*, *90*, 101735.

Dadashpoor, H., Rostami, F., & Alizadeh, B. (2016). Is inequality in the distribution of urban facilities inequitable? Exploring a method for identifying spatial inequity in an Iranian city. *Cities*, *52*, 159–172.

Fang, X., Su, D., Wu, Q., Wang, J., Li, G., & Cao, Y. (2023). Dynamic changes in urban land spatial inequality under the core–periphery structure in urban agglomerations. *Journal of Geographical Sciences*, *33*(4), 743–764.

Faradila, N., Rustiadi, E., & Pravitasari, A. E. (2022). Analisis hierarki pusat-pusat pelayanan dalam pengembangan wilayah Kabupaten Parigi Moutong. *Journal of Regional and Rural Development Planning*, *6*(1), 25–39.

Friedmann, J. (1966). *Regional development policy: A case study of Venezuela*. MIT press.

Husna, C. Z., Pravitasari, A. E., & Putra, A. S. (2025). Regional development strategies in new growth centers around Barsela SEZ, Southwest Aceh Regency. *Indonesian Journal of Planning and Development*, *10*(1), 12–26.

Jufri, A., & Nonce, M. (2016). Identifikasi pusat pertumbuhan di Kabupaten Halmahera Barat menggunakan analisis skalogram. *Indonesian Journal of Spatial Analysis*, *12*(2), 156–172.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, *99*(3), 483–499.

Li, C., Zhang, Y., & Zhao, X. (2024). Investigating the central place theory using trajectory big data. *International Journal of Applied Earth Observation and Geoinformation*, *126*, 103607.

Luthfiah, F., Guswandi, G., & Anggrahita, H. (2023). The role of city spatial plan (RTRW) on regional development in Depok City (West Java Province). *Indonesian Journal of Geography*, *55*(2), 320–329.

Muliana, R., Astuti, P., & Fadli, A. (2018). Kajian Pusat-Pusat Pelayanan Di Kabupaten Kampar. *Jurnal Saintis*, *18*(1), 59–72. https://doi.org/10.25299/saintis.2018.vol18(1).2846

Muzahar. (2000). *Analisis Fungsi Wilayah Kecamatan dalam Pembangunan di Kotamadya Padang*. Universitas Andalas (UNAND), Padang, Indonesia.

Myrdal, G. (1957). *Economic theory and under-developed regions*. Duckworth.

Nguyen, T. T., Esch, T., Hoffmann, E., Bachofer, F., & Buerkert, A. (2024). Towards large-scale analyses of settlement patterns in urbanizing landscapes—Findings of first studies for India, Egypt, and China. *Scientific Reports*, *14*, 25782. https://doi.org/https://doi.org/10.1038/s41598-024-74678-w

OECD. (2023). *OECD regional outlook 2023: The longstanding geography of inequalities*. OECD Publishing. https://doi.org/https://doi.org/10.1787/92cd40a0-en

Pane, T. A. (2013). *Kajian Pengembangan Pusat-pusat Pelayanan Pelayanan di Wilayah Kabupaten Serdang Bedagai Medan*. Universitas Sumatera Utara.

Pemerintah Kabupaten Gorontalo. (2013). *Peraturan Daerah Kabupaten Gorontalo Nomor 4 Tahun 2013 Tentang Rencana Tata Ruang Wilayah Kabupaten Gorontalo Tahun 2012 - 2032*. Pemerintah Kabupaten Gorontalo.

Perroux, F. (1995). Note on the concept of growth poles. , 8(1), 307-320. *Economie Appliquée*, *8*(1), 307–320.

Riyadi, & Bratakusumah, D. S. (2005). *Perencanaan Pembangunan Daerah: Starategi Menggali Potensi dalam Mewujudkan Otonomi Daerah*. PT Gramedia Pustaka Utama.

Rondinelli, D. A. (1985). *Applied methods of regional analysis: The spatial dimensions of development policy*. Westview Press.

Rustiadi, E., Saefulhakim, S., Panuju, D. R., & Pravitasari, A. E. (2018). *Perencanaan dan pengembangan wilayah [Regional planning and development]*. Yayasan Pustaka Obor Indonesia.

Srinivasu, B. (2013). Infrastrukture Development and Economic Growth: Prospects and Perpective. *Journal of Bussinnes Management& Social Scence Research*, *2*(1), 81–91.

Sutikno, & Maryunani. (2007). Analisis potensi dan daya saing kecamatan sebagai pusat pertumbuhan. *Jurnal Bumi Indonesia*, *13*(1), 25–42.

Utari, M. E. S. (2015). ANALISIS SISTEM PUSAT PELAYANAN PERMUKIMAN DI KOTA YOGYAKARTA TAHUN 2014. *Journal of Economics and Policy*, *8*(1), 62–72. https://doi.org/http://dx.doi.org/10.15294/jejak.v7i1.

Wei, Y. D. (2015). Spatiality of regional inequality. *Applied Geography*, *61*, 1–10.

Ye, Q., Li, J., Kong, X., & Zhang, S. (2021). Identification and optimization of the spatial structure of urban and rural settlements from a hierarchical network perspective. *Land*, *10*(11), 1177.