

Quantifying Service Hierarchy and Territorial Typologies in the Mamminasata Metropolitan Area: A Scalogram Analysis

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Abstract : Uneven distribution of higher-order services can reinforce core-periphery disparities within metropolitan regions. This study quantifies the service hierarchy and derives territorial typologies for the Mamminasata Metropolitan Area, South Sulawesi, Indonesia. A cross-sectional dataset covering four aggregated territorial units Makassar, the Mamminasata sections of Gowa and Maros, and Takalar was analysed using a Guttman scalogram of 19 education, health, worship, and commercial facility types. Facility diversity was interpreted alongside gross population density and population-derived built-form indicators. Makassar contained all 19 facility types, followed by Gowa (18), Maros (17), and Takalar (14). The ordered matrix formed a perfectly nested pattern, with a coefficient of reproducibility of 1.00. Population density declined from 83.62 persons ha⁻¹ in Makassar to less than 10 persons ha⁻¹ in each peripheral unit. The integrated results identified Makassar as the service core, Gowa as the inner-transition unit, Takalar as the outer-transition unit, and Maros as the lower-intensity outer zone. The divergence between service completeness and settlement intensity indicates that metropolitan investment should prioritise service capacity, accessibility, and interjurisdictional connectivity.

Keywords: Mamminasata; Service Hierarchy; Territorial Typology; Scalogram; Metropolitan Development

Abstrak : Distribusi layanan tingkat tinggi yang tidak merata dapat memperkuat kesenjangan inti-pinggiran dalam kawasan metropolitan. Penelitian ini mengukur hierarki pelayanan dan menyusun tipologi wilayah di Kawasan Metropolitan Mamminasata, Sulawesi Selatan, Indonesia. Data potong lintang mencakup empat unit wilayah agregat, yaitu Makassar, bagian wilayah Gowa dan Maros yang termasuk dalam delineasi Mamminasata, serta Takalar. Data dianalisis menggunakan skalogram Guttman berdasarkan 19 jenis fasilitas pendidikan, kesehatan, peribadatan, dan perdagangan. Keragaman fasilitas diinterpretasikan bersama kepadatan penduduk bruto dan indikator bentuk terbangun berbasis populasi. Makassar memiliki seluruh 19 jenis fasilitas, diikuti Gowa (18), Maros (17), dan Takalar (14). Matriks terurut

membentuk pola tersarang sempurna dengan koefisien reproduksibilitas sebesar 1,00. Kepadatan penduduk menurun dari 83,62 jiwa ha⁻¹ di Makassar menjadi kurang dari 10 jiwa ha⁻¹ pada setiap unit wilayah penyangga. Hasil analisis menempatkan Makassar sebagai inti pelayanan, Gowa sebagai unit transisi dalam, Takalar sebagai unit transisi luar, dan Maros sebagai zona luar berintensitas rendah. Perbedaan antara kelengkapan pelayanan dan intensitas permukiman menunjukkan bahwa investasi metropolitan perlu memprioritaskan kapasitas layanan, aksesibilitas, dan konektivitas lintas wilayah.

Kata kunci : *Mamminasata; Hierarki Pelayanan; Tipologi Wilayah; Skalogram; Pembangunan Metropolitan*

INTRODUCTION

Metropolitan growth concentrates population, employment, and higher-order services, but agglomeration benefits are seldom distributed evenly among constituent jurisdictions. Core cities tend to accumulate specialised education, health care, administration, commerce, and infrastructure, whereas peripheral territories provide labour, land, ecosystem services, and food. These relationships may generate spread effects by expanding markets and service access, or backwash effects when capital and opportunities remain concentrated in the dominant city (Chen & Partridge, 2013; Peón *et al.*, 2019). Core-periphery differentiation therefore reflects not only population concentration but also unequal combinations of service capacity, accessibility, settlement intensity, and institutional coordination (Fauzi, 2019; UN-Habitat, 2022). In South Sulawesi, regional welfare outcomes are similarly associated with uneven human-development and labour-market conditions (Jumain & Basuki, 2025).

Urbanisation is increasingly conceptualised as a continuum that connects dense centres, transitional zones, secondary towns, and rural hinterlands through flows of people, goods, and services (Cattaneo *et al.*, 2022). Connectivity alone, however, does not remove spatial inequality. Infrastructure provision commonly favours established urban locations (Pandey *et al.*, 2022), while corridor-led expansion can widen differences between well-connected and poorly connected territories (Rustiadi *et al.*, 2021; Schuster-Olbrich *et al.*, 2024). Transport-network quality influences the spatial reach of markets and public services, whereas electricity and educational infrastructure contribute through distinct regional production mechanisms (Sinar *et al.*, 2023; Syarifah & Rahmawati, 2026). Evidence from Makassar further indicates that travel time and accessibility shape public-transport preferences (Jumain *et al.*, 2021). A functional hierarchy of service centres is consequently necessary to identify where metropolitan integration is accompanied by service concentration.

The Mamminasata Metropolitan Area in South Sulawesi consists of Makassar, parts of Maros and Gowa including the Sungguminasa urban area, and Takalar. Its formal spatial framework was established through Presidential Regulation No. 55 of 2011 (Republic of Indonesia, 2011). Makassar is the principal centre for services, trade, logistics, and administration in eastern Indonesia, while the surrounding jurisdictions accommodate residential expansion, transport infrastructure, agriculture, and environmental functions. Previous research has documented water-resource pressures, land-cover conversion, spatial interaction, and sustainability challenges across the metropolitan area (Barkey *et al.*, 2019; Hakim *et al.*, 2020; Surya *et al.*, 2020). In Maros, urban expansion is constrained by the carrying capacity of agricultural land (Ihsan *et al.*, 2020). In the Moncongloe-Pattallassang corridor, new urban development has transformed the metropolitan fringe (Surya *et al.*, 2019), yet recent zoning evidence shows residential dominance alongside limited green and public-service land (Jumain *et al.*, 2026). These findings point to increasing spatial integration without equivalent functional balance.

The existing literature explains physical expansion and land-use change more fully than the cumulative distribution of services across Mamminasata. Land-cover models identify the direction of urban growth but do not establish whether peripheral territories contain a comparable range of education, health, worship, and commercial functions. Raw facility counts are also insufficient because they do not distinguish diversity from capacity, accessibility, or quality. The unresolved empirical question is whether service diversity follows the same metropolitan gradient as population and settlement intensity. This study evaluates that relationship using a Guttman-type scalogram for four territorial units: Makassar, Gowa, Maros, and Takalar. It examines (1) variation in service diversity, (2) correspondence between service hierarchy and population or settlement intensity, and (3) implications for metropolitan spatial planning. The analysis provides a reproducible baseline for subsequent district- or village-level research that incorporates accessibility, spatial clustering, and food-commodity specialisation.

RESEARCH METHODS

A cross-sectional quantitative design was used to compare service diversity and settlement intensity among four territorial units (Rustiadi *et al.*, 2018). The spatial boundary follows the Mamminasata delineation established by Presidential Regulation No. 55 of 2011: Makassar City, 11 districts in Gowa Regency, 12 districts in Maros Regency, and the nine districts of Takalar Regency. The unit of analysis is therefore an aggregated metropolitan component, not an individual district or settlement. Results are interpreted as relative differences among the four units and not as formal urban-rural classifications.



Figure 1. Location of the Mamminasata Metropolitan Area in South Sulawesi, Indonesia
Source: Research team GIS compilation from the 1:50,000 RBI base map and the 2011 Mamminasata delineation

The analytical dataset integrates population, territorial area, and facility inventories derived from official statistical and sectoral records. Nineteen facility types were classified into four functional domains: education, health, worship, and commerce. Facility availability was analyzed using a binary scalogram approach based on Guttman's cumulative scale, where each facility type was coded as present (1) or absent (0) within each territorial unit. The service diversity index (K_i) was calculated from the cumulative number of available functions, while completeness was measured as the proportion of available facilities relative to the total facility types ($J = 19$). The cumulative structure of facility distribution was evaluated using the reproducibility coefficient (CR) to assess the consistency of the functional hierarchy.

Built-form characteristics were examined through population density and population-derived urban intensity indicators. Gross population density was calculated as the ratio of population (P_i) to territorial area (A_i), while estimated building numbers and built-up areas were derived using population-based assumptions. These indicators were used as descriptive proxies to complement facility-based analysis rather than represent observed land-cover conditions. A composite urbanity indicator combining metropolitan share, population density, building intensity,

and facility completeness was applied as an exploratory measure of spatial differentiation. Given the limited number of territorial units, the analysis was restricted to descriptive interpretation without inferential statistical testing.

RESULTS AND DISCUSSION

Service concentration and functional diversity

Service provision was concentrated in Makassar, although the magnitude of concentration differed by sector (Table 1). Makassar contained 1,686 education facilities, 339 health facilities, 1,746 places of worship, and 11,161 commercial establishments. Gowa approached Makassar in education provision (1,559 facilities) but recorded substantially fewer health and commercial facilities. Maros and Takalar had smaller education and health inventories, while both reported more commercial establishments than Gowa. These differences show that total facility counts and functional diversity capture distinct dimensions of metropolitan service provision.

Table 1. Facility inventory and functional diversity by territorial unit

Territorial unit	Education	Health	Worship	Commerce	Facility types present (of 19)
Makassar	1,686	339	1,746	11,161	19
Gowa	1,559	198	1,240	1,643	18
Maros	604	98	848	2,970	17
Takalar	594	133	761	2,707	14

Source: Authors' calculations from the compiled facility dataset

The binary scalogram produced a monotonic hierarchy (Table 2). Makassar recorded all 19 facility types and a completeness ratio of 100%. Gowa lacked one health-facility category (94.74%), while Maros lacked that category and one worship type (89.47%). Takalar recorded 14 types (73.68%). After rows and columns were ordered, no deviation from the cumulative pattern remained ($e = 0$; $CR = 1.00$). The result confirms the internal reproducibility of the matrix, but the perfect coefficient is partly attributable to aggregation and the widespread presence of common facilities at regency scale.

Table 2. Scalogram-based service hierarchy

Rank	Territorial unit	Facility types	Completeness (%)	Service position
I	Makassar	19	100.00	Primary metropolitan service core
II	Gowa	18	94.74	Highly diversified inner-support unit
III	Maros	17	89.47	Diversified outer unit
IV	Takalar	14	73.68	Lower-diversity outer unit

Source: Authors' scalogram calculations

Facility completeness should not be interpreted as a welfare index. Four of the five categories absent from Takalar and one category absent from Maros were places of worship associated with minority religious groups. Their absence may reflect population composition rather than deficient public-service provision. The hierarchy is therefore most useful as a measure of functional variety; capacity, service quality, and access require separate indicators.

Population and settlement intensity

The demographic gradient was substantially steeper than the service-diversity gradient. Makassar accommodated 1.485 million residents on 17,759 ha, corresponding to 83.62 persons ha^{-1} (Table 3). Density in each peripheral unit was below 10 persons ha^{-1} : 9.68 in Gowa, 5.93 in Takalar, and 3.66 in Maros. Thus, Gowa reached 94.74% facility completeness at only 11.6% of

Makassar's density, while Maros combined 89.47% completeness with the lowest density. Service variety therefore extends farther from the core than intensive settlement.

Table 3. Demographic and population-derived built-form indicators

Territorial unit	Area (ha)	Population	Density (persons ha ⁻¹)	Estimated buildings	Buildings ha ⁻¹	Local proxy intensity (%)
Makassar	17,759	1,485,077	83.62	247,513	13.94	69.69
Gowa	68,651	664,883	9.68	110,814	1.61	8.07
Maros	109,010	398,724	3.66	66,454	0.61	3.05
Takalar	56,651	335,846	5.93	55,974	0.99	4.94

Source: Authors' calculations; the built-form indicators are population-derived proxies, not observed land cover

The source analysis reports 51.48%, 23.05%, 13.82%, and 11.64% for Makassar, Gowa, Maros, and Takalar, respectively. Because these values sum to 100%, they represent shares of the metropolitan proxy total rather than percentages of local land that are built up. Table 3 instead reports L_i/A_i , which yields local proxy intensities of 69.69%, 8.07%, 3.05%, and 4.94%. Both measures remain deterministic functions of population and cannot substitute for satellite-derived built-up area or building-footprint observations.

Composite metropolitan gradient

The study-specific composite score combines ordinal classes for metropolitan proxy share, population density, building density, and facility completeness. Makassar obtained the maximum score of 20, followed by Gowa (17), Takalar (15), and Maros (13). Equal intervals across the observed range distinguish a core, an inner transition, and two outer units (Table 4). These categories indicate relative position within this dataset and should not be treated as statutory or universally applicable urban-rural classes.

Table 4. Exploratory composite ordering of the metropolitan gradient

Territorial unit	Composite score	Relative position	Interpretation
Makassar	20	Core	Maximum service diversity and settlement intensity
Gowa	17	Inner transition	Near-complete services with moderate peripheral density
Takalar	15	Outer transition	Higher density but narrower service diversity than Maros
Maros	13	Outer zone	High service diversity with dispersed settlement intensity

Source: Authors' calculations from the four source-analysis components

The composite order differs from the scalogram order for Maros and Takalar. Maros ranked third in functional diversity but last in the composite measure because its population and estimated buildings are dispersed over the largest area. Takalar ranked fourth in functional diversity but third in the composite measure because its density exceeded that of Maros. The reversal demonstrates that service variety and physical urbanisation are related but non-equivalent dimensions.

Metropolitan structure and planning implications

The combined results confirm Makassar's primacy but do not support a simple core-versus-hinterland dichotomy. Makassar's complete facility profile and exceptional density are consistent with agglomeration processes that concentrate higher-order functions in dominant cities (Liu et

al., 2024). Gowa, however, has acquired almost the same range of functions without approaching core-city density. Functional integration has therefore progressed farther than physical convergence, producing a metropolitan transition rather than a uniform outward gradient. Gowa represents the clearest inner transition: it combines near-complete service diversity with substantially lower density than Makassar. Comparable mixed landscapes occur in Indonesian metropolitan fringes where residential, industrial, and agricultural uses coexist during rapid transformation (Jatayu *et al.*, 2020, 2022; Kurnia *et al.*, 2020, 2022). The planning priority is consequently not the indiscriminate addition of facility types, but the development of adequate capacity, public-transport access, and coordinated catchment areas that enable Gowa to operate as a secondary node.

Maros and Takalar follow different outer-zone trajectories. Maros contains 17 facility types but has the lowest density, indicating that functional variety is distributed across an extensive and relatively dispersed territory. Takalar has fewer facility types but higher population and building density. The aggregate data cannot determine whether Marosian facilities are concentrated in individual corridors or secondary centres, yet the contrast is sufficient to show that the two territories require different service and land-use responses. A differentiated polycentric strategy follows from these findings. Service planning should replace binary presence with measures of beds, enrolment, staffing, utilisation, catchment size, travel time, and public-transport connectivity. Higher-order functions can then be strengthened selectively in Gowa, Maros, and Takalar according to demonstrated gaps and existing roles. This approach is preferable to uniform replication because transport conditions and sector-specific infrastructure affect regional performance through different pathways (Sinar *et al.*, 2023; Syarifah & Rahmawati, 2026).

Service investment must also be coordinated with land-use control. Mamminasata's outer territories retain agricultural and environmental functions, while documented land-cover change indicates continuing conversion pressure (Hakim *et al.*, 2020; Surya *et al.*, 2020). Strengthening compact secondary centres can improve access without encouraging continuous ribbon development across productive landscapes. At district or village scale, quantitative zoning and spatially constrained classification could identify contiguous core, transition, and food-production zones (Rustiadi & Kobayashi, 2000; Wang *et al.*, 2019). Linking those zones to commodity specialisation would connect the service hierarchy directly to metropolitan food-system planning.

Methodological limitations

The analysis is constrained by four aggregate observations, which mask within-regency variation and produce a relatively saturated facility matrix. Presence-absence coding does not measure capacity, quality, accessibility, or utilisation. Building and built-form indicators are deterministic population transformations, while worship-facility diversity may reflect religious composition. Accordingly, CR = 1.00 validates only the nested binary ordering. Future research should use district- or village-level facility capacity, travel times, commuting flows, building footprints, and satellite-derived land cover to test the robustness of the observed hierarchy.

CONCLUSIONS AND RECOMMENDATIONS

Mamminasata has a reproducible but differentiated service hierarchy. Makassar occupies the primary position with all 19 facility types and a population density of 83.62 persons ha⁻¹. Gowa forms the strongest inner transition, combining 18 facility types with substantially lower density. Maros and Takalar constitute contrasting outer units: Maros has greater functional diversity but more dispersed settlement, whereas Takalar has higher density but a narrower service portfolio. Service completeness and physical urbanisation therefore do not progress at the same rate. Metropolitan policy should adopt a differentiated polycentric approach. Strategic secondary centres require stronger higher-order service capacity and public-transport access, while interjurisdictional planning should coordinate service catchments, infrastructure investment, and protection of productive landscapes. The next analytical stage should use district- or village-level observations, capacity-adjusted facility indicators, travel-time accessibility, and observed built-up land. Integrating those measures with food-commodity specialisation would provide a stronger basis for defining core, transition, and production zones.

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