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Spatial Analysis of Population Projection in Bombana Regency to 2045 Using Arithmetic and Exponential Growth Models

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Abstract

Population growth projection in Bombana Regency up to 2045 is important because population increase is not accompanied by an even spatial distribution across sub-districts, which may lead to different levels of regional pressure in the long term. Population projection based on arithmetic and exponential growth models integrated with Geographic Information Systems (GIS) is applied to describe variations in the spatial patterns of population growth at the sub-district level and to identify differences in projection results under different growth assumptions. Knowledge of population growth trends and spatial distribution is required to assess the direction of population development in the central to western parts of Bombana Regency, which grow faster than coastal and island areas, as a basis for long-term regional and spatial planning.

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Abstrak

Proyeksi pertumbuhan penduduk Kabupaten Bombana hingga tahun 2045 penting dilakukan karena peningkatan jumlah penduduk tidak diikuti oleh pola distribusi spasial yang merata antarkecamatan, sehingga berpotensi menimbulkan perbedaan tekanan wilayah dalam jangka panjang. Pendekatan proyeksi berbasis model aritmetika dan eksponensial yang diintegrasikan dengan Sistem Informasi Geografis (SIG) digunakan untuk menggambarkan variasi pola spasial pertumbuhan penduduk pada tingkat kecamatan serta untuk mengetahui perbedaan hasil proyeksi berdasarkan asumsi pertumbuhan yang berbeda. Pengetahuan mengenai kecenderungan pertumbuhan dan distribusi penduduk tersebut diperlukan untuk menilai arah perkembangan penduduk di wilayah tengah hingga barat Kabupaten Bombana yang tumbuh lebih cepat dibandingkan dengan wilayah pesisir dan kepulauan sebagai dasar pertimbangan perencanaan wilayah dan tata ruang jangka panjang.

INTRODUCTION

Rapid population growth and accelerating urbanization have reshaped demographic structures across the world, intensifying spatial pressure on land, infrastructure, and basic services, particularly within regions experiencing sustained demographic momentum (Mahtta et al., 2022; Kang et al., 2024). Global assessments indicate that population increase concentrates predominantly in urban and peri-urban areas, while urban land consumption expands at a pace that often exceeds population growth, producing extensive spatial footprints and uneven settlement patterns (United Nations, 2014; Angel, 2023). Urbanization increasingly unfolds through a combination of densification and outward expansion, generating fragmented development patterns that challenge spatial efficiency and long-term territorial coordination (Schiavina et al., 2022; Booker et al., 2025). Such dynamics require demographic information that extends beyond current population counts, emphasizing forward-looking projections capable of anticipating future distribution rather than reacting to observed change. Population projection functions as a strategic instrument for long-range spatial planning, providing structured expectations regarding demographic trajectories across multiple time horizons and enabling planners to address future demand for land, housing, and infrastructure before spatial imbalances consolidate (Diogo et al., 2023). Projections framed over extended periods gain relevance where demographic growth interacts directly with land-use conversion, settlement expansion, and spatial reorganization, conditions increasingly observed across developing regions (Rimal et al., 2025; Tilahun et al., 2025).

The demographic change intertwines closely with heterogeneous urbanization pathways in Indonesia, where population growth, internal migration, and functional reclassification of settlements reshape regional spatial structures beyond metropolitan cores (Yudhistira et al., 2024; Pitoyo et al., 2025). National urbanization trends indicate a steady rise in urban population shares alongside persistent growth in intermediate towns and semi-dense areas, highlighting the need for spatially explicit demographic foresight at sub-national scales (Malamassam, 2022). Southeast Sulawesi exhibits distinctive urbanization trajectories characterized by uneven spatial concentration, gradual expansion of urban clusters, and continued demographic relevance of rural and peri-urban zones, positioning the province within a transitional demographic regime rather than a fully consolidated urban system (Iqbal & Maulana, 2021). Such regional characteristics underscore the importance of demographic projections that address spatial differentiation rather than aggregate growth alone. Bombana Regency occupies a strategic position within this provincial structure, where population changes intersect resource-based economic activity, settlement dispersion, and evolving connectivity patterns. Long-term population projection toward 2045 becomes essential for interpreting how demographic pressure distributes across districts over time, particularly where emerging growth nodes coexist with sparsely populated hinterlands.

Population development in Bombana Regency over the last decade has shown a consistent upward trend, reflecting broader demographic dynamics observed in many non-metropolitan regions of Indonesia where natural increase remains a primary driver of growth rather than large-scale urban migration. Although the total population continues to rise, its spatial distribution across sub-districts exhibits relatively balanced patterns, indicating the absence of extreme concentration in a single urban core while still revealing variations in density related to accessibility, settlement history, and functional roles of each sub-district. Such distribution characteristics position Bombana within a demographic setting where population pressure emerges not from excessive agglomeration but from the cumulative interaction between population growth and spatial capacity at the local level.

An increasing population interacts directly with land carrying capacity, settlement expansion, infrastructure provision, and access to basic services, where land availability functions as a limited resource that must simultaneously accommodate housing needs, transportation networks, public facilities, and service coverage. Within the framework of regional and spatial planning, these conditions necessitate population projections that are not merely numerical but are also presented in a spatially explicit manner to serve as a basis for guiding zoning policies, determining infrastructure development priorities, and allocating services across sub-districts (Nasution et al., 2023). Empirical studies on environmental and land carrying capacity in Indonesia further emphasize that population growth unaccompanied by proportional development of infrastructure and service systems can intensify spatial pressure and trigger land-use inefficiencies as well as service disparities, particularly in developing regions where settlement growth often precedes infrastructure consolidation (Amin et al., 2021; Nurfatimah, 2022; Auliya et al., 2025). The selection of 2045 as the projection horizon aligns directly with Indonesia's long-term national development framework, where demographic structure, spatial demand, and service provision are evaluated within the context of the Golden Indonesia vision and the National Long-Term Development Plan, positioning population projection as a necessary analytical foundation for anticipating spatial demand across extended planning cycles rather than short-term administrative periods (United Nations, 2014).

Previous population projection studies in Indonesia have largely focused on specific administrative units such as metropolitan cities, peri-urban districts, or rapidly growing sub-districts, where demographic change is examined primarily through mathematical projection techniques applied over short to medium horizons. Studies conducted in Medan City demonstrate the application of arithmetic and geometric models to estimate population growth for a single target year, emphasizing model performance based on statistical deviation rather than long-term spatial interpretation (Syahfitri et al., 2025). Similar approaches appear in sub-district level analyses such as Cibinong, where arithmetic, geometric, and exponential models are applied to census data to identify dominant growth tendencies, yet outcomes remain confined to tabular comparisons without spatial elaboration (Herlina et al., 2023). Other case-based studies extend projection outputs toward sectoral impacts, including waste generation in Jakarta, where multiple projection models support environmental estimations but retain an aggregate spatial scale and short projection window (Diani et al., 2024).

Despite extensive application of mathematical projection models, several methodological gaps remain evident within Indonesian population studies. Existing research commonly relies on a single projection method, whether arithmetic, geometric, or exponential, reducing analytical sensitivity to alternative growth assumptions and obscuring uncertainty ranges associated with demographic forecasting. Comparative evaluation between linear and exponential growth structures remains limited, even though each model reflects distinct demographic dynamics, where arithmetic projection aligns with stable population increase and exponential projection corresponds to constant percentage growth associated with expansion or migration-driven contexts. Integration of Geographic Information Systems (GIS) remains marginal, as most studies prioritize numerical tables over spatial visualization, constraining interpretation of inter-district variation and spatial pressure patterns. In Bombana Regency, population projection research remains scarce, particularly studies that extend beyond short-term horizons and incorporate spatial analysis at the sub-district level. This study aims to: 1) estimate the future population of Bombana Regency up to the year 2045 by applying arithmetic and exponential population growth models; 2) evaluate and compare the sensitivity of population projections produced by the two modeling approaches in representing alternative growth assumptions; and 3) examine the spatial distribution of projected population across sub-districts using GIS as an analytical basis for long-term regional and spatial planning in line with Indonesia's national development framework.

METHOD

Study Area

Bombana Regency is located in Southeast Sulawesi Province, Indonesia, with a total area of 3,316.16 km². The regency lies on the southeastern peninsula of Sulawesi Island, south of the equator, between 4°30'–6°25'S and 120°82'–122°20'E (Figure 1). It is bordered by Kolaka Regency and South Konawe Regency to the north, Muna Regency and Buton Regency to the east, the Flores Sea to the south, and the Bone Gulf to the west.

Bombana Regency represents a developing regency where population growth has occurred gradually over the past decade, as indicated by official population statistics, rather than through rapid urban expansion. Population

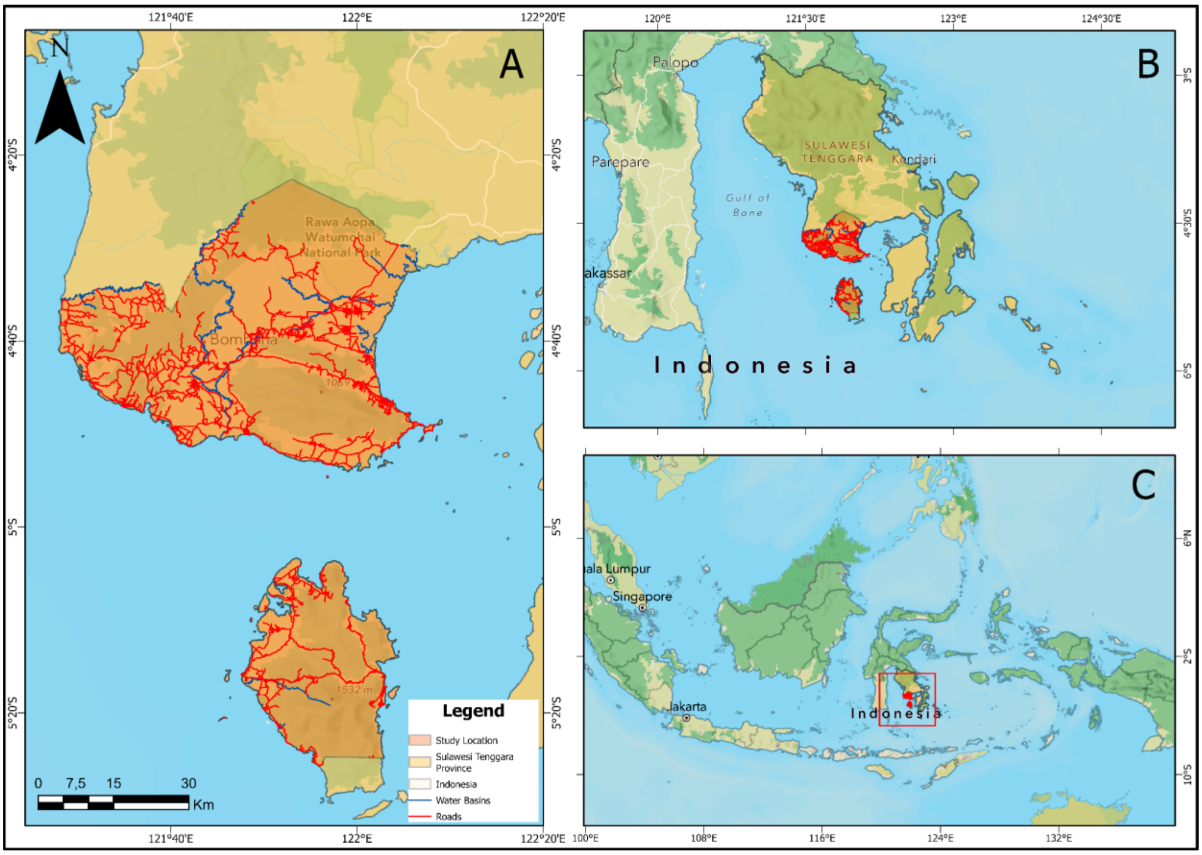

Figure 1. Research Location Map a) Bombana Regency, b) Southeast Sulawesi Province, c) Indonesia

is distributed across multiple sub-districts without a single highly dominant urban center, while physical conditions vary between coastal, lowland, and inland areas. These characteristics result in differences in population density and growth patterns among sub-districts, which are important for spatially based population projection. The combination of steady population increase, dispersed settlement patterns, and spatial variation across sub-districts distinguishes Bombana from regions with strong urban concentration.

Type and Source of Data

This study utilizes demographic and spatial datasets obtained from official Indonesian statistical and geospatial institutions. Population figures for 2020 and 2024 were collected from the national statistical database to represent baseline and mid-term conditions. Administrative boundary data in the form of a shapefile (.shp) was sourced from the Geospatial Information Agency (BIG) to support spatial processing and integration in the GIS environment. These datasets function as the core inputs for projection calculation and spatial representation at the sub-district level.

Population Projection Method

The population projection in this study employs two mathematical approaches: the arithmetic growth model and the exponential growth model. Both models are used to estimate future population trends based on observed demographic data and annual growth rates from the reference years. The arithmetic model assumes a steady yearly increase, while the exponential model calculates population change using a constant percentage relative to the previous year. These models are applied separately for each sub-district, and the results are compared to identify differences in projected growth patterns. The arithmetic projection is expressed as Equation 1:

$$P_a = P_o + (r \times t) \quad (1)$$

where P_a represents the projected population in the year t, P_o is the base year population, r is the annual growth rate, and t is the projection period in year.

Almost the same as arithmetic equations. The exponential projection is formulated as Equation 2:

$$P_e = P_0(1 + r)^2 \quad (2)$$

where P_e is the projected population, P_0 is the initial population, r is the annual growth rate expressed as a decimal, and t is the number of years projected forward.

Data Collection, Processing, and Analysis

Data collection integrates demographic records and spatial datasets to support the calculation and mapping of population projections at the sub-district scale. Pre-processing procedures include coordinate system verification, attribute adjustment, and data formatting to ensure compatibility with GIS operations. Spatial processing is conducted by joining demographic attributes to polygon features through attribute join procedures.

Population projections up to 2045 are calculated using arithmetic and exponential growth models. These projections are not intended to produce precise demographic estimates, but to illustrate long-term population pressure scenarios based on different growth assumptions. The arithmetic model represents the lower bound of potential population growth, while the exponential model represents the upper bound.

Projection results are processed within a GIS environment and classified using standard interval methods to generate choropleth maps depicting the spatial distribution of projected population change. Map symbology and legends are standardized across projection outputs to support visual comparison, emphasizing the use of projection results for long-term spatial planning purposes rather than deterministic demographic prediction.

RESULT AND DISCUSSION

Baseline Population Distribution

Poleang (14,336-15,522), Poleang Barat (12,258-13,607), and Rumbia (12,385-12,943) form the highest concentration zones in both 2020 and 2024, followed by Lantari Jaya and Poleang Timur in the upper-mid range. Sub-districts located at the periphery, such as Mata Usu (1,806-2,047) and Kepulauan Masaloka Raya (2,332-2,748), remain in the lowest interval (Table 1). Spatial patterns in 2020 (Figure 2) and 2024 (Figure 3) show that population intensity is most pronounced along the central–western corridor, while eastern coastal and island areas retain lower totals. The consistent dominance of Poleang and its adjacent sub-districts aligns with their administrative and service role, whereas distant island areas continue to register modest population numbers.

The administrative centers naturally evolve into focal points for population concentration due to the range and threshold of services provided (Berry, 1967). The concentration in the central-western corridor indicates that these sub-districts act as growth poles that draw in the population through better accessibility and infrastructure von Böventer, 1975). Incremental increases between 2020 and 2024 reflect steady growth across most sub-districts, though the relative ranking between zones does not experience major shifts.

Comparison of the baseline maps further emphasizes the stability of the spatial structure. A concentration of high-density classes in the Poleang cluster (Figure 2), which remains a numeric increase across districts (Figure 3). Regions such as Kabaena Tengah, Rumbia

Table 1. Baseline Population in Bombana Regency

No.	Sub-district	2020	2024	No.	Sub-district	2020	2024
1	Kabaena	3,120	3,402	12	Poleang Barat	12,258	13,607
2	Kabaena Barat	7,829	8,668	13	Poleang Selatan	6,911	7,853
3	Kabaena Selatan	3,325	3,640	14	Poleang Tengah	3,676	4,030
4	Kabaena Tengah	4,064	5,162	15	Poleang Tenggara	4,246	4,748
5	Kabaena Timur	7,566	8,583	16	Poleang Timur	10,152	11,058
6	Kabaena Utara	4,031	4,729	17	Poleang Utara	10,968	11,980
7	Kepulauan Masaloka Raya	2,332	2,748	18	Rarowatu	6,342	7,124
8	Lantari Jaya	8,475	9,692	19	Rarowatu Utara	7,147	8,019
9	Mata Oleo	7,079	8,264	20	Rumbia	12,385	12,943
10	Mata Usu	1,806	2,047	21	Rumbia Tengah	7,267	8,200
11	Poleang	14,336	15,522	22	Tontonunu	5,391	6,036

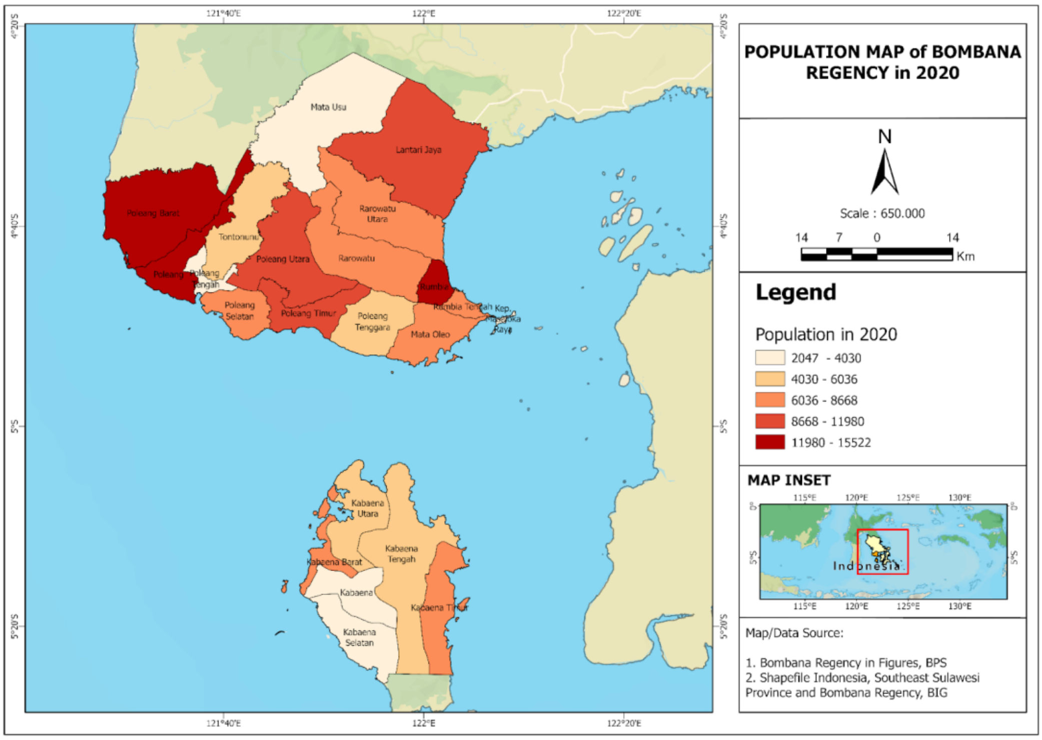

Figure 2. Population Map in Bombana Regency in 2020

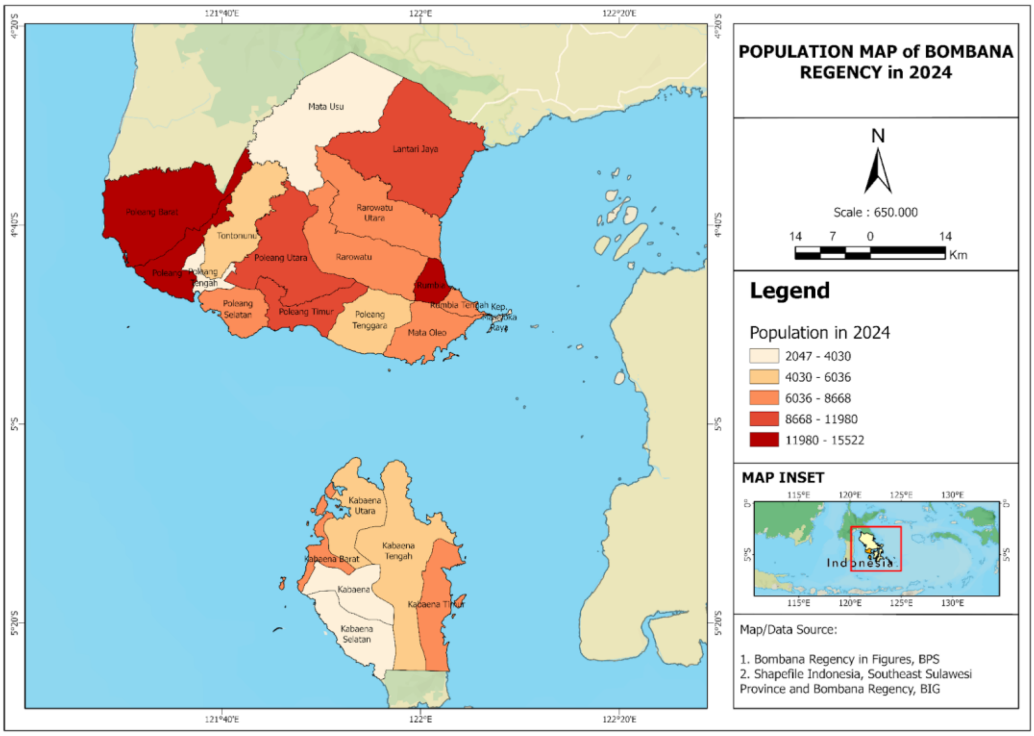

Figure 3. Population Map in Bombana Regency in 2024

Tengah, and Rarowatu Utara transition into slightly higher classes in 2024, while Kabaena Selatan, Mata Usu, and the island territories maintain their lower interval positions. The spatial distribution does not shift dramatically between the two points, indicating that growth follows existing demographic hierarchies rather than forming new dominant centers. The pattern suggests that population change advances through incremental expansion from already established nodes toward adjoining areas rather than abrupt increases in remote districts. This phenomenon reflects spatial inertia, where the momentum of historical growth dictates the direction of future expansion. According to Sheppard (2017), core regions that have an initial advantage tend to strengthen their position over time, often at the expense of the periphery. This explains why the Poleang cluster continues to grow while island territories remain in the lower density intervals (Fujita & Krugman, 2004).

Evaluation of differences between central and peripheral growth zones shows that increases occur more strongly where initial populations were already high. Sub-districts in the mid-to-upper range in 2020 maintain similar relative positions in 2024, while areas in the lowest group do not exceed their category. The 2020–2024 supports the interpretation that growth is gradual and structurally tied to initial demographic baselines rather than producing new competitive centers (Table 1). The transition from 2020 (Figure 2) to 2024 (Figure 3) reinforces the presence of a core population corridor, surrounded by intermediate districts, then low-density coastal and island regions at the outer extent. This reinforces the concept of path dependency in regional development, where the spatial structure is locked into a specific trajectory based on its historical baseline (Martin & Sunley, 2006). The lack of new competitive centers suggests that current regional development has not yet reached a stage of spread effects strong enough to overcome the backwash effects that concentrate growth in the established core (Romer, 2009).

Population Projection and Spatial Distribution Pattern

Both models generate consistent hierarchical ordering, where Poleang, Poleang Barat, Rumbia, and Lantari Jaya remain as the highest values, followed by Poleang Timur and Rarowatu Utara as mid-level zones (Table 2). The arithmetic model advances in a steady and predictable range, while the exponential model produces a sharper escalation concentrated in sub-districts that already had higher baseline totals. The lowest groups, including Mata Usu and Kepulauan Masaloka Raya, retain slower numerical growth, and the overall spread across districts aligns with the established population structure. The arithmetic projection characterizes gradual increments that extend existing categories, while the exponential projection intensifies the upper tiers and broadens the gap between high and low population zones. The divergence between these models highlights the critical importance of selecting appropriate growth assumptions for regional planning. While arithmetic growth is often used for short-term facility planning, the exponential model serves as a warning for potential carrying capacity overruns in core areas, which can lead to land-use conflicts and environmental pressure (Malthus, 1967).

The growth population under the arithmetic model accumulates across the central–western corridor, extending through Poleang Barat, Poleang, and Rumbia, followed by moderate expansion in Poleang Timur and Rarowatu Utara (Figure 4). Rumbia Tengah, Kabaena Tengah, and Kabaena Timur emerge as intermediate areas that progress without exceeding the highest class. Mata Usu and Kepulauan Masaloka Raya remain in the lowest interval. The spatial pattern under arithmetic conditions does not produce abrupt changes and aligns with the baseline structure observed in previous years. The strongest values continue to cluster around existing service and administrative centers, while peripheral island zones maintain slower trajectories. This

Table 2. Sub-District Population Projection in 2045 Based on Arithmetic and Exponential Models

No.	Sub-district	P_a	P_e	No.	Sub-district	P_a	P_e
1	Kabaena	4,883	6,234	12	Poleang Barat	20,689	28,259
2	Kabaena Barat	13,073	17,677	13	Poleang Selatan	6,911	7,853
3	Kabaena Selatan	5,294	6,859	14	Poleang Tengah	3,676	4,030
4	Kabaena Tengah	10,927	27,534	15	Poleang Tenggara	4,246	4,748
5	Kabaena Timur	13,922	20,751	16	Poleang Timur	10,152	11,058
6	Kabaena Utara	8,394	14,463	17	Poleang Utara	10,968	11,980
7	Kepulauan Masaloka Raya	4,932	8,670	18	Rarowatu	6,342	7,124
8	Lantari Jaya	16,081	24,793	19	Rarowatu Utara	7,147	8,019
9	Mata Oleo	14,485	24,419	20	Rumbia	12,385	12,943
10	Mata Usu	3,312	4,919	21	Rumbia Tengah	7,267	8,200
11	Poleang	21,749	27,076	22	Tontonunu	5,391	6,036

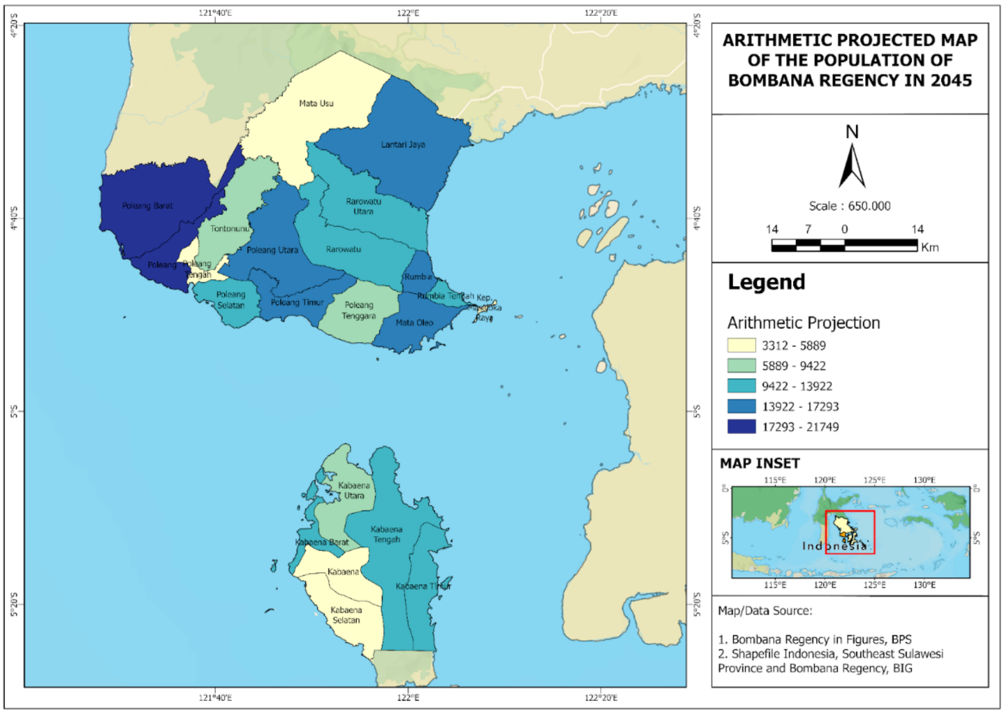

Figure 4. Population Projection Map in 2045 Based on the Aritmethic Method

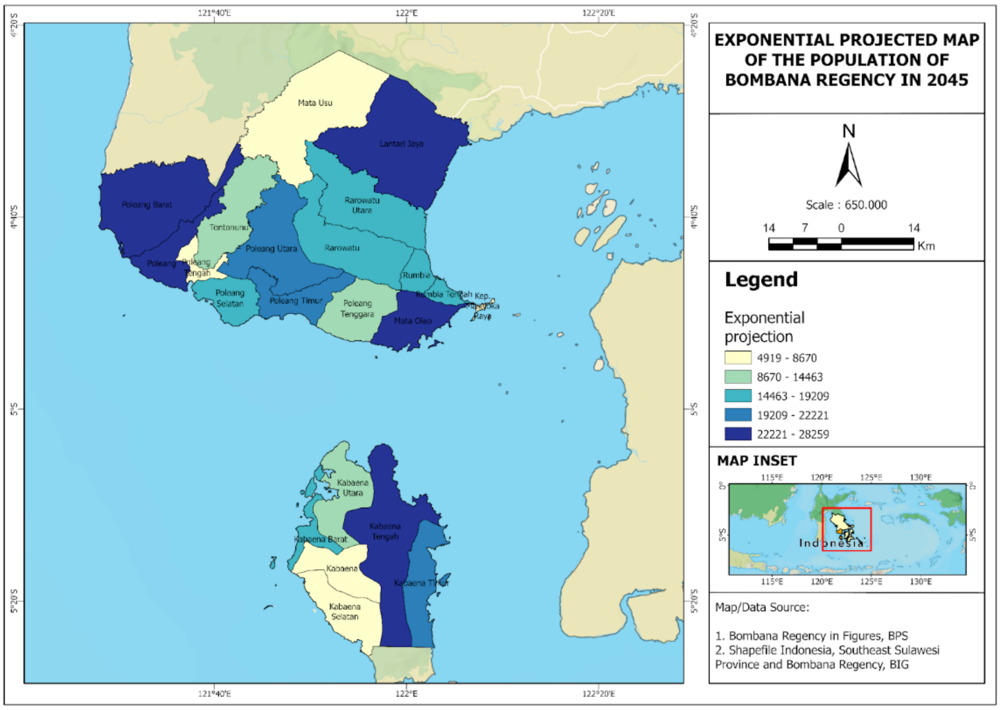

Figure 5. Population Projection Map in 2045 Based on the Exponential Method

suggests a stable but polarized regional economy. As noted by Hansen (1967), without direct policy intervention to improve accessibility in the periphery, population growth will remain structurally biased towards nodes with established market potential.

The exponential model demonstrates more pronounced escalation, especially across the same central–western axis, where Poleang Barat and Poleang shift into the upper range and Rumbia and Lantari Jaya advance toward higher population classes (Figure 5). The escalation under exponential conditions increases contrast between core and peripheral areas. Moderate increments appear in Rarowatu, Poleang Timur, and Kabaena Tengah, while Mata Usu and Kepulauan Masaloka Raya experience the least change among island and coastal territories. The spatial structure becomes more polarized under exponential projection, where high-growth districts show accelerated upward movement and low-growth districts remain relatively static in their lower categories. This polarization reflects spatial decoupling, where the growth rate of core districts outstrips the surrounding region, creating a starker center-periphery divide. This emphasizes that decreasing transport costs often paradoxically increases the concentration of population in the primary core (Krugman, 1991).

Comparative Projection Interpretation Between Arithmetic and Exponential

The comparative bar chart illustrates multi-temporal values across 2020, 2024, and 2045 for the ten most populated sub-districts, highlighting how both projection methods extend observed growth trajectories. Poleang Barat, Poleang, and Lantari Jaya occupy the upper tier and retain their position in 2045 under both methods, while Mata Oleo, Poleang Selatan, and Rumbia Tengah remain in the lower portion of the top group (Figure 6). Arithmetic outputs advance steadily from the 2024 levels, while exponential values rise sharply from the same starting point, particularly in Poleang Barat and Poleang, where the divergence between the two projections becomes more distinct. The ranking structure observed in 2020 and 2024 continues into 2045, indicating that districts with the largest historical values sustain their position throughout the progression. The widening gap between the two projections in the year 2045 represents a planning interval of uncertainty. Planners must decide whether to provide infrastructure based on the conservative arithmetic trend or the aggressive exponential scenario, with the latter requiring significantly more investment in urban services to avoid diseconomies of scale such as congestion and slum formation (Overman & Venables, 2005).

Differences between the two models appear most clearly in the widening interval between arithmetic and exponential results for the highest population districts. Poleang Barat and Poleang show the most substantial separation, where exponential values rise substantially above arithmetic estimates, while Kabaena Tengah and Poleang Selatan experience more moderate differences. The lower growth zone within the top ten, including Mata Oleo and Rumbia Tengah, records smaller distances between the two projection lines, signaling a slower progression rate relative to the upper group. Arithmetic growth retains closer alignment with historical pacing, while exponential values amplify the upward trajectory and intensify the contrast between districts. This widening interval is a spatial manifestation of the Matthew Effect (Merton, 1968), in which districts that are already demographically rich gain even more, while stagnant ones remain trapped in low-growth cycles. This disparity emphasizes the need for a polycentric spatial strategy to redistribute pressure from the Poleang-Rumbia corridor (Davoudi, 2003).

Spatial hierarchy within the chart also conveys that historical dominance influences projection magnitude. Districts that already

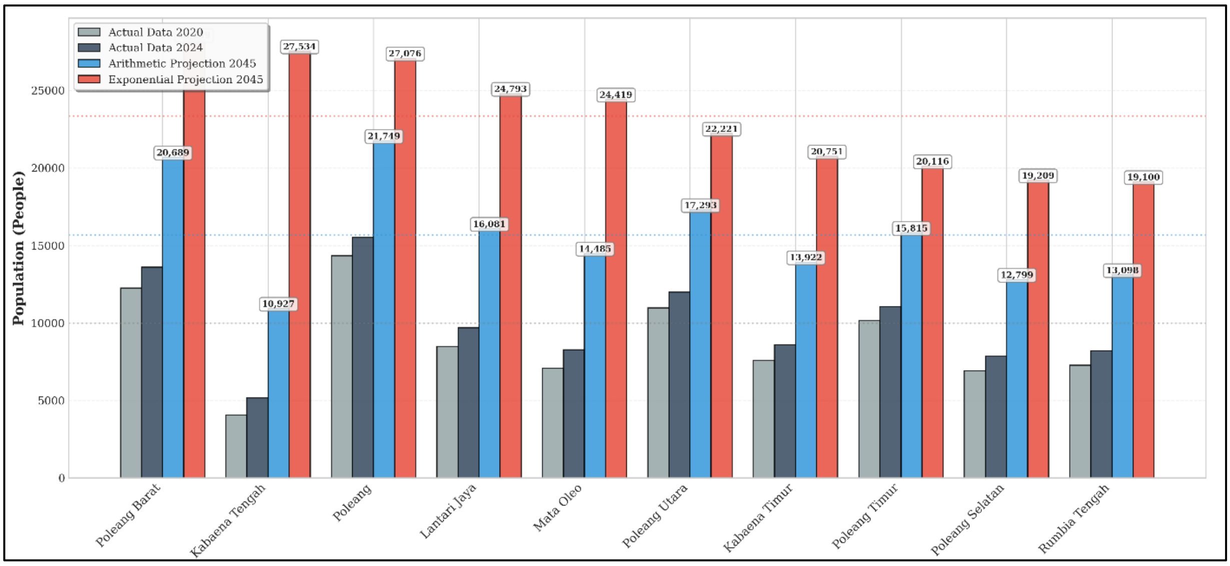

Figure 6. Comparative Analysis of Population Projections 2045 in Top 10

held large populations in 2020 and 2024 receive proportionally higher values in both models, while mid-ranked districts grow at a slower rate and maintain their position. This distribution results in a tiered progression where Poleang Barat, Poleang, and Lantari Jaya form the primary cluster; Kabaena Timur, Poleang Timur, and Rumbia follow as intermediate areas; and Mata Oleo and Poleang Selatan remain at the lower edge of the top ten. Arithmetic projections extend current trends, while exponential calculations expand separation within the ranking structure without altering the order established in the historical dataset. In conclusion, the findings suggest that the region is experiencing locked-in demographic concentration. To achieve a more equitable distribution by 2045, it is imperative to implement regional policies that foster secondary growth centers in intermediate districts, thereby bridging the widening gap between the central corridor and the peripheral territories (Karst, 1969; Rustiadi et al., 2009).

This study has a major limitation in its use of deterministic arithmetic and exponential growth models, where projections are based solely on historical trends without considering dynamic external factors. Factors such as changes in spatial planning policies, local economic fluctuations, and the potential for natural disasters in coastal and island areas have not been integrated into the model. Furthermore, the reliance on aggregated sub-district-level data limits analysis of density variations at microscales or more detailed spatially explicit scales (Rustiadi et al., 2009). Therefore, interpretation of the 2045 projections should be approached with caution, as the assumptions of linearity or constant acceleration in these models may not fully capture sudden shifts in migration dynamics or future changes in the administrative status of the region.

The policy implications of these findings are crucial for regional development planning, particularly in anticipating increasingly sharp population polarization. The predicted continued dominance of the central-western corridor necessitates a strategy for decentralizing public services and infrastructure investment to peripheral areas. If growth follows an exponential scenario without the intervention of a polycentric spatial strategy, core districts such as Poleang and Rumbia will face severe pressure on their environmental carrying capacity, triggering diseconomies of scale (Davoudi, 2003; Overman & Venables, 2005). Local governments should consider developing new growth hubs in interconnected areas to distribute the demographic burden more equitably and prevent permanent marginalization in island regions.

Future research strongly recommends integrating more complex GIS-based models, such as Cellular Automata (CA) or Agent-Based Modeling (ABM), to more accurately simulate the interaction between population growth and land-use change (Verburg et al., 2015). Future research should also explore broader socioeconomic variables, including transportation accessibility and digital connectivity, influencing the direction of population mobility. Integrating remote sensing data to map the physical expansion of settlements multi-temporally will provide a valuable additional dimension in validating population projection models, resulting in more adaptive and evidence-based policy recommendations (Rustiadi et al., 2009).

CONCLUSION

This study estimates population change in Bombana Regency toward 2045 using arithmetic and exponential projection models supported by sub-district demographic data and GIS-based spatial interpretation. Findings indicate that population growth follows the existing hierarchical structure rather than forming new dominant centers, where Poleang, Poleang Barat, and Lantari Jaya remain the primary concentration zones from the baseline years into the projected horizon. Arithmetic outputs advance steadily and maintain proportional relationships between districts, while exponential projections intensify growth in upper-tier sub-districts and widen the gap between central and peripheral areas. Spatial patterns reinforce the presence of a core corridor across the central–western region, balanced by slower increases in coastal and island territories.

Both models confirm that future growth aligns closely with initial demographic baselines, and variation between sub-districts is shaped by the magnitude of their starting population rather than abrupt structural change. Arithmetic results reflect a continuation of current trends, whereas exponential results emphasize the acceleration of districts that already demonstrate high population totals.

Projection outputs do not indicate a shift in regional dominance but underline the persistence of established population centers and the limited rise of outer sub-districts.

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REFERENCE

Amin, S., Amri, N., Rasyid, A. R., Nugraditama, M. F., & Alisha, S. B. (2021). Study of Environmental Carrying Capacity on the Development of Formal Housing in Moncongloe District, Maros Regency. *EPI International Journal of Engineering, 4*(2), 120–126. https://doi.org/10.25042/10.25042/epi-ije.082021.03

Angel, S. (2023). Urban Expansion: Theory, Evidence and Practice. *Buildings and Cities, 4*(1), 124–138. https://doi.org/10.5334/bc.348

Auliya, I., Widiatmaka, & Syartinilia. (2025). Land Capability Analysis for Sustainable Land Use Planning: A Case Study of Bogor Regency, Indonesia. *Journal of Natural Resources & Environment Management, 15*(3), 509–518. https://doi.org/10.29244/jpsl.15.3.509

Berry, B. J. (1967). *Central places in southern Germany*. Prentice-Hall.

Booker, K., White, I., Fu, X., & Wilson, M. (2025). Modelling Urban Growth for Long-Term Planning under Future Climate Uncertainty: A Systematic Review and Decision Pathway. *Cities, 167*, 106310. https://doi.org/10.1016/j.cities.2025.106310

Davoudi, S. (2003). European Briefing: Polycentricity in European Spatial Planning: from an Analytical Tool to a Normative Agenda. *European Planning Studies, 11*(8), 979-999. https://doi.org/10.1080/0965431032000146169

Diani, M. R., Haniifah, D., & Dianty, F. R. (2024). Analisis Proyeksi Pertumbuhan Penduduk dan Volume Sampah DKI Jakarta terhadap Dampak yang Ditimbulkan. *Journal of Waste and Sustainable Consumption, 1*(1), 27–45. https://doi.org/10.61511/jwsc.v1i1.2024.691

Diogo, V., Jacobs-Crisioni, C., Baranzelli, C., & Lavalle, C. (2023). Integrated Spatial Simulation of Population and Urban Land Use: A Pan-European Model Validation. *Applied Spatial Analysis and Policy, 16*(4), 1463–1492. https://doi.org/10.1007/s12061-023-09518-x

Fujita, M., & Krugman, P. (2004). The New Economic Geography: Past, Present and the Future. *Papers in Regional Science, 83*(1), 139-164. https://doi.org/10.1007/s10110-003-0180-0

Hansen, N. M. (1967). Development Pole Theory in a Regional Context. *Kyklos, 20*(4), 709-727. https://doi.org/10.1111/j.1467-6435.1967.tb00871.x

Herlina, N., Kustiawati, D., Halimi, D. L., & Sari, A. M. (2023). Proyeksi Pertumbuhan Penduduk Kecamatan Cibinong Dengan Metode Matematik. *ETNIK: Jurnal Ekonomi dan Teknik, 2*(2), 145–149.

Iqbal, L. M., & Maulana, A. (2021). Demystifying the Geography of Urbanization in Indonesia (Case Study: Southeast Sulawesi Province). *Geographica: Science and Education Journal, 3*(2), 76-91. https://doi.org/10.31327/gsej.v3i2.1704

Kang, H., Fu, M., Kang, H., Li, L., Dong, X., & Li, S. (2024). The Impacts of Urban Population Growth and Shrinkage on the Urban Land Use Efficiency: A Case Study of the Northeastern Region of China. *Land, 13*(9), 1532 https://doi.org/10.3390/land13091532

Karst, K. L. (1969). Regional development policy: A case study of Venezuela. *Hispanic American Historical Review, 49*(2), 368. https://doi.org/10.1215/00182168-49.2.368

Krugman, P. (1991). Increasing Returns and Economic Geography. *Journal of Political Economy, 99*(3), 483-499. https://doi.org/10.1086/261763

Mahtta, R., Fragkias, M., Güneralp, B., Mahendra, A., Reba, M., Wentz, E. A., &

Seto, K. C. (2022). Urban Land Expansion: the Role of Population and Economic Growth for 300+ Cities. *Npj Urban Sustainability, 2*(1), 1-11 https://doi.org/10.1038/s42949-022-00048-y

Malamassam, M. A. (2022). Spatial Structure of Youth Migration in Indonesia: Does Education Matter?. *Applied Spatial Analysis and Policy, 15*(4), 1045–1074. https://doi.org/10.1007/s12061-022-09434-6

Malthus, T. R. (1967). *Essay on Principle of Population 1798*. Readex Microprint.

Martin, R., & Sunley, P. (2006). Path Dependence and Regional Economic Evolution. *Journal of Economic Geography, 6*(4), 395-437. https://doi.org/10.1093/jeg/lbl012

Merton, R. K. (1968). The Matthew Effect in Science: The Reward and Communication Systems of Science are Considered. *Science, 159*(3810), 56-63. https://doi.org/10.1126/science.159.3810.56

Nurfatimah. (2022). Analysis of the Carrying Capacity of Settlement Land in Tamanggung District. *INSOLOGI: Jurnal Sains dan Teknologi, 1*(5), 505–511. https://doi.org/10.55123/insologi.v1i5.839

Overman, H. G., & Venables, A. J. (2005). *Cities in the Developing World* (No. 695). London School of Economics and Political Science. Centre for Economic Performance.

Pitoyo, A. J., Sukamdi, S., Alfana, M. A. F., & Widaryoko, N. (2025). Internal Migration in Indonesia: Remapping Trajectories. *International Journal of Population Studies, 11*(6), 116-129. https://doi.org/10.36922/ijps025190084

Rimal, B., Rijal, S., & Tiwary, A. (2025). Prediction of Urban Growth and Sustainability Challenges Based on LULC Change: Case Study of Two Himalayan Metropolitan Cities. *Land, 14*(8), 1675. https://doi.org/10.3390/land14081675

Romer, P. M. (2009). Two Strategies for Economic Development: Using Ideas and Producing Ideas. In *The strategic management of intellectual capital* (pp. 211-238). Routledge.

Rustiadi, E., Saefulhakim, S., & Panuju, D. R. (2009). *Perencanaan dan Pengembangan Wilayah.* Yayasan Pustaka Obor Indonesia.

Schiavina, M., Melchiorri, M., Corbane, C., Freire, S., & Batista e Silva, F. (2022). Built-up Areas are Expanding Faster than Population Growth: Regional Patterns and Trajectories in Europe. *Journal of Land Use Science, 17*(1), 591–608. https://doi.org/10.1080/1747423X.2022.2055184

Sheppard, E. (2017). Economic Theory and Underdeveloped Regions. *Regional Studies, 51*(6), 972–973. https://doi.org/10.1080/00343404.2017.1278973

Syahfitri, S., Deasy, D., Sugarda, A., & Aprilia, R. (2025). Penggunaan Model Aritmatik dan Geometrik dalam Laju Pertumbuhan Penduduk di Kota Medan pada Tahun 2029. *AKSIOMA: Jurnal Sains Ekonomi dan Edukasi, 2*(1), 180–189. https://doi.org/10.62335/2xnt8c71

Tilahun, G. A., Gebremariam, E., & Desta, H. (2025). Analysis of Land Use Land Cover Changes and Population Dynamics in Awash River Basin (ARB), Ethiopia using GIS and Remote Sensing. *Scientific Reports, 15*(1), 34017. https://doi.org/10.1038/s41598-025-12824-8

United Nations. (2014). *World Urbanization Prospects: The 2014 revision, highlights*. United Nations. http://esa.un.org/unpd/wup/highlights/wup2014-highlights.pdf

Verburg, P. H., Crossman, N., Ellis, E. C., Heinimann, A., Hostert, P., Mertz, O., Nagendra, H., Sikor, T., Erb, K.-H., Golubiewski, N., Grau, R., Grove, M., Konaté, S., Meyfroidt, P., Moran, E. F., Parker, D. C., Chowdhury, R. R., Reenberg, A., Rocha, S., Mayaux, P., Cooke, S., Peterseil, J., & Zhen, L. (2015). Land system science and sustainable development of the earth system: A global land project perspective. Anthropocene, 12, 29-41. https://doi.org/10.1016/j.ancene.2015.09.004

von Böventer, E. (1975). Regional Growth Theory. *Urban Studies, 12*(1), 1-29.

https://doi.org/10.1080/00420987520080011

Yudhistira, M. H., Brodjonegoro, B. P. S., & Qibthiyyah, R. M. (2024). Unlocking Urban Potential. *Bulletin of Indonesian Economic Studies, 60*(2), 129–159. https://doi.org/10.1080/00074918.2024.2389492