



Land use management based on movement patterns

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ABSTRACT

Background: Spatial Plan Regulation in Bantaeng Regency for 2012 -2032, Bantaeng Subdistrict is designated as a Local Service Center /*Pusat Kegiatan Lokal* (PKL), which results in a high density of activities. This is marked by the presence of government centers, commerce and services, health facilities, education, worship places, and public spaces. The interaction of traffic movements using transportation generates movement patterns that lead to congestion, delays, noise, and air pollution. **Methods:** This study in Bantaeng Subdistrict used quantitative and qualitative methods with 300 respondents. Population movement was analyzed using the Origin-Destination Matrix, while spatial analysis mapped traffic patterns with ArcGIS and Google Earth, producing daily desire line maps for land use and movement evaluation. **Findings:** The results of the study show that the highest movement pattern originates from residential areas towards commercial and service areas. The movement classification is categorized as follows: >14 as low movement lines, 15-27 as moderate movement lines, and 28-43 as high movement lines. Efforts to minimize transportation system issues are included in land-use management directives, which are expected to benefit both the government and the community in planning development strategies. **Conclusion:** The land-use management directives for Bantaeng Subdistrict include the preparation of public transportation routes that can connect local service centers with transit terminal points in the city center. This can be supported by accelerating the terminal development plan in Letta Village. Additionally, policies to strengthen the support capacity of local service centers as alternative travel destinations to the city center are recommended, with Lembang Village being designated as a religious center. **Novelty/Originality of this article:** The movement patterns are based on land use in Bantaeng Subdistrict, emphasizing land-use changes due to the movement patterns that occur, which are represented using the latest method, the Origin-Destination (OD) Matrix.

KEYWORDS: land use; movement patterns; origin-destination matrix (OD matrix); land use management.

1. Introduction

The development of a city and increasing population growth have brought significant changes in various systems of community activities within urban areas. This is influenced by the growing movement of the population towards socio-economic activities. The rapid changes have created increasingly complex impacts in the field of transportation, particularly on transportation facilities and infrastructure. This is because transportation plays a crucial role in supporting and driving the dynamics of development, acting as a catalyst for economic growth and regional development (Mediansyah, 2017). One of the regions experiencing population growth and increased mobility levels each year is Bantaeng Subdistrict, Bantaeng Regency.

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Based on Regional Regulation Number 2 of 2012 concerning the Spatial Plan of Bantaeng Regency for 2012-2032, Bantaeng Subdistrict is designated as a Local Service Center. The implications of this designation on population movement in Bantaeng Subdistrict are evident in the increased land use activities. This condition is marked by the presence of government centers, commerce and services, health facilities, education, places of worship, and public spaces.

Land-use regulation plays an important role in shaping movement systems (Aditiana, 2014). The interaction between movements at activity centers generates traffic flow interactions and influences human movement to carry out activities. With increased concentration, the provision of public transportation must be improved and made more efficient, encouraging people to reduce the use of private vehicles and instead opt for public transportation, cycling, or walking (Kadarisman et al., 2016).

The transportation system is a crucial component in supporting various activities within a city (Pratama, 2012). Improving the public transportation system is certainly not an easy task, but it is not impossible (Wahyusetyawati, 2017). One of the efforts to address transportation issues is understanding the movement patterns occurring within the study area. Movement patterns in a transportation system are described in terms of the flow of movement (vehicles, passengers, and goods) from origin zones to destination zones within a specific area and during a certain period. These movement patterns can be represented using the Origin-Destination Matrix method.

The Origin-Destination Matrix (ODM) is a two-dimensional matrix that contains information about the volume of movement between locations (zones) within a specific area. When an ODM is applied to a transportation network system, it generates movement flows that illustrate the movement patterns within the region. ODM data can be obtained using both conventional and non-conventional methods (Tamin, 2008). A transportation system is expected to provide transport services with good accessibility, organized effectively and efficiently (Wenur et al., 2021).

This study aims to analyze the movement patterns occurring in Bantaeng Subdistrict by identifying land use in the area and examining the movement patterns between zones using the Origin-Destination Matrix (ODM) method within the framework of land-use management in Bantaeng Subdistrict.

2. Methods

2.1 Research method

This research was conducted in Bantaeng Subdistrict, Bantaeng Regency, encompassing five villages. The location was selected based on land use and the relatively high movement flow of the community. The study in Bantaeng Subdistrict employs both quantitative and qualitative research methods, utilizing numerical data and focusing on objective measurement of results, which are then analyzed statistically to explain the phenomena experienced by the population and to illustrate the traffic generation patterns within Bantaeng Subdistrict on maps (TB1 Population and Sample, n.d.). The research was conducted over two days, specifically on May 16, 2023, and May 18, 2023. The first day fell on a weekday, while the second day was a holiday, to observe the differences in community movement patterns.

The study in Bantaeng Subdistrict utilized both primary and secondary data types and sources. Primary data were obtained through the distribution of questionnaires to 300 respondents across five villages in Bantaeng Subdistrict, while secondary data included literature reviews and previous studies related to this research, such as the origin-destination matrix tables sourced from *Manual Kapasitas Jalan Indonesia*/Indonesian Highway Capacity Manual (MKJI), village boundary maps obtained from Bantaeng in Figures, and the positioning of Bantaeng Subdistrict within the neighborhood unit RT/RW of Bantaeng Regency

2.2 Analysis method

2.2.1 Analysis of population movement

Land use is one of the primary determinants of movement and activity (Kumaat, 2013). Population movement analysis is utilized to understand the potential movement occurring in Bantaeng Subdistrict. This analysis is based on identifying the movements of individuals, referring to the respondents' (community) perspectives when faced with various alternative conditions. The analysis of population movement begins by examining the distribution of movement using the Origin-Destination Matrix (ODM) method, which is a two-dimensional matrix containing information about the volume of movement between locations (zones) within a specific area (Safitri, 2016). The structure of the Origin-Destination Matrix can be illustrated in Table 1.

Table 1. Origin-destination matrix

Origin/Destination	1	2	3		N	O _i
1	T ₁₁	T ₁₂	T ₁₃	.	T _{1N}	O ₁
2	T ₂₁	T ₂₂	T ₂₃	.	T _{2N}	O ₂
3	T ₃₁	T ₃₂	T ₃₃	.	T _{3N}	O ₃
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
N				.	TN _n	O _n
D _d	D ₁	D ₂	D ₃	.	D _n	T

Tamin (2000) in Yelsin (2014)

The symbols in the formula represent the movement from the origin zone i to the destination zone d (T_{id}) the total number of movements originating from the zone i (O_i) the total number of movements destined for the zone d (D_d) and the total number of movements in the matrix.

2.2.2 Spatial analysis

Spatial analysis is conducted after determining the traffic generation volume and the magnitude of traffic movement directed toward each zone. Subsequently, this analysis visualizes the traffic generation from the Origin-Destination Matrix (ODM) onto maps using ArcGIS version 10.8 and Google Earth Pro, resulting in daily traffic desire line maps. Thus, traffic generation patterns are obtained, where the lines indicate the trips associated with traffic movement. This analysis is utilized by the researcher to observe the distribution of traffic between zones in residential areas within Bantaeng Subdistrict.

3. Results and Discussion

3.1 Land use in Bantaeng District

Bantaeng Subdistrict serves as the capital of Bantaeng Regency, South Sulawesi, Indonesia. This study focuses on five urban villages within Bantaeng Subdistrict: Lamalaka, Lembang, Letta, Pallantikang, and Tappanjeng. The research area covers approximately 4.075 km² and is bounded by Karatuang Village and Mallilingi Village to the north, Lamalaka Village to the east, the Flores Sea to the south, and Bissappu Subdistrict to the west. The geographical location and boundaries of the research area are presented in Figure 1.

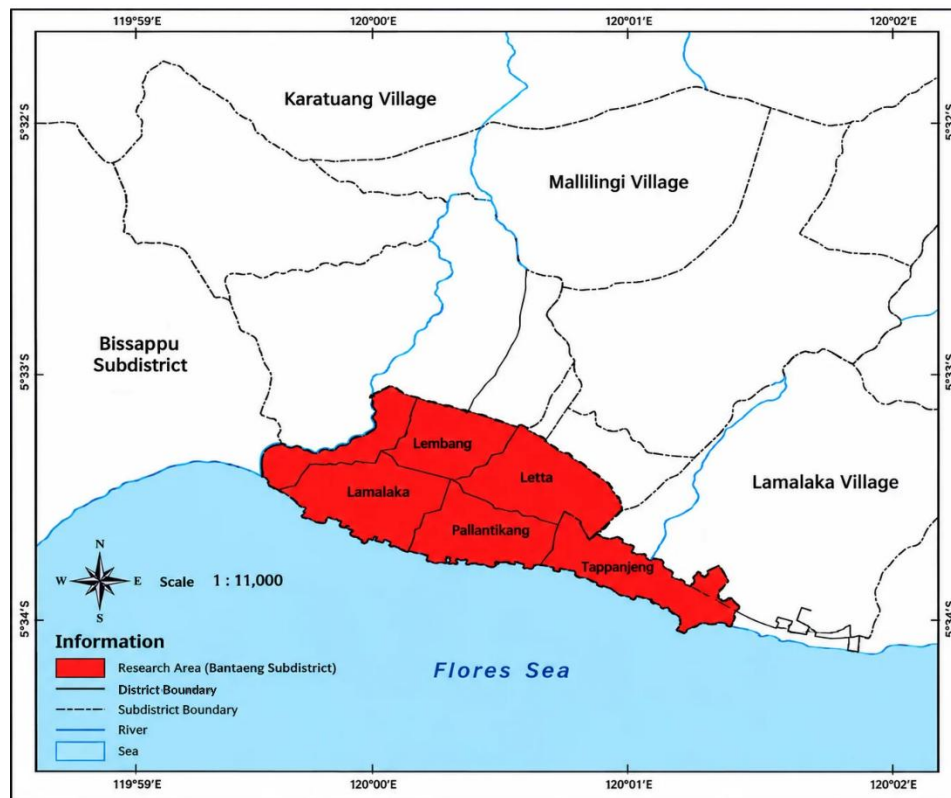


Fig. 1. Research orientation map

Land use in Bantaeng Subdistrict comprises education, residential, trade and services, and religious facilities, among other uses. The research area encompasses five urban villages: Lamalaka, Lembang, Letta, Pallantikang, and Tappanjeng, which are located along the southern coastal area of Bantaeng Regency. Its strategic location and diverse land-use patterns provide an important geographical context for examining the characteristics and dynamics of the study area.

Table 2. Land use in Bantaeng District

Type	Area (ha)	Percentage (100%)
Education	4.09	1.05
Commerce and services	4.08	1.05
Worship	0.45	0.12
Office	11.20	2.88
Residential	224.06	57.64
Green Open Space	12.95	3.33
Non-Green Open Space	0.76	0.20
Vacant Land	6.25	1.61
Health	3.10	0.80
Rice Fields	121.76	31.32

The table shows that land use in Bantaeng District is dominated by residential areas, which cover 224.06 hectares or 57.64% of the total area. This indicates that residential development is the district's primary land use. Rice fields are the second-largest land-use category, covering 121.76 hectares (31.32%) and reflecting the continued importance of agricultural land alongside residential development. Other land uses account for considerably smaller proportions, including green open space at 12.95 hectares (3.33%), office areas at 11.20 hectares (2.88%), vacant land at 6.25 hectares (1.61%), education facilities at 4.09 hectares (1.05%), commerce and services at 4.08 hectares (1.05%), health facilities at 3.10 hectares (0.80%), worship facilities at 0.45 hectares (0.12%), and non-green open space at 0.76 hectares (0.20%). Overall, the distribution indicates that land use in Bantaeng District is strongly concentrated in residential and agricultural functions, while

public facilities, commercial activities, and open spaces occupy relatively limited areas. The spatial distribution of these land-use categories is presented in the following land-use map of Bantaeng District.

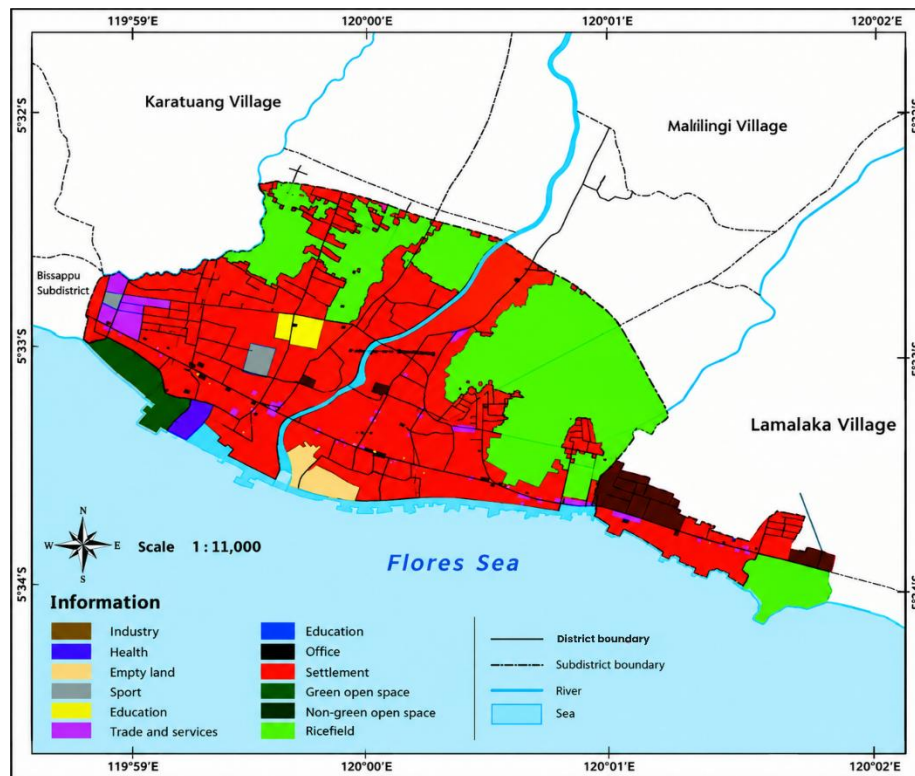


Fig. 2. Land use in Bantaeng District

3.2 Attractions and pulls of Bantaeng District

Trip generation and attraction are used to describe current movement patterns, which will be utilized to forecast future movement (Rahmadani, 2015). The trip generation and attraction in Bantaeng Subdistrict reflect the travel characteristics of respondents from the zones formed, resulting in diverse data such as respondents' origin addresses, occupation, age and gender, purpose and reason for travel, and the mode of travel used. Below is a summary of the trip-generation and attraction data gathered through questionnaires at seven community movement distribution points in Bantaeng Subdistrict.

Table 3. Age and gender

Age (year)	Amount (soul)	Gender	
		P	L
11_15	27	17	10
16-20	54	30	24
21-25	61	38	23
26-30	43	27	16
31-35	40	19	21
36-40	38	11	27
>40	37	19	18
Amount	300	161	139

In Table 3, the recap of age and gender reveals that the 21-25 age group has 61 respondents, the largest number, with 38 male respondents and 23 female respondents. Meanwhile, the 11-15 age group has 27 respondents, the smallest number, with 17 male respondents and 10 female respondents. After the recap of respondents by age group and gender, a further recap was conducted based on the respondents' occupations.

Table 4. Work

Work	Amount
Student/University Student	114
Civil Servant	35
Housewife	47
Merchant/Entrepreneur	40
And so on	64
Amount	300

Table 4 summarizes age and gender, showing that civil servants (PNS) account for 35 respondents, while students account for 114 respondents in completing the origin-destination matrix questionnaire. The other category includes occupations such as farmers, makeup artists, sailors, and construction workers. After summarizing respondents by gender, the next step was to summarize respondents by vehicle type.

Table 5. Types of vehicles

Type of Vehicle	Amount
Motorcycle	226
Car	52
Bicycle	10
Pickup truck	12
Amount	300

Table 5 above shows that motorbikes dominate, with 226 respondents, while bicycles have the fewest, with only 10 respondents. After recapping respondents by gender, we further summarized movements by origin and destination. The origins and destinations in Bantaeng Subdistrict were tabulated according to the movements of 300 respondents, with some respondents having more than one travel destination.

Table 6. Passenger origin and destination

Area	Amount	
	Origin	Goal
Residential	224	43
Health	53	72
Offices	40	47
Trade and services	59	163
Public spaces	44	110
Places of worship	64	45
Education	58	62
Amount	542	542

The commerce and service area is the highest-movement destination, with 163 respondents, while the residential area is the lowest-movement destination, also with 163 respondents.

3.3 Origin–destination matrix (OD matrix) of Bantaeng District

The Origin-Destination Matrix (ODM) analysis in Bantaeng Subdistrict examines the number and distribution of respondents' movements between different destination zones. The zone-based analysis provides information on traffic generation (O_i), traffic attraction (D_d), and the total number of trips (T) generated between zones. In this analysis, the destination zones are categorized according to their primary land-use functions, namely residential areas, worship facilities, educational facilities, commerce and services, offices, public spaces, and health facilities. For ease of interpretation, residential areas are represented by Zone A, worship facilities by Zone B, education by Zone C, commerce and services by Zone D, offices by Zone E, public spaces by Zone F, and health facilities by Zone

G The following section presents the Origin-Destination Matrix (ODM) for Bantaeng Subdistrict.

Table 7. Origin-destination matrix of Bantaeng District

Goal \ Origin	A	B	C	D	E	F	G	Total (O _i)
A		18	37	43	27	36	23	184
B	8		12	17	8	4	15	64
C	11	3		22	3	2	17	58
D	16	7	2		2	13	19	59
E	2	9	5	11		5	8	40
F	3	5	1	13	3		28	53
G	3	3	5	17	4	12		44
D _j	43	45	62	123	47	72	110	542

Based on the table above, it can be concluded from the seven movement nodes in the origin-destination matrix that the most dominant origin zone is the residential area, with a total of 184 origin points, while the lowest is in the office zone, with 40 origin points. This is then visualized in the Desire Line Mapping, which depicts respondents' journeys from origins to the seven destination zones.

Desire Line Mapping utilizes the Sturges Method approach. The Sturges Method contains a rule for determining how widely data should be selected in a bar graph on a histogram. This rule was published in the American Statistical Association (ASA) journal in 1926 (Sari et al., 2018). Sturges considered the number of data points in an interval as derived from the binomial coefficient and assumed that a well-distributed data set could be approximated by a binomial distribution with a probability of 0.5 (yielding a symmetric distribution). The rule is derived using binomial expansion identities and the properties of logarithms, resulting in Sturges' rule.

$$K = 1 + 3,322 (\log N) \quad (\text{Eq. 1})$$

The application of Sturges' rule begins by identifying the maximum and minimum values and determining the number of observations in the dataset. In this analysis, the maximum value is 43, while the minimum value is 1, with a total of 42 observations. The class range is therefore obtained by subtracting the minimum value from the maximum value, resulting in a range of 42. The number of class intervals is then calculated using Sturges' formula, $K = 1 + 3,322 (\log N)$, where (N) represents the number of observations. With 42 observations, the calculation produces approximately 6.36 class intervals, which is rounded to 6 intervals for practical classification. Based on the class range of 42 and the resulting number of intervals, the class width is calculated as approximately 7. Thus, the data can be grouped into class intervals with a width of 7 to facilitate the subsequent analysis and interpretation of the distribution of observations.

Table 8. Line classification

Movement	Classification of desire lines
> 14	Low
15-27	While
28-43	High

Table 8 presents the classification of desire-line movements into three categories: low, moderate, and high. The classification is based on the frequency of movements, with higher values indicating stronger movement intensity. The low category represents relatively limited movement, while the moderate category indicates an intermediate level of movement. The high category reflects the greatest movement intensity among the observations. This classification facilitates the identification of dominant movement

patterns and provides a basis for interpreting the spatial distribution of desire lines within the study area.

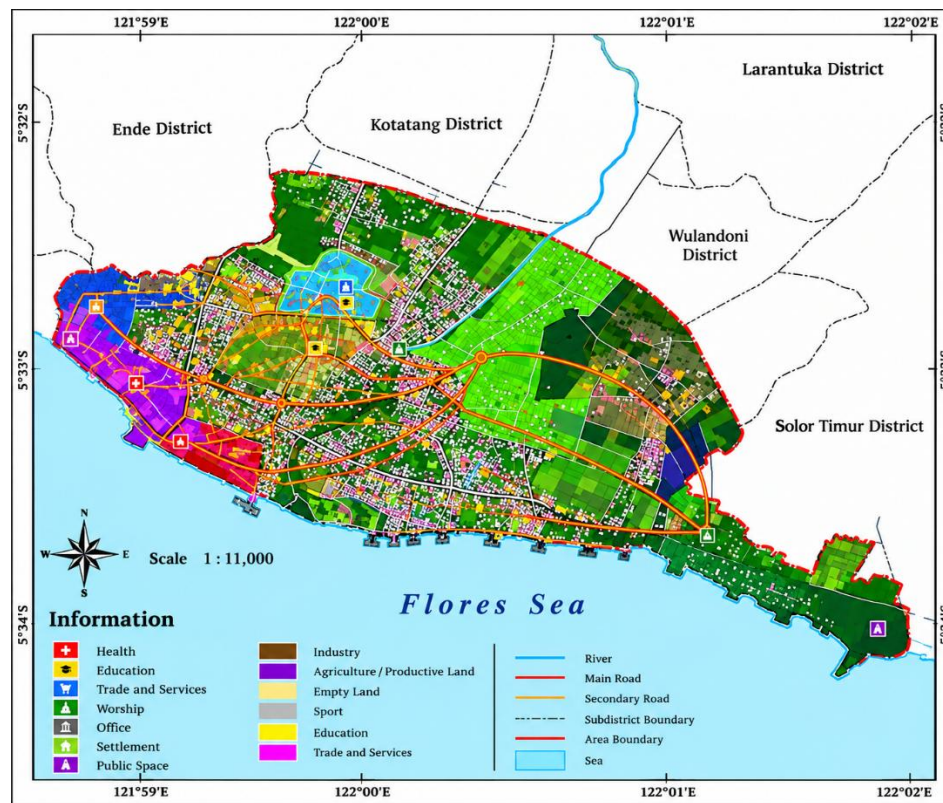


Fig. 3. Desire line map

3.4 Guidelines for land use management in Bantaeng District

The analysis of the spatial structure type in Bantaeng District, based on indicators of daily movement of the population, reveals a relatively high density in the built-up areas scattered throughout the study area. With the increasing activities and mobility of urban residents, there is a growing need for more space (Wiyono, 2012). The following considerations should be taken into account:

The dependence on private vehicle usage in the identified spatial structure can be mitigated through policies that prepare public transportation routes. The transportation system serves as a fundamental element of infrastructure that influences urban development patterns (Putra & Adeswastoto, 2018). This can be supported by expediting the planning and development of terminals in Letta Village. The establishment of planned terminals can accommodate the travel needs of the community, which tends to prefer public transportation modes. This shift is expected to positively impact traffic flow, thereby facilitating mobility and enhancing accessibility. Furthermore, it can potentially create job opportunities for the local population (Lansart, 2015).

In the spatial structure, policies for strengthening the support capacity of local service centers that can serve as alternative destinations beyond the city center need to be considered. Therefore, Lembang Village is directed to function as a center for religious activities. This is expected to reduce the proportion of trips from this peri-urban area to the city center. Additionally, to address issues related to road users in Lamalaka Village, the development of office areas is aimed at serving as a destination for public transport routes.

Considering the existing conditions, where there are trade and service areas in Tappajeng Village, they are directed towards commercial trading and service zones. Educational facilities in Bantaeng District are distributed across several locations, which may also influence the movement patterns of the community, particularly educators and

students. Therefore, the development of educational areas is directed toward Pallantikang Village, which is expected to accommodate the movement of students and educators.

Public facilities or green open spaces are locations favored by the community for engaging in sports activities. Furthermore, green open spaces play a vital role in maintaining environmental ecosystem balance in urban areas (Hidayah et al., 2021). Their provision is supported by Law Number 26 of 2007 on Spatial Planning, which mandates that every planning area unit must provide green open spaces/*Ruang Terbuka Hijau* (RTH) amounting to 30% of the total area, comprising 20% for public space and 10% for private space. Health facilities also require development around green open spaces, with the hope that visitors to health services can enjoy public or open spaces nearby. Thus, development is directed toward the coastal area of Tappajeng Village.

Areas with high road network density and residential density will result in more efficient mobility (Hermawan et al., 2009). Given the existing conditions, there is a need to develop residential or housing areas that are integrated with the presence of public and social facilities. This aims to ensure that movement patterns are effective and efficient. Based on this, the development of housing areas in the future is more appropriately designated for Mallilingi Village. Below is the map of land use management directions.

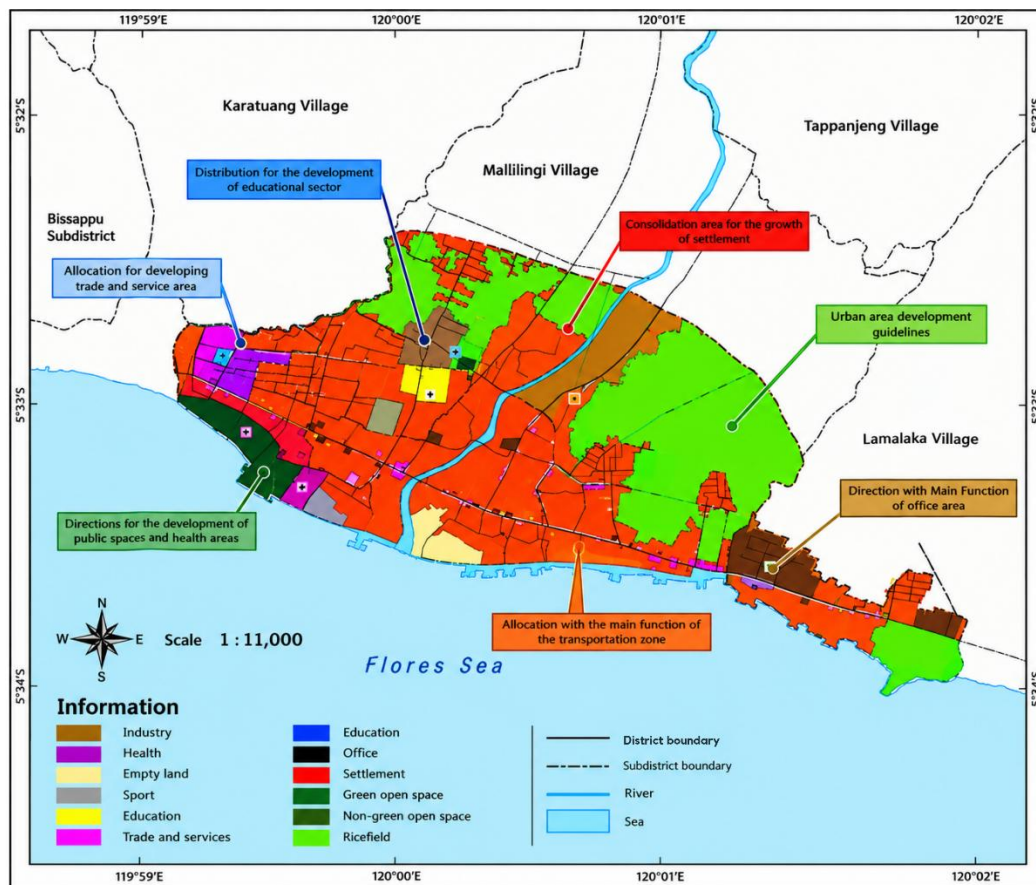


Fig. 4. Land use management direction map

4. Conclusion

The movement patterns in Bantaeng District consist of three classifications: > 14 as low movement lines, 15-27 as moderate movement lines, and 28-43 as high movement lines, with movement along line 43 representing trade and service destinations. To improve traffic conditions in Bantaeng District, land use management is directed towards minimizing the impacts caused by dense movement flows.

The land use management direction for Bantaeng District includes the preparation of public transport routes that can connect local service centers with transit terminal points

in the city center. This can be supported by expediting the planning and development of terminals in Letta Village. Policies for strengthening the support capacity of local service centers can serve as alternative destinations besides the city center, with Lembang Village designated as a center for religious activities. Tappajeng Village is directed toward commercial trading and service areas, while the development of educational zones is aimed at Pallantikang Village, and the development of public and health areas is directed toward the coastal region of Tappajeng Village, in accordance with existing conditions.

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Author Contribution

Conceptualization, H.H.S.; Methodology, H.H.S., N.W.; Investigation, N.W., S.Q., A.R.F.A.; Data Curation, S.Q., A.R.F.A.; Writing – Original Draft Preparation, N.W.

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Declaration of Generative AI Use

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