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Analysis of the Carrying Capacity and Land Capacity for Residential Areas in the Southern Part of Medan City

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Abstract*. The increasing population triggers a demand for land for housing and other activities. Along with this, issues arise regarding the limited availability of land, especially in rapidly developed areas. This limitation has the potential to create an imbalance between the growing need for space and the existing land capacity. This study evaluates the land carrying capacity in four sub-districts in the southern part of Medan City, namely Medan Tuntungan, Medan Johor, Medan Amplas, and Medan Denai, in dealing with the continuously growing population. Using a spatial analysis approach with ArcGIS 10.8 software and detailed spatial data, this research identifies potential areas for residential development and projects the capacity of land to accommodate future populations. The analysis covers physical and environmental aspects such as land slope, soil type, natural disaster risks, and access to public facilities. The results show that each sub-district has different potentials and challenges. Medan Tuntungan, with its large area and flat land conditions, shows significant potential for residential development, although attention must be given to the existence of protected areas and agricultural land that must be preserved. Medan Johor, as an economic center, faces substantial pressure on land use, with some areas nearing their maximum capacity. Medan Amplas and Medan Denai, which are more urban, experience stricter land limitations. Population growth projections indicate a significant increase in land demand in some sub-districts in the coming decades. Without effective management, this has the potential to exert high pressure on the environment and urban infrastructure. This research emphasizes the importance of spatial planning and sustainable development policies to maintain a balance between housing needs and environmental conservation.*

Keywords*: Carrying Capacity, Land Capacity, Medan City, Residential Area.*

1. INTRODUCTION

Medan City, as the capital of North Sumatra Province, faces rapid population growth each year. This population increase continues over time, creating a significant demand for housing and various regional service facilities. As the population grows, the demand for land in Medan City also increases, prompting changes in land use. The conversion of non-built-up land into built-up areas has become an inevitable trend due to the urgent need for space for housing, offices, and other activities.

According to data from the Central Statistics Agency (BPS) of Medan City, the population in 2013 was recorded at 2,135,516 people, which then increased to 2,474,166 people in 2023. This figure reflects an increase of 13.69% over the past ten years, equivalent to 338,650 people. On average, Medan's population increases by approximately 33,865 people annually. This growth has led to an increase in the demand (demand) for residential

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land, while the availability (supply) of land in Medan City is increasingly limited and challenging to expand.

With a population growth rate of 13.69% over ten years, Medan City continues to require new land for future residential development, but the supply of land is limited. This population growth also creates significant pressure on land resources, infrastructure, and the environment (Aris and Nuraini, 2024; Aris et al, 2024). The high utilization of land for development needs impacts environmental quality decline, particularly due to unbalanced management between the required and available land.

The southern area of Medan City is one of the regions experiencing rapid growth. Based on the Mayor of Medan's Decree No. 146/17.K of 2023 regarding the Delineation of Planning Areas in the Preparation of the Detailed Spatial Plan for Medan City for 2023-2024, this area includes four sub-districts: Medan Tuntungan, Medan Johor, Medan Amplas, and Medan Denai, which have developed considerably in recent years. Growth in this area is influenced by several factors, such as population growth, land availability and prices, and economic dynamics dominated by trade and services. The increase in settlements has led to more limited land availability in the area.

This research focuses on evaluating the carrying capacity and capacity of residential land in the southern region of Medan City to meet land needs due to population growth over the next 30 years. The findings of this study are expected to serve as a guideline in evaluating the Regional Spatial Plan (RTRW) and effective land use to create safe, comfortable, and productive regional spaces for both natural and built environments.

2. THEORETICAL BASIS

Land

Land includes the physical and biotic environment that serves as a support system for human life and well-being. Land as a physical environment encompasses elements of climate, topography, hydrology, and vegetation that can affect the ability of land to be utilized (Permata Sari et al., 2021; Nuraini et al, 2018; Harmoko et al, 2024b). Additionally, land comprises the Earth's surface made of solid, liquid, and even gaseous substances. According to the Food and Agriculture Organization (FAO), land is the physical environment, including climate, relief, soil, water, vegetation, and other elements impacting its use. It also includes the results of past and present human activities, such as coastal reclamation and vegetation clearing, which have the potential to bring positive or negative environmental impacts.

Land Carrying Capacity

Land carrying capacity is a critical aspect in meeting housing needs, especially for low-income communities (MBR). Urban land limitations often hinder access to adequate housing and may reduce the land's ability to support life (Syarif, 2011). In land suitability analysis, the physical characteristics of the soil as a medium for plant root growth are highly considered. Based on Technical Guidelines (Permen PU No. 20/PRT/M/2007), land carrying capacity is evaluated through overlay methods, weighting, and scoring of various relevant maps, such as climatology, topography, geology, and hydrology maps. The results of the land carrying capacity analysis provide an overall picture of land suitability for various purposes, including housing.

Land Capacity

Land capacity refers to the environmental ability to accommodate activities that utilize natural resources in a specific area. This capacity acts as a measure of how well an ecosystem can support space use without causing environmental degradation. Land capacity also considers how human activities can take place sustainably without exceeding the natural carrying capacity.

Land Use

Land use reflects the level of human civilization in utilizing available resources. Land use is defined as human intervention on land to meet life's needs, both material and spiritual (Lindarti, 2023). It encompasses all human activities utilizing land resources, including agriculture, recreation, and housing (Lindgren, 1985, in Susanto, 2023). Land use involves how humans utilize land for specific purposes, whether for economic, social, or ecological activities (Permata Sari et al., 2021).

Land Capability Units (LCU)

The Technical Guidelines for Physical, Economic, and Socio-Cultural Analysis in Spatial Plan Preparation, as stipulated in Minister of Public Works Regulation No. 20/PRT/2007, explain that Land Capability Units (LCU) are key parameters in assessing the ability of land to support various uses. The various LCU types analyzed include morphology, workability, slope stability, foundation stability, water availability, drainage, erosion resistance, waste disposal, and disaster susceptibility.

Settlement

A settlement is part of a residential environment that includes more than one housing unit, equipped with infrastructure, facilities, utilities, and supporting functions, both in urban and rural areas (Law No. 1 of 2011 on Housing and Settlement Areas). A settlement area is a residential location that encompasses more than just houses or housing complexes (Rachmah et al., 2018). Settlements can also be defined as part of the living or residential environment serving as a dwelling place, whether urban or rural (Stevani et al., 2023).

In this context, land carrying capacity plays a vital role in determining how far a settlement can develop and support its elements. Land carrying capacity refers to a region's ability to support human activities without degrading environmental quality and available natural resources. Therefore, the development of settlement areas must consider the capacity of available land, including space, water availability, sanitation, and other supporting infrastructure.

The formation of settlement environments in a region always has unique characteristics, reflecting the character of its inhabitants. Along with changes in norms, cultural roles, and behavior, community characteristics may also shift due to modernization and environmental characteristics (Nuraini, C., 2019). For instance, modernization in rural areas often leads to physical changes that increase land demand without considering adequate carrying capacity. This can reduce environmental quality and increase pressure on natural resources.

The above explanation highlights that understanding land, carrying capacity, capacity, and land use is crucial in planning sustainable settlement development. In this study, it is essential to understand how the characteristics of land in the area, including its carrying and capacity, can influence settlement development. By considering various factors such as infrastructure, facilities, and changes due to modernization, this research aims to provide an overview of how far the southern part of Medan City can support the sustainability of existing settlements and identify potential problems arising from mismatches between land use and carrying capacity. This is crucial to ensure settlement development in the area proceeds sustainably, not only meeting current housing needs but also preserving environmental quality and societal well-being in the future.

3. RESEARCH METHOD(S)

Research Approach

This research employs a quantitative approach, explaining and presenting results in numerical or nominal values. The results are clearly described with the support of images, tables, or graphs. The presented quantitative data includes population numbers, land area,

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and the extent of land capable of supporting and accommodating residential needs in the southern region of Medan City.

The quantitative descriptive method aims to describe numerical data by explaining the research results in detail using figures representing the characteristics of the research subject (I Kadek Fajar Arcana, et al., 2021; Nuraini et al, 2023a; Pohan et al, 2024; Permana et al, 2023). The data is then presented in tables, diagrams, or graphs to facilitate understanding (Nuraini, 2024; Nuraini et al, 2023b; Nuraini et al, 2024. This research begins with an analysis of the carrying and capacity of each sub-district separately, which is then combined and averaged to obtain the carrying and capacity results of the entire southern region of Medan City.

Research Time and Location

This research began in 2024, with population and residential land carrying and capacity projections planned for the next 30 years. The research location was conducted in the southern part of Medan City, consisting of Medan Tuntungan sub-district with an area of 2,519.64 ha, Medan Johor with an area of 1,662.55 ha, Medan Amplas with an area of 1,071.69 ha, and Medan Denai with an area of 935.38 ha (Figure 1).

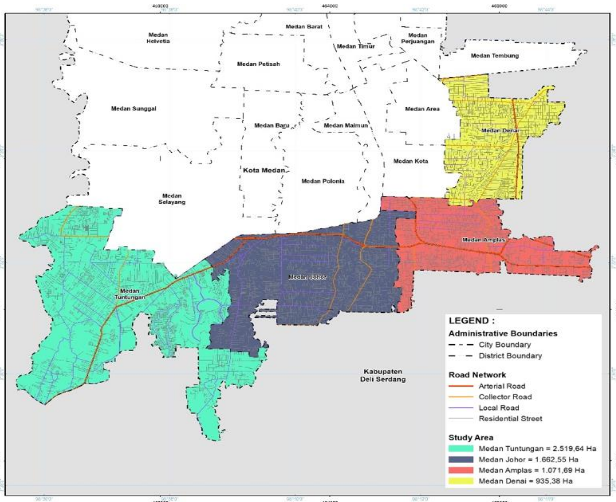

Figure 1. Research Location Map

Source: Medan City Spatial Planning Document (RTRW)

Data Collection Method

Data collection in this research was conducted using both primary and secondary methods. Generally, secondary data collection was carried out through literature studies from various government institutions such as the Medan City Statistics Agency (BPS) and the Department of Housing, Settlement Areas, Public Works, and Spatial Planning (PKPCKTR) of Medan City. Primary data, on the other hand, was obtained through field ground checks on the existing conditions of the study area, especially concerning existing land use.

Data Analysis Method

Data analysis was performed after the primary and secondary data collection. The analysis process involved several stages. The first stage was population analysis, which included projecting population growth for the next 30 years. Then, a land carrying capacity analysis was conducted using the Multi-Criteria Analysis (MCA) method, which involves map overlay techniques, weighting, and scoring with GIS applications. The detailed explanation of these processes is as follows:

a. Population Growth Analysis

The arithmetic method was applied for population projection analysis, assuming that the population increases annually. The formula for population projection using the arithmetic method is as follows:

$Pt = Po \times (1+r)^t$ where $r = \frac{1}{t}\left(\frac{Pt}{Po} - 1\right)$

Explanation:

Pt = Population in year t

Po = Initial population in the base year

r = Population growth rate

t = Time period between the base year and year t

b. Land Carrying Capacity Analysis for Settlements

The land carrying capacity analysis for settlements used the Multi-Criteria Analysis (MCA) method by overlaying physical variables as the basis for weighting and scoring. The variables used are listed in Table 1.

Table 1. Variables for Land Carrying Capacity Analysis

No	Variabel
1	Slope Gradient
2	Flood-Prone Areas (FPA)
3	Agricultural Land Base
4	Land Capability Units
5	Land Use
6	Spatial Planning Patterns

Source: Ministry of ATR/BPN and Bappenas, 2020

Each map of these variables was then classified according to the suitability level as settlement areas. These classifications are detailed in Table 2.

Table 2. Variable Classification

Criterion	Code	Classification
Slope Gradient	KL-1	0-15%
	KL-2	15-25%
	KL-3	25-40%
	KL-4	>40%
Flood-Prone Areas (FPA)	B-1	Not in FPA; Low flood hazard risk
	B-2	Moderate flood hazard risk
	B-3	High flood hazard risk
Agricultural Land Base	LP-1	Not in Agricultural Land Base / LP2B
	LP-4	Within Agricultural Land Base / LP2B
Land Capability Units	SKL-1	High & Very High Capability
	SKL-2	Medium Capability
	SKL-3	Low Capability
	SKL-4	Very Low Capability
Spatial Planning Patterns	PR-4	Protected Zones
Land Use	PL-1	Residential Buildings, Grasslands, Yards, Plantations, Shrubs, Vacant Land, Mixed Crops, Dry Fields/Fields
	PL-2	City Forest, Commercial and Service Buildings, Swamps, Rice Fields, Lakes
	PL-3	Industrial Buildings, Health Buildings, Sports Buildings, Tourism and Entertainment Buildings, Educational Buildings, Religious Buildings, Office Buildings, Social Buildings, Transportation Buildings
	PL-4	Roads, Green Belts, Cemeteries, Road Medians, Sports Fields, Water Reservoirs, Paved Surfaces/Fields, Water Channels, Rivers, Parks

Source: Ministry of ATR/BPN and Bappenas, 2020

Different variables were combined using the overlay method. The combined results were reclassified into zones and typologies, as follows:

a. ZPK 1: Suitable Land (Priority Development Zone for Settlements)

b. ZPK 2: Moderately Suitable Land (Conditional Development Zone for Settlements)

c. ZPK 3: Less Suitable Land (Limited Development Zone for Settlements)

d. ZPK 4: Unsuitable Land (Protected and Buffer Zones).

The classification is presented in Table 3.

Table 3. Settlement Development Zones and Typologies

Zone and Typology	Definition Criteria	
ZPK 1: Suitable Land (Priority Zone for Residential Development)	KL-1	Slope Gradient 0-15%
	B-1	Not in FPA; Low flood hazard risk
	LP-1	Not in Agricultural Land Base / LP2B
	SKL-1	High & Very High Capability
	PL-1	Residential Buildings, Grasslands, Yards, Plantations, Shrubs, Vacant Land, Mixed Crops, Dry Fields/Fields
ZPK 2: Sufficiently Suitable Land (Conditional Residential Development Zone)	KL-2	Slope Gradient 15-25%
	B-2	Moderate flood hazard risk
	SKL-2	Medium Capability
	PL-2	City Forest, Commercial and Service Buildings, Swamps, Rice Fields, Lakes
ZPK 3: Less Suitable Land (Limited Residential Development Zone)	KL-3	Slope Gradient 25-40%
	B-3	High flood hazard risk
	SKL-3	Low Capability
	PL-3	Industrial Buildings, Health Buildings, Sports Buildings, Tourism and Entertainment Buildings, Educational Buildings, Religious Buildings, Office Buildings, Social Buildings, Transportation Buildings
ZPK 4: Unsuitable Land (Protected and Buffer Zone for Residential Development)	KL-4	Slope Gradient >40%
	LP-4	Within Agricultural Land Base / LP2B
	SKL-4	Very Low Capability
	PL-4	Roads, Green Belts, Cemeteries, Road Medians, Sports Fields, Water Reservoirs, Paved Surfaces/Fields, Water Channels, Rivers, Parks
	PR-4	Protected Zone

Source: Ministry of ATR/BPN and Bappenas, 2020

The classification results will be divided into two categories, namely 'Go Area' and 'No Go Area'. The 'Go Area' category includes ZPK 1, which is identified as a potential area, and ZPK 2, which is an area with constraints that can be considered a Conditional Development Zone. Meanwhile, the 'No Go Area' category includes ZPK 3 and ZPK 4, which are classified as areas with significant limitations. Areas in this category have a low level of land suitability and are considered unsuitable for residential development based on physical and ecological parameters.

The land suitability levels for settlement development are obtained through the overlay process, as illustrated in Figure 2.

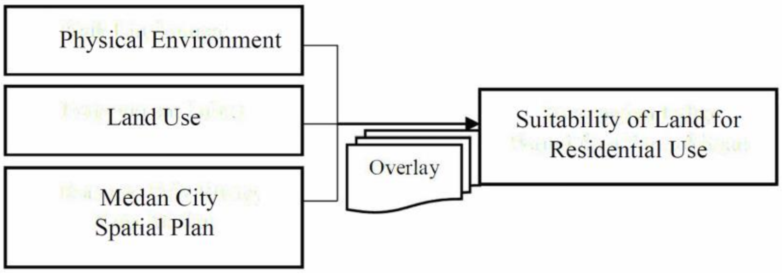

Figure 2. Land Suitability Analysis Diagram

The overlay process was conducted using ArcGIS software utilizing the union function. Subsequently, filtering was applied to each variable with the lowest value, namely ZPK 4, which was then classified as a No Go Area. After categorizing variables with a ZPK 4 value, the same process was applied to variables with a ZPK 3 value, also classified as No Go Areas. This process continued for variables with ZPK 2 and ZPK 1 values, which were classified as Go Areas.

c. Land Carrying Capacity for Residential Areas

Population growth in each region is closely related to the land carrying capacity and the number of people that can be accommodated by the available land area. Therefore, the results of the land carrying capacity analysis and population projections are used to analyze areas that can still be developed for residential zones and areas that cannot. The potential land area for housing utilization is assumed to be 60%, with the remaining 40% allocated for Infrastructure, Facilities, and Utilities (PSU) (Lutfi Muta'ali, 2014). The carrying capacity of the land for housing is calculated through the following steps:

1) Calculating the developable land area using the formula:

Lpm = Lwp x 60%

Explanation:

Lpm : Developable land area

Lwp : Potential land area

60% : Land coverage ratio

Source: Lutfi Muta'ali, 2014

2) Calculating the housing carrying capacity using the formula:

$$\mathbf{DDpm} = \frac{\mathbf{Lpm/Jp}}{\boldsymbol{a}}$$

Explanation:

DDpm : Housing Carrying Capacity

Lpm : Developable land area

Jp : Population

a : Coefficient

Source: Lutfi Muta'ali, 2014

The coefficient values can be found in Table 4 below:

Table 4. Coefficient of Space Requirement per Capita

No	Geographic Zone	Space Requirement (ha/capita)
1	Rural Zone	0.0133
2	Suburban Zone	0.0080
3	Urban Zone	0.0026
4	City Center Zone	0.0016
5	Metropolitan City Center	0.0006

Source: Ministry of Public Works Regulation No. 11/PERMEN/M/2008

Calculation results will produce values interpreted as follows:

DDPm Value > 1 ➔ High residential carrying capacity, still capable of accommodating the population.

DDPm Value = 1 ➔ Optimal residential carrying capacity.

DDPm Value < 1 ➔ Low residential carrying capacity, unable to accommodate the population.

3) Calculating the number of people that can be accommodated using the formula:

DT = DDpm x Jp

Explanation:

DT : Land Capacity

DDpm : Housing Carrying Capacity

Jp : Population

Source: Lutfi Muta'ali, 2014

4. FINDINGS AND DUSCUSSION

Study Area Condition

The southern region of Medan City has a total area of 6,189.26 ha, or 21.6% of the total area of Medan City. The area of each subdistrict is shown in Table 5.

Table 5. Area of Southern Medan City

Subdistrict	Area (ha)
Medan Tuntungan	2,519.64
Medan Johor	1,662.55
Medan Amplas	1,071.69

Medan Denai	935.38
Total	**6,189.26**

Source: Medan City Administration

The population of the southern region of Medan City in 2013 was 468,973, increasing to 558,666 in 2023. Detailed population data for each subdistrict is shown in Table 6.

Table 6. Population of Southern Medan City

Subdistrict	Area (ha)	Population 2013 (People)	Population 2023 (People)	Density (People/ha)	Growth Rate
Medan Tuntungan	2.519,64	82.534	100.132	39,74	0,02
Medan Johor	1.662,55	126.667	154.868	93,15	0,02
Medan Amplas	1.071,69	116.922	131.770	122,96	0,01
Medan Denai	935,38	142.850	171.896	183,77	0,02
Total	**6.189,26**	**468.973**	**558.666**		

Source: Medan City Statistics Agency 2024

Most areas in the southern region of Medan City have a slope of 0–8%. Nearly all subdistricts in this region exhibit similar slopes. Based on land carrying capacity criteria for housing, this slope is categorized as flat to gently sloping, suitable for residential development. The southern region of Medan City is also situated at an elevation of 15–60 meters above sea level. The area's geological composition includes the Medan Formation, Toba Tuff, Sibayak Center, and Alluvium.

Population Projection

Population analysis, such as population projection, involves scientific calculations utilizing specific components, including population growth rates. This projection aims to estimate future population figures, which are vital for long-term planning. The data enables governments and urban planners to determine the extent to which available land can accommodate the population as residential areas.

For Medan City, population projections play a significant role in city planning and resource management. Through these projections, infrastructure, public facility needs, and policies required to support population growth can be predicted. Detailed population projection data for Southern Medan City is presented in Table 7.

Table 7. Population Projection for the Southern Region of Medan City

Subdistrict	Population 2023	Population Projection		
		2.033	**2.043**	**2054**
Medan Tuntungan	100,132	123,652	152,696	192,583

Medan Johor	154,868	193,015	240,559	306,489
Medan Amplas	131,770	149,493	169,600	194,854
Medan Denai	171,896	210,226	257,102	320,825
Total	**558,666**	**676,386**	**819,957**	**1,014,751**

Source: Population Analysis 2024

From 2023 to 2033, the population of the southern region of Medan City is projected to increase by 117,720 people and by 261,291 people from 2023 to 2043. Population density is calculated by dividing the total population by the area. Data on population density for the southern region of Medan City is presented in Table 8.

Table 8. Population Density in the Southern Region of Medan City

Subdistrict	Area (ha)	Population 2033 (People)	Density 2033 (People/Ha)	Population 2043 (People)	Density 2043 (People/Ha)	Classification
Medan Tuntungan	2,519.64	123,652	49	152,696	61	Low
Medan Johor	1,662.55	193,015	116	240,559	145	Low
Medan Amplas	1,071.69	149,493	139	169,600	158	Medium
Medan Denai	935.38	210,226	225	257,102	275	High
Kota Medan Bagian Selatan	**6,189.26**	**676,386**	**109**	**819,957**	**132**	**Low**

Source: Population Analysis 2024

Population density in the southern region of Medan City is generally classified as low, based on the classification outlined in the Indonesian National Standard Number 03-1733-2004 regarding Housing Environment Planning Guidelines, as shown in Table 9.

Table 9. Population Density Classification

Classification	Population Density
Low	< 150 people/ha
Medium	151 – 200 people/ha
High	201 – 400 people/ha
Very High	> 400 people/ha

Source: SNI 03-1733-2004

Based on this classification, Medan Denai is projected to become a high-density subdistrict due to the limited availability of undeveloped land. Conversely, Medan Tuntungan is projected to remain the least dense subdistrict, attributable to its large area and relatively low proportion of developed land.

Land Carrying Capacity and Housing Land Capacity

Analysis of land carrying capacity begins with the collection of key variables relevant to ensuring the validity of the analysis. These variables include physical and environmental aspects such as slope gradients, disaster-prone areas, and existing land use. The processed data results in maps of areas with development potential. The next step involves a quantitative analysis to determine the carrying capacity and housing land capacity, including projections for how long the land can accommodate the continuously growing population.

Supporting Variables

Land use is one of the primary variables in the analysis of land carrying capacity in the southern region of Medan City. Land use data is necessary to identify built-up and undeveloped land and its designated purposes. Built-up land refers to areas utilized and constructed for various needs, such as housing, offices, industry, tourism facilities, and others. Undeveloped land includes areas either unused or utilized but not yet built upon, such as green open spaces (RTH), agricultural land, plantations, and sports facilities or fields. Information regarding land use types in the southern region of Medan City is presented in Table 10.

Table 10. Land Use in the Southern Region of Medan City

Category	Type	Area (ha)
Undeveloped	Green Belt	4.16
Undeveloped	Sports Fields	29.74
Undeveloped	Cemeteries	31.86
Undeveloped	Road Medians	14.34
Undeveloped	Grass Fields	46.77
Undeveloped	Paved Surfaces/Fields	44.85
Undeveloped	Shrubland	211.72
Undeveloped	Parks	9.54
Undeveloped	Vacant Land	129.33
Undeveloped	Mixed Crops	453.61
Undeveloped	Urban Forests	38.46
Undeveloped	Plantations	145.29
Undeveloped	Rice Fields	102.69
Undeveloped	Dry Fields/Farms	652.16
Undeveloped	Ponds	42.26
Undeveloped	Swamps	1.39
Undeveloped	Lakes	20.68
Undeveloped	Water Channels	5.59
Undeveloped	Rivers	48.86
Total Undeveloped Area		**2033.31**
Built-up	Industrial Buildings	17.86
Built-up	Healthcare Buildings	5.32
Built-up	Sports Buildings	0.73
Built-up	Tourism and Entertainment Buildings	7.92
Built-up	Water Storage Buildings	0.06

Category	Type	Area (ha)
Built-up	Educational Buildings	25.01
Built-up	Commercial Buildings	101.27
Built-up	Religious Buildings	16.73
Built-up	Office Buildings	7.53
Built-up	Residential Buildings	1796.91
Built-up	Defence and Security Buildings	0.85
Built-up	Social Buildings	2.26
Built-up	Transportation Buildings	1.06
Built-up	Building Yards	1791.83
Built-up	Roads	380.59
Total Built-up Area		**4155.95**
Grand Total		**6189.26**

Source: PKPCKTR Office, Medan City, 2024

Based on Table 10 regarding land use types in the southern region of Medan City, the dominant built-up land type is residential buildings, covering 1,796.91 ha or approximately 43.24% of the total built-up land. Meanwhile, the largest undeveloped land type is used for agriculture in the form of dry fields/farms, covering 652.16 ha or approximately 32.07% of the total area in the southern region of Medan City. A land use map is provided in Figure 3.

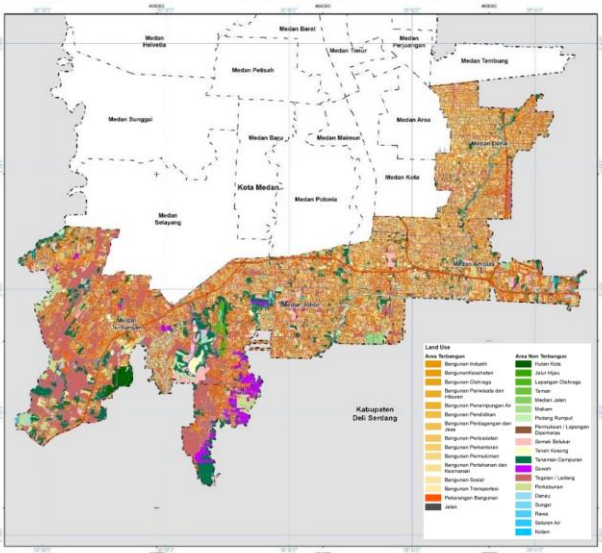

Figure 3. Land Use in the Southern Part of Medan City

Another variable in land carrying capacity analysis is Land Capability. The Land Capability Unit (LCU) analysis was conducted following the guidelines in Ministry of Public Works Regulation No. 30 of 2007 concerning Technical Guidelines for Physical, Environmental, Economic, and Socio-Cultural Analysis, utilizing the overlay technique to determine land carrying capacity and development limitations. This analysis includes Morphological LCU Analysis, Feasibility LCU Analysis, Slope Stability LCU Analysis, Foundation Stability LCU Analysis, Water Availability LCU Analysis, Drainage LCU Analysis, Erosion LCU Analysis, Waste Disposal LCU Analysis, and Natural Disaster LCU Analysis. The results of the SKL analysis can be seen in Figure 4.

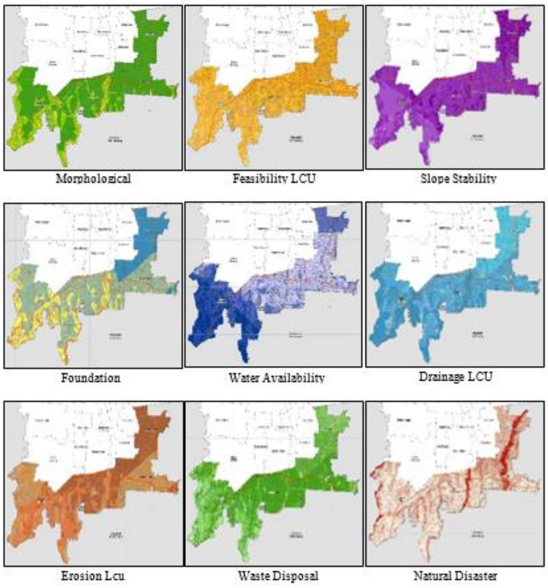

Figure 4. SKL Analysis Map

Source: Analysis Results, 2024

After determining the class of each LCU, all nine LCUs were overlaid and scored based on the weighting system set out in the guidelines. The final map generated is the Land Capability Map, shown in Figure 5.

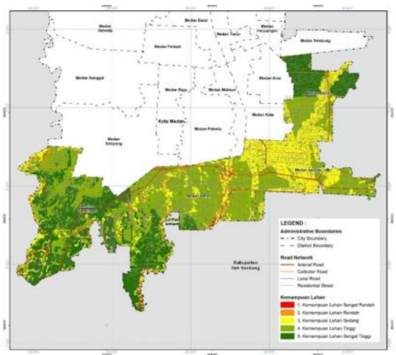

Figure 5. Land Capability Map

Source: Analysis Results, 2024

Several other variables integrated into the land carrying capacity analysis include slope gradients, flood-prone areas (FPA), rice field baselines, and spatial planning patterns. These variables aim to provide a comprehensive evaluation of land feasibility for sustainable development and spatial utilization. These variables are visually represented in Figure 6.

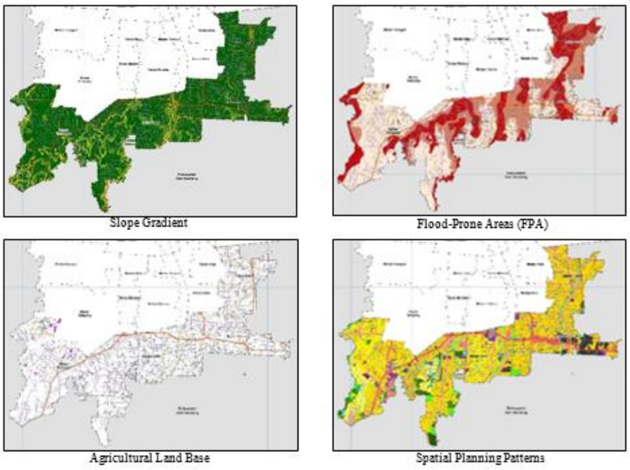

Figure 6. Other Supporting Variables

Source: Medan City PKPCKTR Office, 2024

Land Carrying Capacity for Residential Areas

The land carrying capacity analysis for the southern part of Medan City was conducted using ArcGIS software, producing four residential development zone classes: ZPK 1, ZPK 2, ZPK 3, and ZPK 4. The area of each residential development zone by district is detailed in Table 11 and Figure 7.

Table 11. Residential Development Zone Areas by District

Subdistrict	Go Area		No Go Area		Area (ha)
	ZPK 1	ZPK 2	ZPK 3	ZPK 4	
Medan Amplas	231.58	415.81	288.20	136.09	1071.69
Medan Denai	87.74	285.25	437.64	124.75	935.38
Medan Johor	491.72	471.28	399.37	300.19	1662.55
Medan Tuntungan	1311.20	278.71	335.69	594.03	2519.64
Area (ha)	**2122.25**	**1451.05**	**1460.91**	**1155.06**	**6189.26**
Potential Areas	**3573.30**		**2615.96**		

Source: Analysis Results, 2024

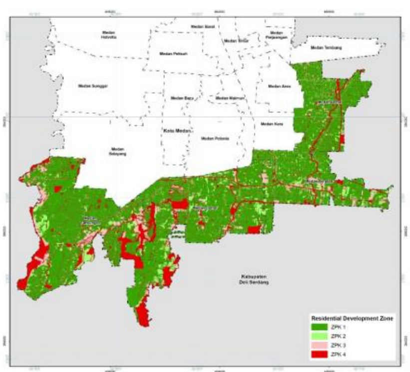

Figure 7. Residential Development Zones

Source: Analysis Results, 2024

From Table 11, the total potential area comprising ZPK 1 and ZPK 2 ("go areas") is 4,688.33 ha or 76% of the southern part of Medan City. Meanwhile, non-potential areas (ZPK 3 and ZPK 4, "no-go areas") cover 1,500.93 ha or 24% of the total area. The areas available for residential development are illustrated in Figure 8.

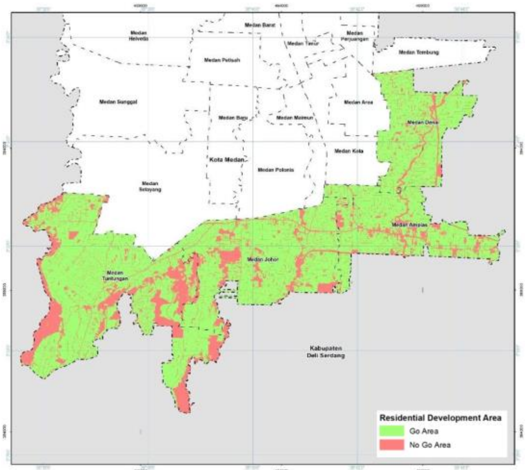

Figure 8. Areas Available for Residential Development

Source: Analysis Results, 2024

The areas estimated for residential development amount to 60% of the total available potential land, with the assumption that 40% will be allocated for infrastructure and public facilities. Calculating residential land carrying capacity requires a space requirement coefficient (ha/capita) adjusted to the characteristics of each district. Based on the characteristics of the southern districts of Medan City, all are categorized as urban zones with a space requirement coefficient of 0.0026 ha/capita. Using these coefficients, calculations were made to determine the population capacity of each area until its limit. The 2023 residential land carrying capacity by district is shown in Table 12.

Table 12. Residential Land Carrying Capacity, 2023

Subdistrict	Lwp	LPm	JP 2023	a	DDDpm	DT	Remarks
Medan Tuntungan	1,765,06	1,059,03	100,132	0.0026	4.07	407,321	Capable of Accommodating Population
Medan Johor	1,306,88	784,13	154,868	0.0026	1.95	301,589	Capable of Accommodating Population
Medan Amplas	839,75	503,85	131,770	0.0026	1.47	193,789	Capable of Accommodating Population
Medan Denai	776,64	465,98	171,896	0.0026	1.04	179,224	Capable of Accommodating Population

Source: Analysis Results, 2024

Residential Land Population Capacity

Based on Table 12, the population capacity is as follows: Medan Tuntungan (407,321 people), Medan Johor (301,589 people), Medan Amplas (193,789 people), and Medan Denai (179,224 people). This indicates that all districts can still accommodate the current population. However, to assess future prospects, the population capacity must be compared with projected population growth, identifying when each district's capacity is expected to be exceeded. The results of this projection analysis are shown in Table 13.

Table 13. Population Capacity Limits by District

Year	Population of Medan Tuntungan Subdistrict	Population of Medan Johor Subdistrict	Population of Medan Amplas Subdistrict	Population of Medan Denai Subdistrict
2024	102,267	158,316	133,443	175,391
2025	104,448	161,841	135,138	178,957
2026	106,675	165,444	136,854	182,596
2027	108,949	169,127	138,592	186,309
2028	111,272	172,893	140,352	190,097
2029	113,645	176,742	142,134	193,963
2030	116,068	180,677	143,939	197,906
2031	118,543	184,700	145,767	201,931
2032	121,070	188,812	147,618	206,036
2033	123,652	193,015	149,493	210,226
2034	126,288	197,313	151,391	214,500
2035	128,981	201,706	153,314	218,862
2036	131,731	206,196	155,261	223,312
2037	134,540	210,787	157,232	227,853
2038	137,409	215,480	159,229	232,486
2039	140,338	220,277	161,251	237,213
2040	143,331	225,182	163,299	242,036
2041	146,387	230,195	165,373	246,958
2042	149,508	235,320	167,473	251,979
2043	152,696	240,559	169,600	257,102
2044	155,952	245,915	171,753	262,330
2045	159,277	251,390	173,934	267,664
2046	162,673	256,987	176,143	273,107
2047	166,142	262,709	178,380	278,660
2048	169,684	268,557	180,645	284,326
2049	173,302	274,537	182,939	290,107
2050	176,997	280,649	185,263	296,006
2051	180,771	286,897	187,615	302,025
2052	184,626	293,285	189,998	308,166
2053	188,562	299,814	192,411	314,432
2054	192,583	306,489	194,854	320,825

Source: Analysis Results, 2024

Based on the data presented in Table 13, it can be concluded that the residential land carrying capacity in Medan Tuntungan sub-district is projected to be sufficient to accommodate population growth until after the year 2054. Meanwhile, in Medan Johor and Medan Amplas sub-districts, the residential land carrying capacity is estimated to be exceeded by 2054. On the other hand, Medan Denai sub-district shows that the residential land carrying capacity is projected to be exceeded earlier, specifically in 2026. A graphical visualization of population growth and carrying capacity for each sub-district can be seen in Figure 9

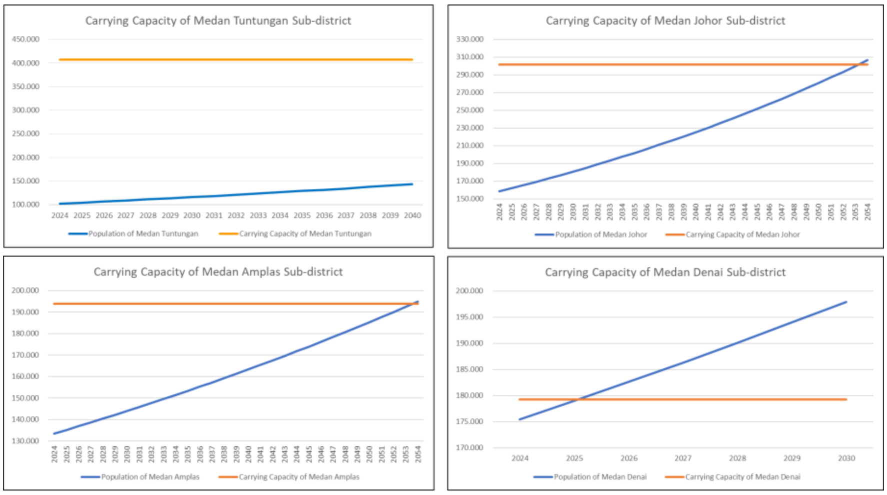

Figure 9. Population Growth and Carrying Capacity Graph

Source: Analysis Results 2024

5. CONCLUSION AND RECOMMENDATION

Based on the overall discussion in this study, the following conclusions can be drawn: 1) The land carrying capacity analysis indicates that 76% of the total area (4,688.33 ha) qualifies as potential areas (go areas) for residential development, while 24% (1,500.93 ha) is considered non-potential (no go areas), 2) The land carrying capacity analysis shows that Medan Tuntungan sub-district can accommodate up to 407,321 people, Medan Johor sub-district 301,589 people, Medan Amplas sub-district 193,789 people, and Medan Denai sub-district 179,224 people, 3) The population carrying capacity across sub-districts varies, with Medan Denai projected to reach its capacity limit in 2026, Medan Johor and Medan Amplas in 2054, while Medan Tuntungan is estimated to sustain population growth beyond 2054.

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