



# Spatial risk assessment of population density and land use: Challenges and solutions for sustainable urban development

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## ABSTRACT

**Background:** The growth of major cities is directly related to the increasing population and rising density. The Special Capital Region (DKI) of Jakarta is the most densely populated, with 15,292 people/km<sup>2</sup> and a population growth rate of 1.11% per year. Land use in Kapuk Village consists of five main types, including residential, religious, socio-cultural, commercial, and other uses. The dominant land use in Kapuk Village is for residential purposes, covering an area of 2.566 km<sup>2</sup>. Kapuk Village is the most densely populated village in Indonesia. Building density is related to the number of residents living in the area. Kapuk Village has the highest population, with a total of 174,349 people and a population density of 34,014 people/km<sup>2</sup>. Vertical housing is a spatial planning concept where housing is built upward and can address land limitations in urban areas. According to data from the Jakarta Provincial Government, slum settlements in Kapuk Village cover an area of 2,594 km<sup>2</sup> or approximately 50.57% of the total area of Kapuk Village. **Methods:** This study employs a qualitative approach with descriptive analysis, integrating literature reviews and secondary data from the Central Statistics Agency and Jakarta Provincial Government. Spatial analysis techniques are applied using land use maps, building density maps, and slum settlement distributions to examine the correlation between population density and urban development patterns. **Findings:** The study reveals that residential land dominates Kapuk Village, covering 2,566 km<sup>2</sup>, with slum areas comprising 50.57% of the total land. High building density contributes to limited open spaces and increased surface temperatures, affecting urban livability. The demand for social services, education, and healthcare surpasses available facilities, worsening urban disparities. The study also identifies the potential of vertical housing as a sustainable solution to accommodate the growing population. **Conclusion:** The research highlights the urgent need for strategic urban planning to address land use inefficiencies and mitigate the negative impacts of overpopulation. Vertical housing, combined with improved infrastructure and social services, can enhance urban resilience. **Novelty/Originality of this article:** This study provides a comprehensive spatial analysis of population density and land use in Kapuk Village, highlighting the direct impact on urban sustainability. It offers a novel perspective on integrating land use planning with social and environmental factors to promote better urban management strategies.

**KEYWORDS:** density; inhabitant; keyword 3; Kapuk Village; land use; residence.

## 1. Introduction

Indonesia is a country with a population of 281,603,800 people and a population growth rate of 1,11% per year (Badan Pusat Statistik, 2024). Rapid population growth must be accompanied by development, particularly in infrastructure and adequate housing. West Java is the province with the largest population in Indonesia, totaling 50,345,200 people.

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DKI Jakarta, with a population of 10,684,900 people—still lower than that of West Java—does not mean it is without issues. The population density of DKI Jakarta is the highest, reaching 15,292 people/km<sup>2</sup>.

The population density in DKI Jakarta can also be attributed to migration from rural to urban areas. The continuous increase in migration to urban areas each year makes cities more crowded and significantly impacts the urban ecosystem. Many factors contribute to the high rate of urbanization, one of which is the city's appeal as a center for economic activities, residential areas, education, and government (Azizah et al., 2022). This indicates that the population density in DKI Jakarta is predominantly driven by people from other regions seeking economic opportunities. As an economic center, Jakarta attracts people from various regions to migrate, making the city increasingly dense each year (Indrajaya & Anggraini, 2021). At the same time, rising consumption due to population growth ultimately affects the declining productivity of natural resources. Population issues faced by both developed and developing countries include overpopulation, high birth and infant mortality rates, urbanization, unemployment, and unequal population distribution. These increasingly complex issues will impact the most crucial aspect of human life: environmental sustainability (Ridwan et al., 2021).

The growth of major cities is directly related to the increasing urban population and its activities. This leads to a rising demand for land use for productive urban functions such as residential areas, businesses, trade, services, and offices (Christina & Rangkuty, 2022). Kapuk Village, located in Cengkareng District, West Jakarta City, is the most densely populated village in Indonesia. High population density can lead to issues such as building and housing congestion, the emergence of slum settlements, and a high demand for educational and healthcare facilities. Therefore, this study aims to analyze the impact of population density and land use in Kapuk Village, Cengkareng District, West Jakarta, DKI Jakarta.

### *1.1 Land use*

Land use refers to human activities carried out on land for various purposes, such as development, agriculture, settlement, and industry. In land use, Indonesia adheres to the concept of welfare, meaning that land is allocated for the well-being of its people (Mukaromah, 2022). A crucial factor in planning is essentially urban planning, which is fundamentally land use planning. Land use can be categorized into two major groups: agricultural land use and non-agricultural land use. Agricultural land use includes rice fields, dry fields, plantations, forests, and others. Non-agricultural land use includes urban or rural areas, industries, recreation, mining, and so on (Savitri & Fransiska, 2022).

### *1.2 Population density*

The population or residents of a country or region can be defined as the people living in that area and those who are legally entitled to reside there. In other words, individuals who possess official documentation allowing them to stay, such as proof of citizenship, even if they choose to live elsewhere. Population density is influenced by three components: birth, death, and migration (Irham et al., 2023). According to Xu et al., (2021), population density is related to urban services. A high population density in a particular area results in a more restricted living space (Ridwan et al., 2021).

The continuous increase in the urban population, combined with limited land, intensifies competition for housing. This drives urban residents to live in highly dense residential areas. The unequal distribution of public facilities, social services, and utilities forces many people to settle in less favorable areas. Consequently, urban residents must adapt to the available facilities, including public infrastructure, social services, education, healthcare, and others. Living in urban areas means facing increasingly limited spaces (Suhaeni, 2011). A higher population in a given area leads to fewer open positions, which in turn contributes to unemployment and wage imbalances among workers.

Overall, population density is one of the variables affecting crime rates, as densely populated areas generally face financial issues, food shortages, and a lack of welfare guidelines, which may lead to crime (Hachica & Triani, 2022). Increasing population density can result in a rise in criminal activities (Nurwati, 2021).

### 1.3 Slum settlements

The Provincial Government of DKI Jakarta has designated certain urban villages in DKI Jakarta that contain slum neighborhoods, one of which is Kapuk Village, located in Cengkareng District, West Jakarta. The slum areas in this village range from mild to moderate and severe typologies. Slum settlements are generally inhabited by low-income residents and those living near the poverty line. A significant portion of the urban poor resides in slum and informal settlements (Ridena, 2021). Poverty is a condition in which an individual or a group of people is unable to meet their basic needs or has limited resources to sustain their livelihood. Basic human needs include shelter or housing, food, education, healthcare, and clothing (Dita, 2022). Slum settlements are typically found in densely populated areas and can have negative impacts on public health.

## 2. Methods

The method used in this article is qualitative, with a literature study approach. The nature of this research is descriptive analysis, which involves systematically presenting the obtained data, followed by interpretation and explanation to ensure clarity for the readers. The literature was collected from scientific articles, journals, and books relevant to this study. In addition to the literature study, data collection was conducted using secondary data from the Central Statistics Agency (Badan Pusat Statistik): *Cengkareng District in Figures* (2024). The collected data includes the study area's total land area, population size, population density, healthcare facilities, and educational facilities in Kapuk Village, Cengkareng District, West Jakarta Administrative City.

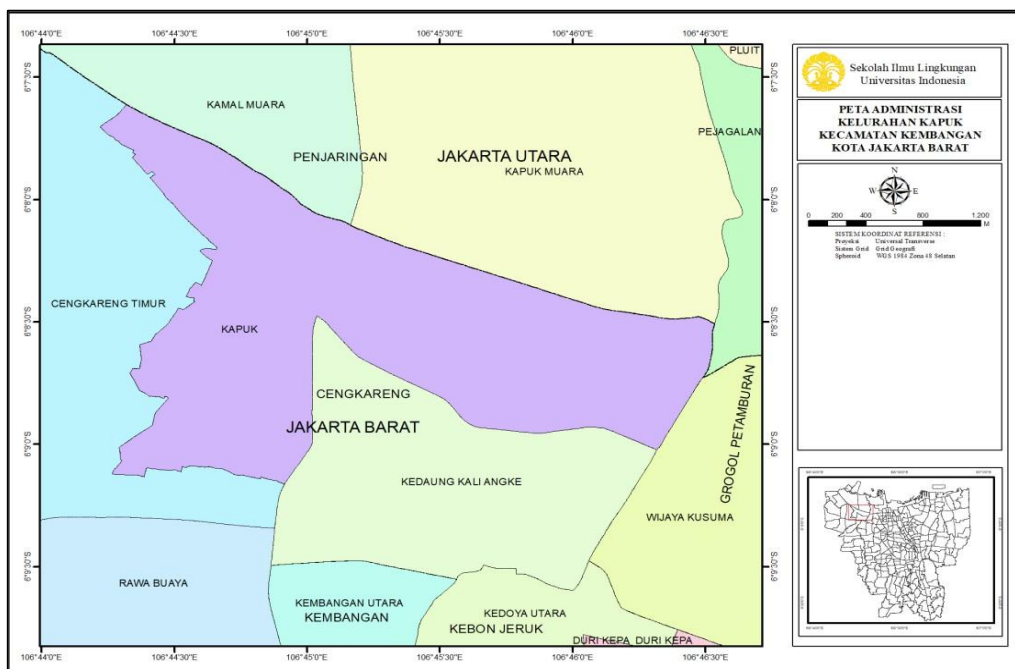


Fig. 1. Administrative map of Kapuk Village, Cengkareng District, West Jakarta Administrative City

In addition to descriptive analysis, this study also utilizes maps, with data sourced from Jakarta Satu, the Provincial Government of DKI Jakarta. The maps presented in this study include a land use map, a building density map, and a slum settlement map. The data

analysis of these maps will be conducted using a qualitative descriptive approach with relevant literature studies. The research location is in Kapuk Village, Cengkareng District, West Jakarta Administrative City, DKI Jakarta Province. The research area directly borders the north with Kapuk Muara and Kamal Muara Villages, Penjaringan District, North Jakarta Administrative City. Below is the administrative map of the research location.

### 3. Results and Discussion

#### 3.1 Land use

Land use planning is a crucial element in urban planning, where appropriate land use can support effective city development. The fulfillment of land needs for construction and the increasing human activities to meet daily necessities are among the factors driving the dynamics of land use changes in a region (Savitri and Fransiska, 2022). Based on land use data from the Provincial Government of DKI Jakarta in 2024, land use in Kapuk Village consists of five main categories: residential, religious, socio-cultural, business, and other uses. Below is the Land Use Map of Kapuk Village, Cengkareng District, West Jakarta Administrative City.

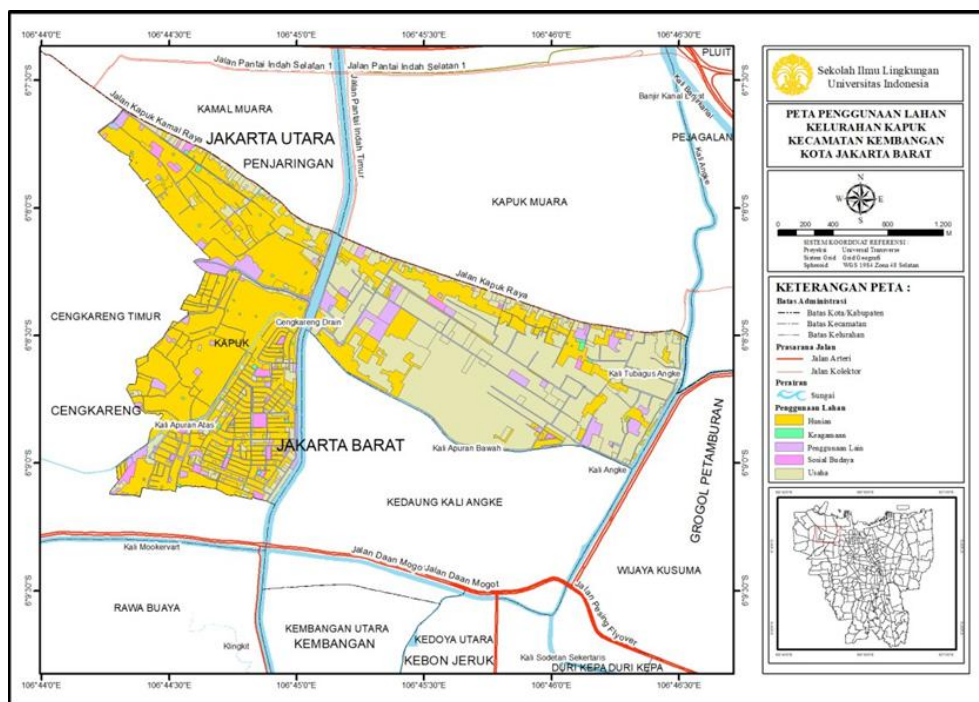


Fig. 2. Land use map of Kapuk Village, Cengkareng District, West Jakarta Administrative City

Based on land use data from the Provincial Government of DKI Jakarta, the dominant land use in Kapuk Village is for residential purposes, covering an area of 2.566 km<sup>2</sup>. The details of residential use include large houses, small houses, boarding houses, very small houses, and medium-sized houses. Residential areas are generally concentrated in the western part of Kapuk Village, indicating that it is a densely populated residential area. Aside from residential use, business activities also occupy a significant portion of land in Kapuk Village, covering 2.022 km<sup>2</sup>. The land used for business activities includes shops, warehouses, small industries, minimarkets, shop houses, hotels, and food stalls. Business activities are predominantly located in the eastern part of Kapuk Village.

In addition to residential and business land use, Kapuk Village also includes religious areas (0.023 km<sup>2</sup>), socio-cultural areas (0.092 km<sup>2</sup>), and other uses (0.330 km<sup>2</sup>). Religious areas consist of mosques, prayer rooms, churches, and temples. Socio-cultural areas include schools, healthcare facilities, offices, and public buildings. Vacant land and green spaces fall

under the category of other uses. The use of land for religious, business, socio-cultural, and other purposes serves as a supporting area for the residents of Kapuk Village and surrounding areas. Vacant land and green spaces should be properly utilized and managed to improve environmental quality. Increasing vegetation density is essential, as Kapuk Village is an area with high building density and population density. Below are the detailed land use areas in Kapuk Village, Cengkareng District, West Jakarta Administrative City.

Table 1. Land Use Area in Kapuk Village, Cengkareng District, West Jakarta Administrative City

Types of Land Use	Land Use Area (m <sup>2</sup> )	Land Use Area (km <sup>2</sup> )	Land Use Area (Ha)	Land Use Description
Residential	2,565,508.52	2,566	256.55	Very Small House, Small House, Medium House, Large House, Boarding House
Religious Belief	22,613.99	0.023	2,261	Mosque, Mushola, Church, Vihara
Other Uses	330,137.49	0.330	33,014	Vacant Land, Green Area
Social and Cultural	91,944.10	0.092	9,194	School, Health Facility, Office, Building
Business	2,021,836.09	2,022	202,184	Shops, Warehouse, Small Industry, Minimarket, Shophouse, Hotel, Food Stall

### 3.2 Building and Population Density

Building density affects comfort and surface temperature in residential areas. The surface temperature of a region is influenced by factors such as vegetation density, building density, and the number of inhabitants (Syahputra et al., 2021). A decrease in vegetation and an increase in building density can raise land surface temperatures. The reduction of vegetation lowers environmental services, while the rising population demand causes an ecological imbalance (Aldzahabi et al., 2024). The high building density in Kapuk Urban Village results in narrow roads and short distances between residences. Increasing building density significantly impacts urban dynamics, including population mobility, land use, and environmental quality (Achsan et al., 2023). Below is the building density in Kapuk Urban Village, Cengkareng District, West Jakarta Administrative City.

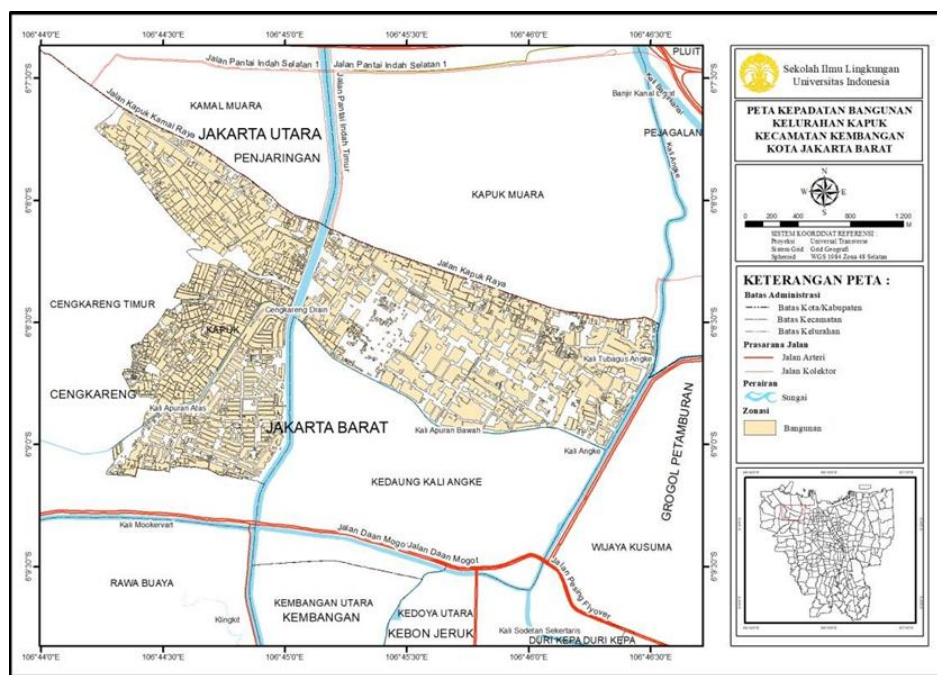


Fig. 3. Map of building density in Kapuk Urban Village, Cengkareng District, West Jakarta Administrative City

Building density is related to the number of residents living in the area. According to data from the Central Bureau of Statistics (2024), Kapuk Urban Village has the highest population in Cengkareng District, with a total of 174,349 residents, consisting of 88,632 males and 85,717 females. In addition to Kapuk Urban Village, other urban villages with a population exceeding 100,000 are Duri Kosambi Urban Village and Cengkareng Timur Urban Village, with 103,866 and 105,526 residents, respectively. Below is the total population and gender ratio for each urban village in Cengkareng District, West Jakarta Administrative City.

Table 2. Total Population and Sex Ratio of Each Urban Village in Cengkareng District, West Jakarta Administrative City

Location	Man (Resident)	Female (Resident)	Total (Resident)	Sex Ratio
Duri Kosambi Village	52,203	51,663	103,866	1.01
Rawa Buaya Village	41,605	40,581	82,186	1.03
Kedaung Kali Angke Village	21,287	20,619	41,906	1.03
Kapuk Village	88,632	85,717	174,349	1.03
East Cengkareng Village	53,209	52,317	105,526	1.02
West Cengkareng Village	42,289	41,862	84,151	1.01
Cengkareng District (Total)	299,225	292,759	591,984	1.02

(Badan Pusat Statistik, 2024)

Cengkareng District has a total area of 25.72 km<sup>2</sup>, and the largest urban village is Duri Kosambi Village, with an area of 5.35 km<sup>2</sup>. Although Duri Kosambi Village has the largest area in Cengkareng District, the highest population density is found in Kapuk Village. Population density is the ratio of the total population to the area size. Kapuk Village has a population density of 34,014 people/km<sup>2</sup>, making it the most densely populated urban village in Indonesia. The increasing demand for housing due to the continuous population growth and the limited availability of land may necessitate vertical development as an effort to address land-use mismatches (Savitri & Fransiska, 2022). According to Melati et al. (2024), vertical housing is a spatial planning concept where residential buildings are constructed upward with multiple stacked floors to address land scarcity in urban areas. Therefore, vertical housing could be a solution to the land limitations caused by population growth.

Table 3. Area Size and Population Density of Each Urban Village in Cengkareng District, West Jakarta Administrative City

Village	Area Size (km <sup>2</sup> )	Percentage of District Area	Percentage of District Population	Population Density (people/km <sup>2</sup> )
Duri Kosambi Village	5.35	20.80%	17.55	19,404
Rawa Buaya Village	3.72	14.46%	13.89	22,117
Kedaung Kali Angke Village	2.98	11.59%	7.08	14,050
Kapuk Village	5.13	19.95%	29.46	34,014
East Cengkareng Village	4.6	17.88%	17.81	22,907
West Cengkareng Village	3.94	15.32%	14.22	21,341
Cengkareng District (Total)	25.72	100	100.00	23,011

### 3.3 Slum Settlements

Kapuk Village is the most densely populated urban village in Indonesia. However, this high population density is not proportional to the quality of its housing settlements. Slum settlements refer to living environments with extremely poor housing conditions, characterized by very high building density within limited land areas, vulnerability to social and environmental diseases, substandard building quality, lack of adequate infrastructure

services, and conditions that endanger the well-being and livelihoods of residents (Fitria, 2014). According to data from the Provincial Government of DKI Jakarta, slum settlements in Kapuk Urban Village cover an area of 2.594 km<sup>2</sup>, or approximately 50.57% of the total area of the village. Population growth often leads to the formation of slum settlements in various parts of the city, as many residents cannot afford decent housing. The presence of slum settlements affects both the health of residents and the overall urban environment (Indrajaya & Anggraini, 2021). Below is a map showing the distribution of slum settlements in Kapuk Urban Village, Cengkareng District, West Jakarta Administrative City

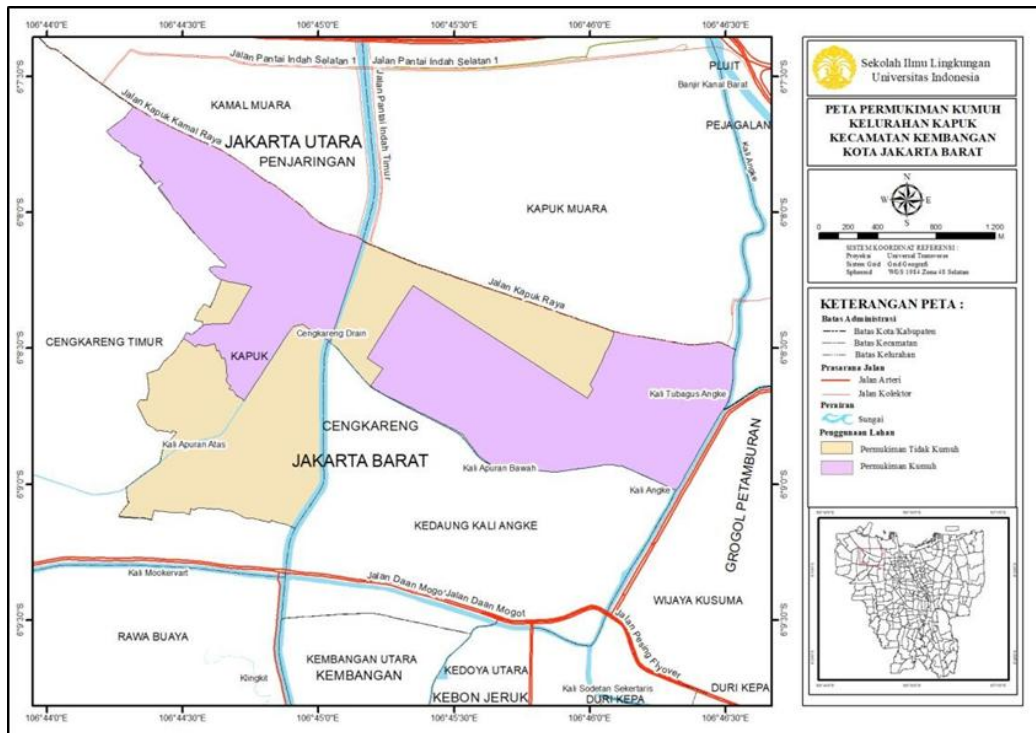


Fig. 4. Map of slum settlement distribution in Kapuk Village, Cengkareng District, West Jakarta Administrative City

Housing based on land use is divided into five types: large houses, small houses, boarding houses, very small houses, and medium houses. According to data from the Provincial Government of DKI Jakarta, the category of small houses in Kapuk Urban Village covers an area of 2.286 km<sup>2</sup>, accounting for 89.1% of the total residential area. Small houses are defined as houses with an area of less than 60 m<sup>2</sup> and are generally targeted at the lower-middle class (Paryoko & Zakariya, 2023). One of the significant issues in densely populated settlements is the limited land area, which affects building sizes, room sizes, and overlapping use of spaces (Mauliani & Sudarwati, 2018). Meanwhile, the large house category occupies the smallest portion of residential land in Kapuk Urban Village, covering only 0.0165 km<sup>2</sup> or 0.644%.

Table 4. Housing Details in Kapuk Urban Village, Cengkareng District, West Jakarta Administrative City

Housing Details	Area Size (m <sup>2</sup> )	Area Size (km <sup>2</sup> )	Area Size (ha)
Large House	16,543.72	0.0165	1,654
Small House	2,286,069.49	2,286	228,607
Boarding House	55,173.23	0.055	5,517
Very Small House	110,882.41	0.111	11,088
Medium House	96,839.67	0.097	9,684

### 3.4 Supporting Facilities

Based on data from the Central Bureau of Statistics, Kecamatan Cengkareng in Figures (2024), educational facilities in Kecamatan Cengkareng include 148 elementary schools (or equivalent), 71 junior high schools (or equivalent), 53 senior high schools (or equivalent), and 9 universities. Kelurahan Kapuk has the highest number of elementary and junior high schools, with 41 and 18 schools, respectively. Population density can affect education quality through various mechanisms, including access to educational facilities, teacher-student ratios, and the availability of educational resources (Rinaldi and Arifin, 2024). High-density areas must be supported by comprehensive supporting facilities, especially in education and healthcare. Duminy (2021) highlights that high-density areas in developing countries often face greater challenges in access to and quality of education compared to low-density areas.

Table 5. Number of Educational Facilities in Each Kelurahan in Cengkareng District, West Jakarta Administrative City

Village	Elementary School/Equivalent	Junior High School/Equivalent	Senior High School/Equivalent	University
Duri Kosambi Village	21	13	7	1
Rawa Buaya Village	18	11	6	1
Kedaung Kali Angke Village	14	2	1	1
Kapuk Village	41	18	7	0
East Cengkareng Village	29	14	17	3
West Cengkareng Village	25	13	15	3
Cengkareng District (Total)	148	71	53	9

(Badan Pusat Statistik, 2024)

Other supporting facilities in Cengkareng District, based on data from the Central Bureau of Statistics (2024), is healthcare facilities. Cengkareng District has 2 hospitals, 1 maternity hospital, 42 polyclinics, and 9 community health centers (Puskesmas) without inpatient services. However, Kapuk Urban Village only has 35 polyclinics and 2 Puskesmas without inpatient services, and no hospitals. Healthcare facilities are crucial for every area, especially Kapuk Urban Village, which has the largest population and the highest population density in Cengkareng District. The continuous population growth each year increases the demand for healthcare facilities (Geraldine & Syafli, 2023). Below is the number of healthcare facilities in each urban village within Cengkareng District, West Jakarta Administrative City.

The healthcare facilities in Kapuk Urban Village need to be increased due to the high population density, which can facilitate the spread of diseases. Tuberculosis tends to cause spatial clustering because most patients share the same social determinants and live in close proximity, increasing the risk of infection (Lestari et al., 2023). Spatially, population density affects tuberculosis cases due to the disease's tendency to spread within groups. Areas with high population density are at greater risk of tuberculosis transmission. Several factors contribute to the spread of tuberculosis, including population density, household economic conditions, available and accessible healthcare services, household sanitation, and hygiene behavior (Siwiendrayanti et al., 2021). Therefore, adequate and well-equipped healthcare facilities, as well as easy access to healthcare services, are necessary to address emerging health issues.



Table 6. Number of Healthcare Facilities in Each Urban Village in Cengkareng District, West Jakarta Administrative City

Village	Hospital	Maternity Hospital	Polyclinic	Community Health Center (Without Inpatient Services)
Duri Kosambi Village	0	0	0	2
Rawa Buaya Village	0	0	0	1
Kedaung Kali Angke Village	0	0	0	1
Kapuk Village	0	0	35	2
East Cengkareng Village	2	0	0	1
West Cengkareng Village	0	1	7	2
Cengkareng District (Total)	2	1	42	9

(Badan Pusat Statistik, 2024)

#### 4. Conclusions

Land use in Kapuk Urban Village is predominantly residential, with a total population of 174,349 people and a population density of 34,014 people/km<sup>2</sup>. This high population density contributes to the emergence of slum settlements, increased building density, limited access to education, and potential health risks. Slum settlements in Kapuk Urban Village cover an area of 2,594 km<sup>2</sup>, accounting for approximately 50.57% of the total area. Adequate and well-equipped healthcare facilities, along with easy access to healthcare services, are essential for Kapuk. Vertical housing can be a solution to land limitations caused by population growth and increasing building density in Kapuk Urban Village.

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#### Author Contribution

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#### Data Availability Statement

Not available

#### Conflicts of Interest

The author declare no conflict of interest

#### Open Access

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