FINAL PROJECT – CP234856

DETERMINING THE NEED FOR GREEN OPEN SPACE LOCATIONS BASED ON THE DISTRIBUTION OF URBAN HEAT ISLAND IN JAKARTA

FARANISSAH NOER AZIZAH

NRP 5015201160

Advisor

Rulli Pratiwi Setiawan, ST, M.sc, PH. D

NIP 197906032008122004

Study Program of Bachelor of Urban and Regional Planning

Department of Urban and Regional Planning

Faculty of Civil, Planning, and Geo Engineering

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APPROVAL SHEET

DETERMINING THE NEED FOR GREEN OPEN SPACE LOCATIONS BASED ON THE DISTRIBUTION OF URBAN HEAT ISLAND IN JAKARTA

FINAL PROJECT

Submitted to fulfill one of the requirements
for obtaining a degree Bachelor of Urban and Regional Planning at
Undergraduate Study Program of Bachelor of Urban and Regional Planning
Department of Urban and Regional Planning
Faculty of Civil, Planning, and Geo Engineering
Institute Technology of Sepuluh Nopember

Oleh : **Faranissah Noer Azizah**
NRP. 5015201160

Approved by Final Project Examiner Team:

1. Rulli Pratiwi Setiawan, ST, M.sc, PH. D Advisor
2. Mochamad Yusuf, S.T., M.Sc. Examiner 1
3. Anoraga Jatayu, S.T., M.Si. Examiner 2

SURABAYA

July, 2024

STATEMENT OF ORIGINALITY

The undersigned below:

Name of Student / NRP : Faranissah Noer Azizah / 5015201160

Department : Urban and Regional Planning

Advisor / NIP : Rulli Pratiwi Setiawan, ST, M.sc, PH. D / 197906032008122004

Hereby declare that the Final Project with the title of “Determining the need for Green Open Space Locations based on the distribution of Urban Heat Island in Jakarta” is the result of my own work, is original, and is written by following the rules of scientific writing.

If in the future there is a discrepancy with this statement, then I am willing to accept sanctions in accordance with the provisions that apply at Institute Technology of Sepuluh Nopember.

Surabaya, July 2024

Acknowledge
Advisor

Rulli Pratiwi Setiawan, ST, M.sc, PH. D
NIP. 197906032008122004

Student

Faranissah Noer Azizah
NRP. 5015201160

ABSTRACT

DETERMINING THE NEED FOR GREEN OPEN SPACE LOCATIONS BASED ON THE DISTRIBUTION OF URBAN HEAT ISLAND IN JAKARTA

Student Name / NRP	**:**	**Faranissah Noer Azizah / 5015201160**
Department	**:**	**Urban and Regional Planning**
Advisor	**:**	**Rulli Pratiwi Setiawan, ST, M.sc, PH. D**

Abstract

Urban Heat Island (UHI) is a global issue that affects many cities, including Jakarta, Indonesia. Because of its dense population, expanding infrastructure, and scarcity of green space, Jakarta as the capital and metropolitan center of Indonesia experienced severe effects from UHI. This city is rapidly becoming more urbanized, which has led to a decrease in vegetation and an increase in surface temperature. These changes have made heat-related issues worse and put the population's health at risk. Previous research shows that the intensity of UHI in Jakarta is among the highest in Southeast Asia, with temperatures in some areas reaching 4° C higher than the surrounding rural areas. Due to its critical function in temperature regulation through evapotranspiration and heat absorption, the reduced amount of green open space (GOS) in urban areas is a significant contributing element to urban heat island effect (UHI).

Urban green space is known to have a significant role in mitigating the effects of urban heat islands. In urban areas, a minimum GOS requirement of 30% of the total area is established by the Minister of Public Works and Public Housing Regulation No. 5/PRT/M/2008. Unfortunately, Jakarta lacks green space in lots of locations, particularly in heavily populated regions where it is typically distributed unevenly. The objective of this research is to determine the need of GOS location by analyzing the UHI distribution in Jakarta. To provide a thorough and data-based approach for prioritizing the development of green space in Jakarta, this study will combine spatial analysis with the Analytical Hierarchy Process (AHP) approach. The results of the analysis shown that the variable hierarchy that causes UHI is LULC, vegetation, population density, LST, air temperature, rainfall, and topography. In addition, the distribution of UHI in Jakarta is dominated by high class where city temperature is very hot. Three priority classes are generated following the use of Weighted Overlay Variables to analyze GOS priority sites. It shows that Jakarta has many priority places that need to be developed.

Keywords: ***AHP method, Green Open Space, Urban Heat Island.***

FOREWORD

The author would like to express his gratitude to Allah SWT for all His blessings and guidance so that the author can complete the Final Project with the title "Determining the need for Green Open Space Locations based on the distribution of Urban Heat Island in Jakarta" on time. During the process of preparing the Final Assignment, the author realized that he could not be separated from a lot of help and support from other parties so that this Final Assignment could be completed optimally. On this occasion the author would like to express his deepest gratitude to those who have helped in preparing this assignment, namely:

1. The author's father, mother, sisters, and brothers for the support, motivation and encouragement they have given to the author.
2. Rulli Pratiwi Setiawan, ST, M.sc, PH. D, as a supervisor who has helped, provided suggestions, and input in the successful completion of this final project.
3. All Urban Regional Planning lecturers who have provided valuable lessons both inside and outside the classroom.
4. All stakeholders who have provided space and time to participate become sources of information for the author in providing data to complete this final project.
5. Fellow classmate of IUP 2020 (AYUPI) who have experienced highs and lows together and who have supported and encouraged one another through college life with the author.

The author realizes that this research is still far from perfect, therefore constructive criticism and suggestions are highly expected by the author. Apart from that, the author hopes that the research in this final assignment will be useful for increasing the insight of future readers and researchers.

Surabaya, July 2024

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CHAPTER I
INTRODUCTION

1.1 Background

The concept of urban heat island (UHI) has become a major concern in many places throughout the world, including Jakarta, Indonesia. UHI refers to the higher temperatures recorded in cities compared to their rural counterparts, which are mostly caused by human activity and the built environment (Oke, 1982). This phenomenon is especially important in tropical areas like Jakarta, where the urban heat island effect can worsen heat stress and discomfort for residents, particularly during peak summer months.

Jakarta, as Indonesia's capital and largest urban center, experiences significant UHI effects due to its dense population, extensive infrastructure, and limited green spaces. Utilizing satellite data, studies on the causes of urban heat islands have revealed that the city's rapid urbanization has resulted in a loss of vegetation and a rise in surface temperatures, exacerbates heat-related problems and compromising the health of its residents. According to a study by the Indonesian Ministry of Environment and Forestry, Jakarta's UHI intensity is among the highest in Southeast Asia, with temperatures in some areas reaching up to 4°C higher than the surrounding rural areas. This condition of UHI is largely attributed to the city's dense population, lack of green spaces, and the prevalence of heat-absorbing surfaces such as asphalt and concrete.

The issue of urban heat in Jakarta is becoming larger, with a rising recognition of the necessity to incorporate urban heat issues into urban policy agendas. The decreasing number in green open spaces (GOS) within urban areas is an essential factor contributing to UHI, as these spaces play an important role in temperature regulation by evapotranspiration and shading (Shah et al., 2021). According to Ufaira et al., 2023, the provision of green open space can serve as a proxy for thermal justice among Jakarta's residents by helping to minimize urban heat and increase thermal comfort.

The existence of green open spaces (GOS) in urban areas has been recognized as a crucial factor in mitigating the effects of UHI. In Indonesia, the Ministry of Public Works, and Public Housing Regulation No. 5/PRT/M/2008 sets the minimum requirement for green open spaces in urban areas at 30% of the total area. This regulation aims to ensure that urban areas have sufficient green spaces to provide ecological, social, and aesthetic benefits to residents. The regulation also emphasizes the importance of integrating green spaces into urban planning and development to mitigate the urban heat island effect and improve air quality. It defines green open spaces as areas that contain crops, plants, and vegetation, and includes various types of green spaces such as parks, gardens, green roofs, and green walls. It also emphasizes the need for green spaces to be well-maintained and accessible to the public. The regulation is part of a broader effort to promote sustainable urban development and improve the quality of life for urban residents in Indonesia. It is expected to contribute to the country's efforts to reduce improve air quality and increase the use of green spaces for recreational and environmental purposes.

However, according to a study by Ufaira et al., 2023, the distribution of GOS in Jakarta is frequently unequal, with many regions lacking appropriate green space, particularly in densely populated and low-income neighborhoods. Furthermore, the emergences of the UHI phenomena have been proven in several developing cities such as Jakarta, Indonesia (Saputra et al., 2022); Singapore (Kardinal Jusuf et al., 2007); and German (Menberg et al., 2013). Jakarta (Siswanto et al., 2023); Surabaya (Syafitri et al., 2020); and Bandung (Puspita & Saputra, 2019) are among previous studies that have reported experiencing UHI with the same indication that has an impact on UHI, such as the Land Surface Temperature (LST), Land use changes, and reduced vegetation cover. Each of these studies also confirms that the UHI will continue to increase if activities in cities become increasingly dense without well-organized urban management and without sustainability planning. However, many previous studies only discussed the results of UHI without any direction or strategy to reduce it.

The urgency for this research lies in the need to address the pressing issue of UHI in Jakarta. As the city continues to grow and urbanize, the effects of UHI are likely to worsen, posing significant health risks to residents due to the air quality and environment, particularly the vulnerable populations such as the elderly and young children (Putra et al., 2021). By analyzing the distribution of GOS in Jakarta and identifying areas where they are most needed, this research aims to provide a data-driven approach to prioritize the development of green spaces in locations needed. To achieve this goal, this research will employ a combination of AHP approach and spatial analysis. By integrating these methods, this research aims to provide a comprehensive and data-driven approach to prioritizing the development of green spaces in Jakarta, ultimately contributing to the mitigation of UHI and improvement of environmental conditions in the city.

The results of this research aim to offer recommendations to the government on identifying the locations needed for green open spaces to help mitigate Urban Heat Island (UHI) effects in Jakarta. The findings are expected to contribute to developing sustainable strategies that enhance the resilience of Jakarta's urban environment against climate change impacts.

1.2 Problem Formulation

Based on the problem on the background, this research is intended to answer the following research questions **"How to determine the need of green open space locations based on the distribution of urban heat island in Jakarta?".**

1.3 Goals and Objective

This study aims to determine the need of green open space locations based on the distribution of urban heat island in the city of Jakarta for improving the health, wellbeing, and sustainability of urban residents, as well as for adapting cities to the impacts of climate change. Sequential objectives are required to achieve the goal. Those are as follows:

1. Determine priority factors causing urban heat island and its distribution in Jakarta
2. Determine the need of green open space locations based on the distribution of urban heat island in Jakarta

1.4 Research Scope

The research scope explains the limitations or boundaries of research exploration. The research scope is divided into:

1.4.1 Scope of Area

The scope of the area in this study was conducted in the city of Jakarta which has a total area of 653.83 km2. The administration's boundaries are as follows:

1. North Jakarta
2. East Jakarta
3. South Jakarta
4. West Jakarta
5. Central Jakarta

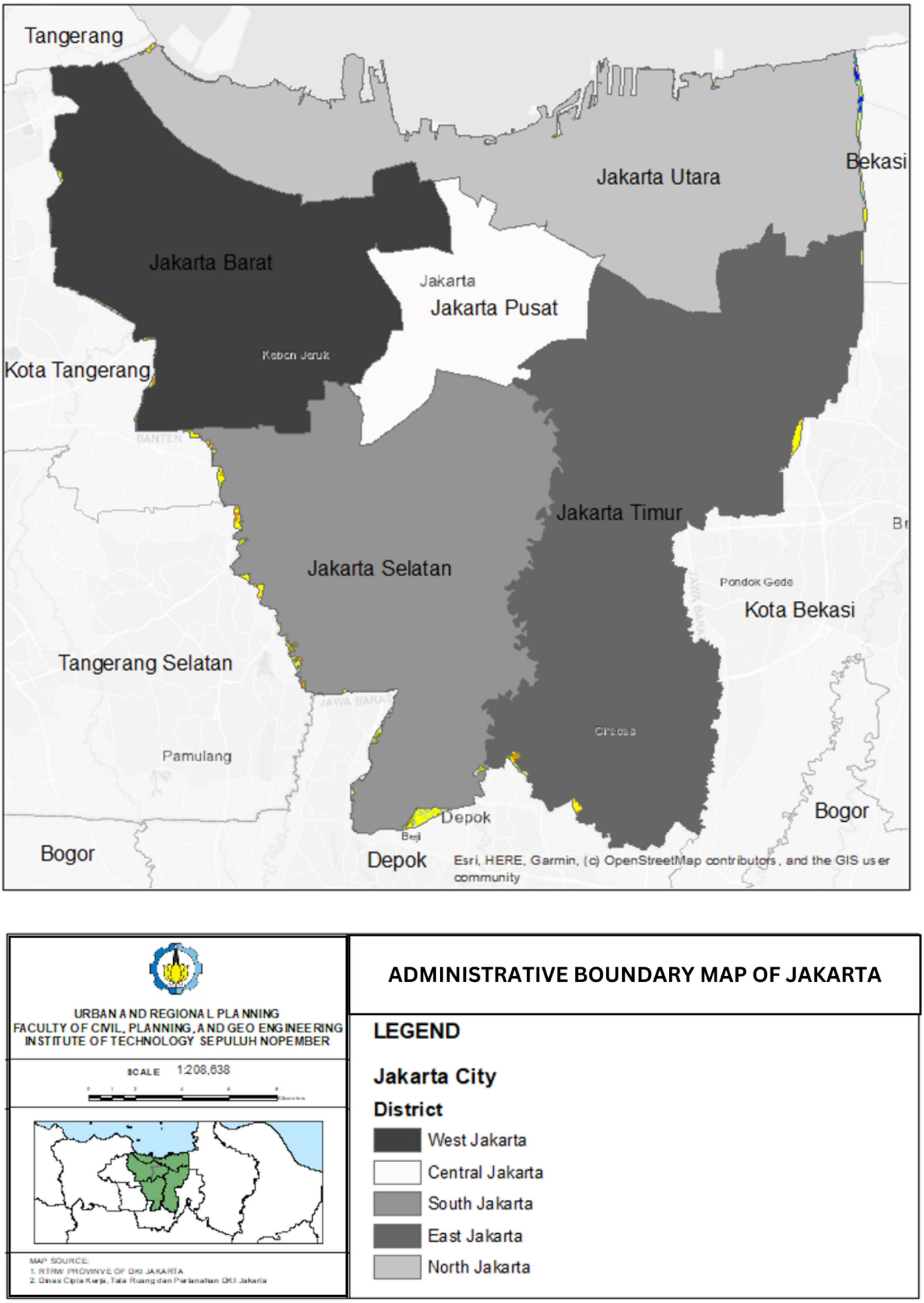


Figure 1 Administrative Boundary Map of Jakarta

Source: Author Analysis, 2024

1.4.2 Scope of Discussion

The scope of this research will focus on identifying the need of green open space locations based on the results of weighting the variables that cause the distribution of urban heat island in Jakarta.

1.4.3 Scope of Substance

The scope of the substance in this study is related to the factors in determining the need of the Green Open Space (GOS) locations based on the distribution of Urban Heat Island (UHI) in terms of theories and previous studies.

1.5 Research Benefit

1.5.1 Theoretical Benefit

This study is expected to be a reference in the field of urban and regional planning, particularly in terms of implementing the direction to combat urban heat islands through the Green Open Space.

1.5.2 Practical Benefit

This study is expected to be a recommendation for the Indonesian Government in Jakarta City, especially on the development of Green Open Space to combat the Urban Heat Island.

1.6 Writing Systematic

The writing systematics of this research proposal are as follows:

CHAPTER I INTRODUCTION

This chapter explains the background, problem formulation, goals and objectives, research scope, benefits, writing systematic, and framework of the research.

CHAPTER II LITERATURE REVIEW

This chapter will be identified and explained the variables associated with urban heat islands to prioritise the location of green open space.

CHAPTER III RESEARCH METHODOLOGY

This chapter explains the approaches, types, variables, population and sample, data collection, analysis technique, and stage of this research.

CHAPTER IV RESULT AND DISCUSSION

This chapter includes a general description of the study in the form of research data, analysis, and discussion in answering the targets and formulation of the results that answer the research objectives.

CHAPTER V CONCLUSION

This chapter contains the results of research, conclusions, and recommendations that can be reviewed to follow up on the results of the study.

1.7 Research Framework

Research flows from background, aims, goals, and research outcomes are all described in the framework of thinking. This research can be conceptualised using the framework that follows.

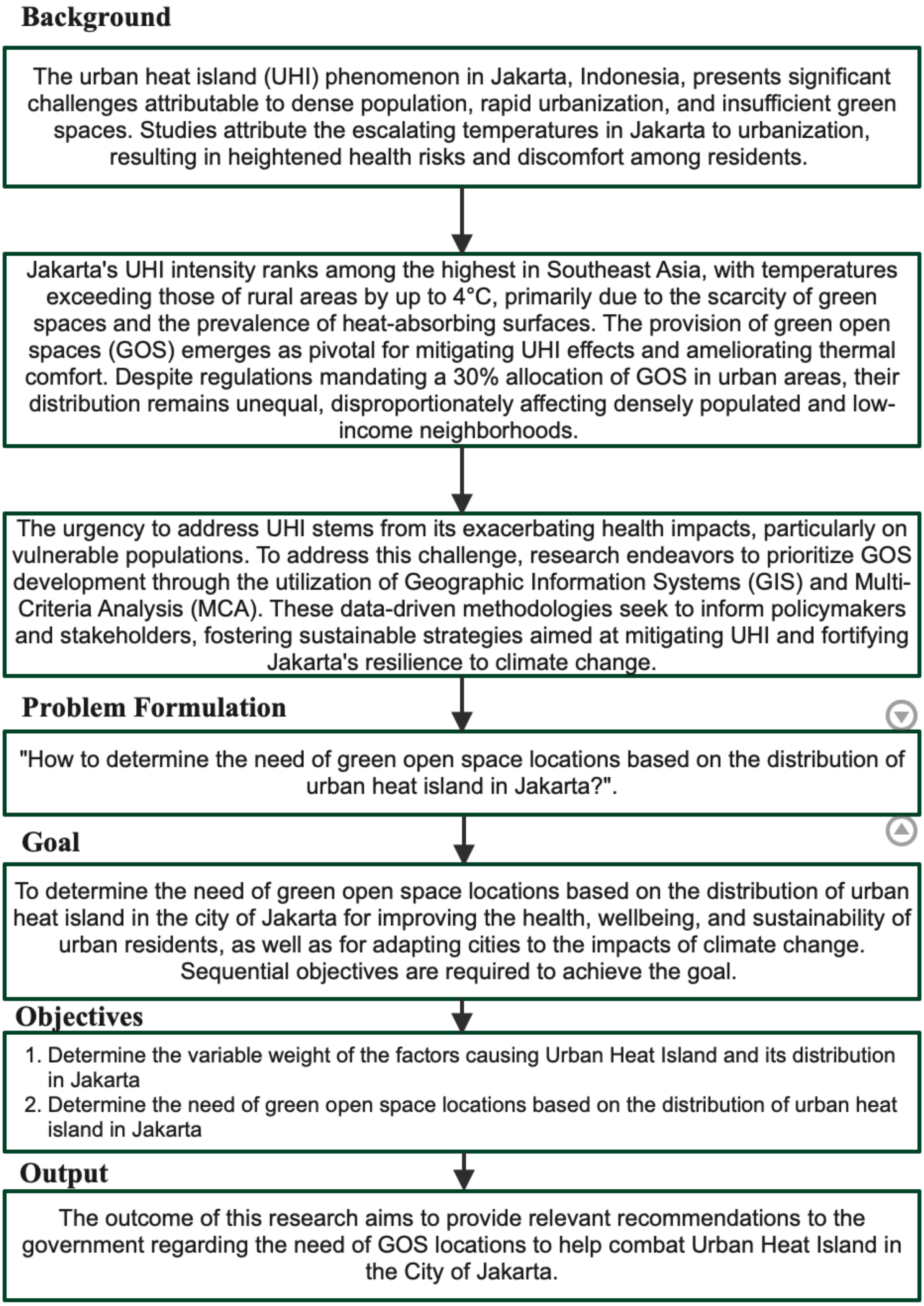


Figure 2 Research Framework

Source: Author analysis, 2024

CHAPTER II
LITERATURE REVIEW

2.1 Green Open Space

According to Article 1 of Law No. 26/2007 on Spatial Planning, green open space is defined as an elongated or clustered area with more open use, where plants grow, including both naturally occurring and intentionally planted vegetation. (Ives et al., 2014) defined green open space as publicly owned land allocated primarily for recreation, sports, nature conservation, passive outdoor enjoyment, and public gatherings. This category encompasses public parks, gardens, reserves, forecourts, and squares. Green spaces offer substantial environmental and social benefits in urban areas.

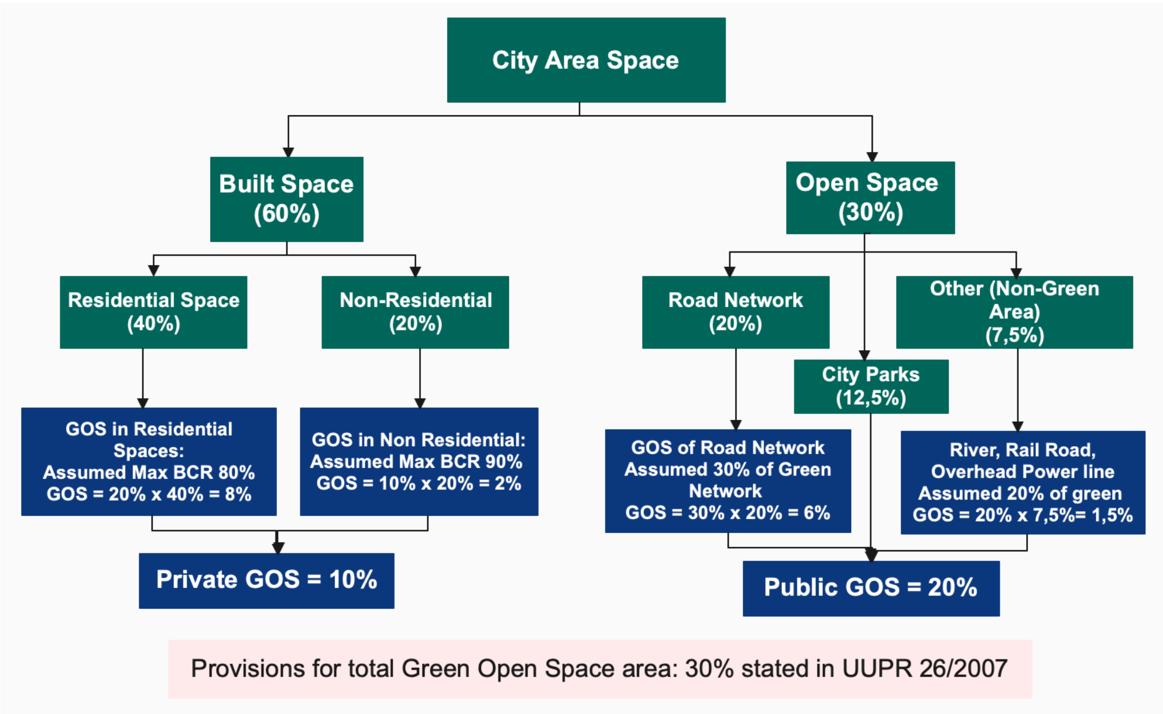


Figure 3 Typology of Green Open Space

Source: Green Open Space Provision UUPR 26/2007

Urban green spaces must meet the standards set forth in Ministerial Regulation Indonesia PU No.5/PRT/M/2008. In urban areas, there needs to be at least 30% of the total area made up of green open space. This thirty percent is split between 10% of privately owned green space and 20% of government-provided green space. The calculation for the area of green open space based on the population is determined by multiplying the number of residents by the standard area of green open space per capita, which is 20 m² per person.

Physically, green open space can be categorized into natural green open space, such as wild habitats, protected areas, and national parks, and non-natural or built green open space, like parks, sports fields, and flower gardens. Functionally, green open space serves ecological, socio-cultural, aesthetic, and economic purposes. Spatially, green open spaces can follow ecological patterns (clustered, elongated, scattered) or spatial patterns aligned with the hierarchy and structure of urban space (Prihandono, 2009).

The DKI Jakarta Provincial Government (Pemprov) state that the area of green open space (RTH) in the capital city area reached 33.34 million square meters or only 5.2% of the total area of the province. of which there is still 24.8% of the RTH area needed. For this reason, there is a study regarding the minimum required area for each unit as follows.

Table 1 Minimum Needs for Green Open Space in Urban Area

No	Unit Environment	Type of GOS	Minimum Area/Unit (m2)
1	250 people	Neighbourhood Park (Taman RT)	250
2	2.500 people	Neighbourhood Park (Taman RW)	1.250
3	30.000 people	Sub-District GOS	9.000
4	120.000 people	District	24.000
5	480.000 people	City Park	25.000
		Urban Forest	

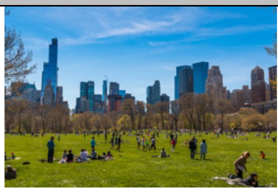
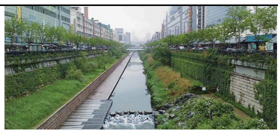
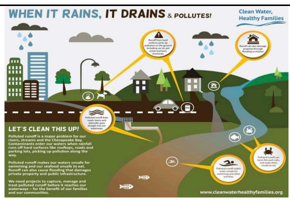
Source: Minister of Public Works Regulation No.05/PRT/M/2008

Green Open Space (GOS) is crucial for maintaining environmental balance and human well-being. Its primary function is ecological, contributing to the microclimate and ensuring smooth operation of natural air and air circulation systems. The role of the eccentric function is also large, starting from the social and cultural, economic, and aesthetic fields. Other than that, in Urban Heat Island phenomenon, Green open spaces can significantly contribute to reducing the urban heat island (UHI) effect (Semenzato & Bortolini, 2023). Urban green spaces (UGS) can provide local cooling and reduce UHI, but a comprehensive exploration of their diverse cooling effects is still needed (Li et al., 2022). According to (Lie et all.,2022) Studies have shown that green spaces, accounting for only about 30% of the study area, can reduce the average land surface temperature by 1.32°C. The spatial features of green spaces, such as area and shape complexity, have a significant influence on their cooling effect (W. Liu et al., 2022).

2.1.1 Type of GOS

In terms of spatial structure, green open spaces can adhere to ecological patterns (such as clustered, elongated, or spread out) and planning patterns that align with the hierarchy and structure of urban space. The following are several examples of types of Green Open Space that can be applied in urban areas:

Table 2 Type of Green Open Space

No	Type		Definition
1.	Urban Green Parks		These are open spaces designed for recreation, relaxation, and community gatherings (De Haas et al., 2021).
2.	Blue Space		This refers to areas dominated by surface waterbodies, such as lakes, reservoirs, rivers, and canals (Hu & Li, 2020).
3.	Linear space/ Greenway		This pertains to green corridors and routes within the urban area, such as rights of way, riverside walks, and cycle paths(Lyapin & Druzhinina, 2019).
4.	Green infrastructure		This includes features that add greenery to buildings and hard surfaces in the urban area, such as green roofs, rain gardens, and street trees (Tanuwidjaja & Chang, 2017).
5.	Urban Forest		This refers to a collection of trees within a city, town, or a suburb (Maleknia et al., 2013).
6.	Community Gardens		Community gardens are shared spaces where individuals or groups can cultivate fruits, vegetables, herbs, and flowers. These gardens promote community engagement, food

No	Type		Definition
			security, and environmental sustainability (Okvat & Zautra, 2011).
7.	Green Roofs		Green roofs are vegetated rooftop spaces installed on buildings. They provide insulation, reduce stormwater runoff, improve air quality, and mitigate the urban heat island effect (Ghofrani et al., 2017).

Source: Author Analysis, 2024

There are a variety of factors, including the urban context, community needs, environmental impact, spatial planning regulations, climate considerations, budget and resources, and long-term sustainability that are related to GOS maintenance, must be considered when deciding what kind of green open space to build.

2.2 Urban Heat Island

2.2.1 Definition of Urban Heat Island

UHI refers to the temperature difference between an urban area and its surrounding rural area (Oke, 1982). Urban Heat Islands (UHIs) are a consequence of urban climate and are regarded as one of the most significant environmental challenges of the 21st century (Abdi et al., 2023). UHI formation is caused by the manifold changes in cities due to urbanization, such as artificial surface cover and anthropogenic heat loss (Menberg et al., 2013). The major impacts of Urban Heat Islands (UHIs) include accelerated climate change, higher energy consumption, increased emissions of air pollutants and greenhouse gases, reduced human health and comfort, and degraded water quality. It has been found that rising urbanization can intensify UHI effects and reduce the concentration of surface aerosol materials (Tao et al., 2015; L. Xu et al., 2019). UHIs are typically measured using Land Surface Temperature (LST), which captures the temperature of the Earth's surface, including roads, buildings, and other impervious surfaces (Bokaie et al., 2016).

The distinction between rural and urban areas is frequently referred to as UHI. This can also be quantified to take local and regional climate change on urban surfaces into account. The land surface temperature value was utilized to calculate the UHI. Following is the formula to estimate calculated UHI (Rahman et al., 2022).

$$UHI = \frac{LST - LSTm}{SD}$$

Where:

- UHI = Urban Heat Island
- LST = Land Surface Temperature
- LSTm = Mean of Land Surface Temperature
- SD = Standard Deviation of temperature

2.2.2 Indicators of UHI

Several indicators are used to map out the spread of Urban Heat Island (UHI) and pinpoint the main causes of it. The indicators have been used to previous UHI studies. These indicators are often used to analyse the distribution of UHI across various urban regions. Additionally, the AHP approach will be used to analyse this indication to give a thorough knowledge of the primary variables causing UHI and to aid in the development of efficient mitigation methods.

A. Land Surface Temperature

LST is a critical parameter in understanding and studying urban heat islands. Land Surface Temperature (LST) is defined as the temperature condition of the outer part of an object on the ground surface, including natural and artificial features like soil, water bodies, vegetation, roads, buildings, and other land cover elements. LST is typically measured using remote sensing technologies, such as satellite-based sensors, and is an essential component in assessing the spatial distribution and intensity of UHIs. Land surface temperature (LST) is commonly used to measure the intensity of the SUHI effect (Wang et al., 2023). LST is a dynamic variable that changes throughout the day and night due to solar radiation, heat absorption, and radiative cooling. During the day, urban surfaces, like asphalt and concrete, can absorb and store heat, leading to elevated LST. At night, these surfaces release heat more slowly than natural landscapes, resulting in higher nighttime LST values within urban areas (Hu & Li, 2020; Schwarz et al., 2011; Siswanto et al., 2016).

There are many kinds of classifications of land surface temperature values used by previous researchers. This class difference is due to differences in the objectives of the research. In this study, we will use the most frequently used general classification. The following is the LST classification table that will be used as follows.

Table 3 Land Surface Temperature Classification

No	Temperature Threshold (°C)	Category
1	< 21	Very Cold
2	21 – 24	Cold
3	24 – 28	Cool
4	28 – 32	Hot
5	> 32	Very Hot

Source: (Himayah et al., 2020)

Understanding LST is crucial for a comprehensive analysis of UHIs because it allows for the quantification of temperature differences between urban and rural environments. LST data can be used to monitor UHI formation, assess the effectiveness of mitigation strategies, and guide urban planning to reduce UHI impacts.

B. Land Use Land Cover (LULC)

Land use refers to the human activities and functions that take place on a particular piece of land. It involves the allocation and management of land for various purposes, such as residential, commercial, industrial, agricultural, recreational, and natural or open space use. Land use decisions have significant implications for the environment, socio-economic development, and quality of life in each area. Land use change influenced by population density through urbanization. The conversion of natural land cover to fulfil human requirements owing to expanding population into pavement, buildings, and other impermeable surfaces that absorb and retain heat adds to the UHI phenomena (Fortuniak, 2009). Land use is closely related to the formation and exacerbation of UHIs. The distribution and types of land use in urban areas can significantly impact local temperatures and climate. The land use classification system was created by the (National Landuse Database, 2006) to help identify land use locations. The following is the classification of Land Use as follows.

Table 4 Land Use Classification

No.	Land Use Classification	Class
1.	Agricultural	1. Field crops
		2. Ploughed field
		3. Fallow land
		4. Horticulture and Orchards
		5. Improved pasture
		6. Field Margin

No.	Land Use Classification	Class
2.	Woodland	1. Conifer woodland
		2. Mixed woodland
		3. Broadleaved woodland
		4. Undifferentiated young woodland
		5. Scrub
		6. Felled woodland
		7. Land cultivated for afforestation
3.	Unimproved Grassland and Heathland	1. Unimproved grassland
		2. Heathland
		3. Bracken
		4. Upland mosaic
4.	Water and Wetland	1. Sea/Estuary
		2. Standing water
		3. Running water
		4. Freshwater marsh
		5. Salt marsh
		6. Bog
5.	Rock and Coastal Land	1. Inland rock
		2. Coastal rocks and cliffs
		3. Inter-dal sand and mud
		4. Dunes
6.	Minerals and Landfill	1. Mineral workings and quarries
		2. Landfill waste disposal
7.	Recreation	1. Indoor recreation
		2. Outdoor recreation
		3. Allotments
8.	Transport	1. Roads
		2. Car parks
		3. Railways
		4. Airports
		5. Docks
9.	Residential	1. Residential
		2. Institutional and communal
10.	Community Buildings	1. Institutional buildings
		2. Educational buildings
		3. Religious buildings
11.	Industrial and Commercial	1. Industry
		2. Offices
		3. Retailing
		4. Storage and warehousing
		5. Utilities

No.	Land Use Classification	Class
		6. Agricultural buildings
12.	Vacant and Buildings	1. Previously developed land which is now vacant
		2. Vacant buildings
		3. Derelict land and buildings
13.	Defence Land and Buildings	

Souces: (National Landuse Database, 2006)

Land cover refers to the physical surface of the Earth, encompassing natural features like vegetation, water, and ice, as well as human-made structures such as buildings and roads. It differs from land use, which describes how people utilize the land, including the arrangements, activities, and inputs they undertake in a certain land cover type to produce, change, or maintain it. The specific types of land cover can vary depending on the context and the classification system used. According to (F. Xu et al., 2017) Here are some common categories of land cover:

Figure 4 Land Cover Classification

Type	Subtype	Description
Woody vegetation	Riparian forest	Woodland adjacent to water bodies (e.g., the Danube River, backwater, backwater lake and creek)
	Forest	A complex of trees and other woody vegetation not adjacent to the water body
	Copse	A thicket of trees or shrubs
Agricultural land	Arable land	Land where crops such as maize, wheat and rye are sown
	Grassland	Grass-dominated land mown for fodder production or grazed
	Orchard	Garden with fruit trees close to settlements
Water body	Artificial pond	A gravel pit for extraction of gravel filled with water
	Backwater	A water body periodically or seasonally connected to the main channel
	Backwater lake	A stagnant water body close to and not connected with the main channel
	Creek	A small narrow stream
	Ditch	A long narrow excavation for drainage and irrigation
	River	Danube River
Margin	Field hedge	Closely spaced shrubs and trees in line separating fields from each other
	Field margin	Non-woody vegetation and grass strips in line between fields
	Road hedge	Closely spaced shrubs and trees in line separating roads from adjoining fields or other facilities
	Road margin	Non-woody vegetation and grass strips in line separating road from adjoining fields or other facilities
Built-up Land	Vegetated path	Unpaved path covered with vegetation (e.g., in forest, between fields)
	Path	Paved path with concrete or other surfaces
	Road	Routes with one or more lanes
	Settlements	Houses/homesteads grouped together
	Construction site	Bare land used for construction
	Industrial land	Land used for industrial purposes (e.g., wastewater treatment)

Source: (F. Xu et al., 2017)

Land cover plays a crucial role in the urban heat island (UHI) phenomenon, as it affects the amount of heat absorbed and released by urban surfaces. (Rizki et al., 2024; Semenzato & Bortolini, 2023) studies have shown that the type and distribution of land cover can significantly influence the magnitude of UHI. For example, the presence of vegetation, such as green roofs and walls, can help mitigate UHI by providing shade, cooling through evapotranspiration, and reducing the urban heat island effect.

The physical nature of land (land cover) and human activities on the land (land use) are included in Land Use and Land Cover (LULC), which is frequently cited as a variable combined. In remote sensing applications, these combined variables are typically used to analyse and forecast changes in patterns of land use and cover. The following table shows the class parameters for the LULC classification that adopting by the previous research.

Table 5 LULC Classification

Class	Classification
1	Waterbodies
2	Vegetation
3	Agriculture
4	Vacant Land
5	Built-up

Source: (Ahirwar et al., 2020; Mukesh Kumar et al., 2018; Pokhrel, 2019)

C. Vegetation

Vegetation refers to plant life, including various types of plants, trees, shrubs, grasses, and other forms of greenery that grow in a particular geographic area or ecosystem. Vegetation is a fundamental component of the Earth's natural environment and plays a crucial role in many ecological processes and human interactions with the environment. Vegetation can be quantified using various indices, such as the Normalized Difference Vegetation Index (NDVI), which is a widely used metric to quantify the health and density of vegetation. NDVI is calculated using the formula:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Where NIR stands for near-infrared radiation and Red stands for red light. This formula measures the difference between the reflectance of near-infrared and red light, which is reflected by vegetation. The result is a value between -1 and +1, where:

Table 6 NDVI Classification

No	Value	Category
1	< - 0.0206 to – 0.0266	Non-Vegetation
2	- 0.026 to 0.192	Very Low Vegetation

No	Value	Category
3	0.192 to 0.294	Low Vegetation
4	0.294 to 0.573	Moderate Vegetation
5	> 0.573	High Vegetation

Source: (Januar et al., 2016; Peraturan Menteri Kehutanan Nomor P.32/Menhut-II/2009, n.d.)

Direct and indirect effects of vegetation on urban thermal energy balance exist (Gunawardena et al., 2017). It immediately influences the microclimate by lowering local and surface air temperatures, which then has an impact on air temperatures over larger areas. The conversion of agricultural areas into commercial and industrial zones contributes to the Urban Heat Island (UHI) phenomenon (Jang et al., 2020). Therefore, Vegetation plays a crucial role in mitigating the urban heat island (UHI) effect by providing natural cooling, shading, and evaporative cooling processes.

D. Air Temperature

Air Temperature (AT) in the context of Urban Heat Islands (UHIs) refers to the temperature of the air near the ground, typically measured at a height of about 1.5 meters (5 feet) above the surface. This temperature is influenced by the urban environment and can be significantly warmer than the air temperature in surrounding rural areas due to the urban heat island effect (Jabbar et al., 2023). According to the studies of air temperature in Jakarta, shown that is significantly higher than in surrounding rural areas due to the urban heat island effect. This is caused by the degradation of Green Open Space (GOS) and the high percentage of built-up land area in Jakarta (Yunita et al., 2022). During 2001-2014, the surface temperature in Jakarta increased by 2-4°C, while the air temperature also increased by 2-3°C. Regions with green open space have lower surface temperatures, with a difference of roughly 3.2°C compared to built-up areas (Rushayati et al., 2016). Here is the category of temperature.

Table 7 Temperature Threshold Category

No	Temperature Average (°C)	Classification
1	20 – 24	Low
2	25 – 30	Normal
3	31 - 35	High

Source:(Adeanti & Harist, 2018)

E. Rainfall

Rainfall is the precipitation of water droplets from the atmosphere to the Earth's surface. It occurs when atmospheric water vapor condenses into droplets heavy enough to fall due to gravity. Rainfall is a crucial part of the water cycle, replenishing freshwater in rivers, lakes, and aquifers. It supports plant growth, influences weather patterns, and is vital for various ecosystems. Following is the table shown the parameter of rainfall classification (mm/year).

Table 8 Rainfall Intensity

No	Rainfall (mm/year)	Category
1	< 1000	Very Low
2	1000 – 1500	Low
3	1500 – 2000	Moderate
4	200 – 2500	High
5	> 2500	Very High

Source: (Nugroho et al., 2010)

Rainfall in the context of green open space and urban heat island (UHI) refers to the amount of precipitation that occurs in an area, which plays a crucial role in mitigating the effects of UHI. The correlation between rainfall, green open space, and Urban Heat Island (UHI) is complex and influenced by various factors. Studies have shown that UHIs can enhance heavy rainfall, thunderstorms, and other convective weather in urban downwind areas, leading to increased precipitation rates (Sidek, 2012). However, the relationship between green open spaces and rainfall is more nuanced. Green spaces can increase rainfall through evapotranspiration, which adds moisture to the air, potentially enhancing precipitation (Qiu et al., 2017). On the other hand, the correlation between green spaces and UHI is also important. Green spaces can mitigate UHI by reducing the urban heat island effect, which in turn can affect local rainfall patterns (Wirayuda et al., 2023).

F. Topography

Topography refers to the study of the shape and features of the Earth's surface, including the relief, elevation, and distribution of landforms, water bodies, urban microclimate, and other natural and human-made features. Topographic classification involves the process of categorizing and grouping landforms based on their characteristics, such as height, slope, and surface texture. The following are the characteristics of land in the Topography category based on (Bermana, n.d.) studies.

Table 9 Topography Classification

No	Topography Class	Slope (%)	Height Difference (m)
1	Lowland	0 – 2	< 5
2	Slopping	3 – 7	5 – 50
3	Undulating – Gentle hills	8 – 13	25 – 75
4	Steep hills	14 – 20	50 – 200
5	Very Steep hills	21 – 55	200 – 500
	Steep Mountain	56 – 140	500 – 1000
	The mountain that very steep	> 140	> 1000

Source: (Bermana, n.d.)

According to the studies, topography has a role in the placement of green open space. (Maleknia et al., 2013) shown that land nearest to waterbodies is ideal for the growth of GOS and maintaining environmental health in the area. Topography can help locate regions with the highest cooling potential. For example, Topographic features like hills and valleys can create natural shading and ventilation, which can help reduce the heat load on urban areas. This can be particularly beneficial in cities with dense urban development.

G. Population Density

The population density of Jakarta is defined as the number of people per unit area, typically measured in square kilometres. In Jakarta, the population density is extremely high, with approximately 16,000 residents per square kilometre (Putra et al., 2021). The concentration of people in cities for economic, educational, and social gains resulted in urbanisation, which increased population density in the urban region. Furthermore, urbanisation can have an impact on population density by changing how people are distributed inside cities. For example, urbanisation can result in the construction of high-density residential areas, such as apartments and condominiums, which can contribute to higher population density (Liu & Yamauchi, 2014). Higher population densities often lead to increased urban heat island intensity due to the concentration of heat sources and reduced green spaces. Therefore, it is essential to strategically locate green open spaces to maximize their cooling effects and reduce the urban heat island impact (Li et al., 2022).

According to the studies by (Putra et al., 2021; Siswanto et al., 2023), found that the urban heat island phenomenon in Jakarta is a significant issue, particularly due to the rapid urbanization and lack of green spaces. To address this issue, the city of Jakarta can prioritize the creation and strategic placement of green open spaces to reduce the urban heat island effect. This can involve urban planning strategies like green roofs, green walls, and urban parks, which are part of green open spaces. These measures can help mitigate the heat island effect by providing shade, cooling the air through evapotranspiration, and reducing the overall intensity of the Urban Heat Island effect (Siswanto et al., 2023). According to BPS (Central Bureau of Statistics) there is the formula and classification regarding population density:

$$Population\ Density = \frac{Total\ Population}{Total\ Area}$$

Where:

- Population Density is the number of people per unit area.
- Total Population is the total number of people in the area.
- Total Area is the total area of the land or region being considered.

Table 10 Population Density Classification

No.	Population Density (people/km2)	Category
1.	< 340	Very Low
2.	340 – 500	Low
3.	510 – 1000	Moderate
4.	1001 – 5000	High Density
5.	> 5001	Very High Density

Source: (Made et al., n.d.)

2.3 Based Practice of Green Open Space that have an impact on reducing Urban Heat Island

In Jakarta, the capital city of Indonesia, the urban heat island (UHI) effect poses significant challenges to residents due to the densely built-up environment and high population density. However, the presence of green open spaces plays a crucial role in mitigating this phenomenon and improving urban climate resilience. One study conducted by (Rizki et al., 2024) investigated the role of green open spaces in Jakarta in reducing surface temperatures and found that areas with higher green space coverage experienced lower temperatures compared to densely built-up areas. This highlights the importance of green open space in moderating the UHI effect in the city.

The study in Baghdad city found that Urban Green Infrastructure, including green roofs, green walls, parks, and road trees, can help reduce pollution and significantly mitigate the Urban Heat Island (UHI) effect by up to 4ºC, thereby improving indoor and outdoor thermal comfort (Abdulateef & A. S. Al-Alwan, 2022). Another case study identifies various typologies of GOS and emphasizes the diversity of GOS and their potential impact on UHI mitigation including green industry, greening parking lots, and urban greening (Fardani & Yosliansyah, 2022). This research demonstrates the effectiveness of GOS in reducing UHI by up to 3°C. This highlights the importance of GOS in improving thermal comfort.

Therefore, the strategic placement of green open spaces can enhance natural ventilation and air circulation within urban areas. (Ufaira et al., 2023) found that well-designed green corridors and parks in Jakarta help disperse heat and pollution, lowering localised temperature extremes and enhancing air quality. Other aspect such as accessibility and proximity to road, waterbodies, and the existence of green open space (GOS) need to be considered to determine the priority location of GOS. (Maleknia et al., 2013) discovered that water bodies operate as natural heat sinks, absorbing surplus heat and creating microclimates that help to mitigate the UHI effect in metropolitan areas. The presence of water bodies in parks and along riverbanks enhances the cooling effect of Jakarta's green open spaces. Additionally, the socio-economic benefits of green open spaces contribute to urban heat island mitigation efforts in Jakarta. Research by (Ufaira et al., 2023) emphasized the role of parks and green recreational areas in providing residents with cooler and more comfortable outdoor environments, thus reducing the reliance on energy-intensive cooling systems in buildings.

In conclusion, the existence of green open spaces in Jakarta significantly impacts the urban heat island effect by reducing surface temperatures, improving air quality, and enhancing overall urban liveability. Continued efforts to prioritize green space development and urban greening initiatives are essential for building climate-resilient cities in Indonesia's capital.

2.4 Previous Research

The following is some previous research used in this research.

Table 11 Previous Research

No	Researcher	Research Title	Goals	Variables	Data Sources	Methods	Result
1.	(Putra et al., 2021)	Increasing Urban Heat Island area in Jakarta and its relation to land use changes	Identify changes in UHI areas from 2008 to 2018 and their relation to land use changes.	• Land use 2008-2018 • Land Surface Temperature	• Landsat satellite image in 2008, 2013, and 2018	• Spatial analysis method using ArcGIS • Comparati on method	From 2008 to 2018, the Urban Heat Island (UHI) phenomenon in Jakarta expanded and intensified. The study reveals that developed land uses, such as residential, commercial, industrial, and transportation facilities, have a more significant impact on UHI intensity than undeveloped land uses. Among undeveloped land uses, non-farm green spaces (such as cemeteries, parks, and sports fields) contribute more to temperature increases than agricultural land and water.
2.	(Arifah & Susetyo, 2018)	Determining Green Open Space Priorities based on the Urban Heat Island Effect in the East Surabaya Region	Determine green open space (GOS) priority location (adding green open space in areas that have not yet been built) as well as to reduce urban air temperature and could reduce the effect of urban heat island phenomenon.	• NDVI • Temperature Humidity Index (THI) • Population • Density	• Landsat 8 • Band 4, 5, • 10, 11 • Governance • Agency: • BPS, • Bappeko, • and BMKG.	• Overlay Analysis Technique (for GOS priority location) • Intersect tools (for direction of GOS Priority)	Prioritization of GOS location is based on an overlay between the variables. The GOS priority results taken from overlay scores of 4 (moderate priority) and 5 (high priority), show the need for greening with the concept of green building in built areas, implementation of green lanes, and greening of green open spaces.
3.	(Siswanto et al., 2023)	Spatio-temporal characteristic s of urban heat Island of Jakarta metropolitan	This study provides a thorough analysis of urban heat island (UHI) in Greater Jakarta, those are: • How the intensity of Land Surface (SUHI) and Air	• Land Surface Temperature • Air temperature (day & night)	• Remote Sensing (MODIS & Landsat) • Surface Meteorologi cal Observatory	• Spatial Analysis using GEE and ArcGIS • UTFVI calculation	Jakarta's Urban Heat Island (UHI) exhibits both similarities and differences in temporal and spatial parameters. The SUHI (Surface Urban Heat Island) profile is most noticeable with an asymmetrical north-south orientation and a symmetrical east-west orientation. The shape of the heat island profile is influenced by urban density and the historical expansion

No	Researcher	Research Title	Goals	Variables	Data Sources	Methods	Result
			Surface air (AUHI)is measure, which both of those variables are important for human thermal comfort and are expected to worsen because of climate change. • The trend of assessment of 20 years SUHI area. • How land use change contributes to UHI development in Jakarta metropolitan.	• Land use change 2004-2020 • Land cover 2004-2020 • Topography			of city development. Over a 20-year period, the SUHI trend shows an increase in nighttime temperatures from March to May and an increase in daytime temperatures from March through August. Significant changes in land use and land cover, such as the expansion of built-up and barren land and the reduction of water bodies and vegetation areas, contribute to global warming. These changes directly lead to rising air and surface temperatures.
4.	(Aryaguna et al., 2022)	Green Open Space Priority Modelling Using GIS Analysis In West Jakarta	By using spatial modelling "Decision trees" and the involvement of experts from relevant agencies in DKI Jakarta, determine the priority location of green open space based on the aspects of ease and need in procurement. Consider the Analytical Hierarchy	• Flood risk • Air quality • Population • Distance of road • Distance of Water sources • Building density • Distance to GOS asset • Land Subsidence	• Literature • Government agency • Field survey	Decision tree methods, namely: • GIS-MCA • AHP	The outcome, which was analysed using the decision tree method in this study, indicated some promise for GOS in relation to the variables used: • in terms of the ease of procurement: land that hasn't been developed, making it simpler for the government to buy and acquire land, especially for organisations involved in land procurement. • Land based on needs: To enhance environmental quality, avert calamities, and provide environmentally friendly public facilities, GOS is necessary.

No	Researcher	Research Title	Goals	Variables	Data Sources	Methods	Result
			Process (AHP) when determining the rules in the decision tree.				• Interviews with the community regarding the urgency of the need for GOS have revealed that parks are more needed than other types of GOS. The society, particularly in densely populated areas, requires parks as a place for children to play, gather, learn, and socialise.
5.	(Marsawal et al., 2021)	Green Open Space Planning in Improving the Quality of Space in the Mamuju Urban Area	This research concentrates on the development of green open spaces in the Mamuju Urban Area to reduce greenhouse gas emissions while preserving the spatial quality of the area. Analyzing emission potential will guide the planning of green spaces in Mamuju.	• Disaster Prone • Land Use • Population Density • Road Network	• Survey and Direct Observation	• Quantitative descriptive • AHP method • ArcGIS Overlay • Landsat 8 year 2020	From 2016 to 2020, the amount of Green Open Space (GOS) in the Mamuju Urban Area decreased. Analysis using AHP methods revealed that the emission potential is categorized as very high, primarily in mixed designation zones. The discussion indicates that GOS planning for the Mamuju Urban Area should allocate 49.04% to "private green open space" and 40.04% to "public space."

Source: Author Analysis, 2024

The five journals analysed focus on various aspects of urban heat island (UHI) and green open space (GOS) in Jakarta. While there are differences between these journals' specific objectives, approaches, and conclusions, there are also commonalities in their discussion, namely:

1. Urban Heat Island (UHI): All five journals deal with UHI, exploring its characteristics, trends, and impacts on the environment and human comfort.
2. Land Use Changes: Changes in land use are a common theme across the journals, highlighting their effects on UHI intensity and distribution.
3. Remote Sensing and GIS: Many of the journals employ remote sensing and GIS techniques to analysed UHI and GOS, demonstrating the importance of spatial analysis in understanding urban environments.
4. Sustainable Planning: The journals emphasize the need for sustainable planning and resilience in urban development, particularly in the context of UHI and GOS.

The journals collectively emphasize the importance of understanding UHI and its relation to land use changes. They also highlight the need for sustainable planning and resilience in urban development. Given this background, these journals related to the research aims to identify priority locations for green open spaces in Jakarta based on the distribution of UHI.

The research will use weighted overlay and remote sensing methods to assess the distribution of UHI and identify the priority location for Green Open Space in Jakarta to reduce UHI. This will assist in identifying high-intensity UHI by utilising the Analytic Hierarchy Process (AHP) approach to identify the variable that becomes the priority factor of the UHI phenomena in Jakarta. The tools intersect method on ArcGIS is then applied to establish the GOS priority location. Expert judgement and decision tree techniques will also be used in the study to determine the priorities sites according to variables combined with previous findings.

The results of this study will give Jakartan politicians and urban planners information that can help them to develop green open space initiatives that address to the specific needs of various regions in Jakarta. The research attempts to make Jakarta's urban environment more resilient and sustainable by combining UHI with GOS planning.

2.5 Synthesis of Research

The theories discussed in this chapter are combined in a synthesis of the literature to develop a set of variables and indicators that will serve as the basis for the analysis carried out in this study. The primary goal of this synthesis is to pinpoint the variable that priority factor that impact the Urban Heat Island (UHI) phenomena in Jakarta and map out its distribution to find a suitable priority location for Green Open Space (GOS).

However, some variables have been added or modified to fit aspects of determining the priority location of GOS based on UHI distribution of this study area. Determining priority's location of GOS was developed by putting into Temperature Humidity Index (THI), vegetation (NDVI), population density, building density, accessibility and proximity to road and waterbodies, and accessibility and proximity to the existence of GOS. While taking into consideration the Land Surface Temperature (LST), Land Use, Land Cover, Vegetation, Air Temperature, Rainfall, Topography, and Population Density, the variable is determined as the main factors impacting UHI. Based on the theoretical review that has been compiled, the synthesis of this research literature can be used as variables to support the research "Determining the need of Green Open Space Location based on distribution of Urban Heat Island in Jakarta" can be seen in the following table.

Table 12 Synthesis

Aspect	Variables	Sources
Factors causing Urban Heat Island	Land Surface Temperature (LST)	(Putra et al., 2021; Siswanto et al., 2023)
	Land Use Land Cover (LULC)	(Siswanto et al., 2023; Ufaira et al., 2023)
	Vegetation	
	Air Temperature	
	Topography	
	Rainfall	(Sidek, 2012)
	Population Density	(Zhou & Chen, 2018)
Note: The first objective will use this variable to determine which variable has the biggest impact on the causes contributing to Jakarta's Urban Heat Island. In this analysis, the AHP approach will be applied.		
Determine the Locations needed for Green Open Space	Land Surface Temperature (LST)	(Muzaky & Jaelani, 2019)
	Land Use Land Cover (LULC)	(Marsawal et al., 2021; (Arifah & Susetyo, 2018)
	Vegetation	(Aryaguna et al., 2022)
	Population density	(Marsawal et al., 2021; Ufaira et al., 2023)
Note: These elements will be analysed in the second objective to determine the need of GOS location in Jakarta. ArcGIS overlay will be utilised for the analysis, and data will be entered based on the literature review and common research parameters.		

Source: Author Analysis, 2024

CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Approach

Based on the methodological approach, this research employs a positivistic approach, which is a scientific methodology based on facts, theories, and fundamental concepts tailored to field conditions. According to the positivistic approach, symptoms/phenomena can be defined, are relatively fixed and tangible, can be observed and quantified, and the link between symptoms is causative (Sugiyono, 2011). Understanding the distribution of urban heat islands (UHI) requires an emphasis on the collecting of empirical data. One can accurately assess UHI in different urban regions by measuring empirical data, such as land surface temperature (LST), vegetation, rainfall, air temperature, and land use types.

In this study, a theoretical framework was developed based on theories, fundamental concepts, and previous research that were relevant to the study, and the theory was then synthesized into variables in the study. Based on theoretical research, several criteria must be addressed when identifying the intensity of the Urban Heat Island and determining the need locations of Green Open Space in Jakarta. The data obtained from these factors is then assessed and analysed to create conclusions and responses to research questions.

3.2 Research Type

This research is included in the type of quantitative descriptive research, namely the determination of the need of GOS locations based on the distribution of UHI which has been determined by the relevant variables analysed by the GIS technique, namely Tools Intersect using ArcGIS, where this tool combines the geometry of the input layers and produces features that contain information from all the input layers. According to (Sugiyono, 2011) descriptive research is a method that functions to describe or give an idea of the object under study through data or samples that have been collected as they are without conducting analysis and making generally applicable conclusions. This description is to explain related to the results of the analysis of the criteria of the criteria of determining the need locations of GOS based on the distribution of UHI and the process of selecting the GOS location.

This study chose a quantitative approach because the analysis was carried out to achieve goals and objectives by processing numerical data. The factors of the theoretical study results will be weighted to determine the weight of the factors that are the main factors in the distribution of UHI in Jakarta, then the result will be used to determine the distribution of UHI in Jakarta. Other than that, to answer the second objective, tools intersect on ArcGIS will be used.

3.3 Research Variable

The variables of research will be investigated and might be qualitative or quantitative. The variables are determined based on the findings of a literature study that took into consideration theories, concepts, previous research, and the current conditions of the research field. The table below contains a list of research variables, along with operational definitions for each variable:

Table 13 Research Variable

Objective	Aspect	Variables	Operational Definition
Determine the variable weight of the factors causing Urban Heat Island and its distribution in Jakarta.	Factors causing Urban Heat Island.	Land Surface Temperature (LST)	The temperature of the top layer of soil, which can be affected by various factors such as solar radiation, humidity, vegetation, and human activities.
		Land Use Land Cover (LULC)	Land Use Land Cover in Jakarta, includes various activities such as agriculture, housing, industry, forestry, and infrastructure.
		Vegetation	A collection of plants that grow in a certain area. Examples of vegetation are tropical rainforests, grasslands, and tundra.
		Air Temperature	Air temperature measures how hot or cold the atmosphere is at a specific location and time. It is influenced by factors such as solar radiation, altitude, and weather conditions. For example, air temperature might be 25°C during the day in the tropics.
		Topography	Physical characteristics of the land surface, including shape, altitude, and geographic features such as mountains, hills, valleys, plains, and rivers.
		Rainfall	The amount of water that falls to the earth's surface, Precipitation is measured in millimeters (mm) or inches (in) and is usually recorded over a certain period (daily, monthly, annually).
		Population Density	The number of people living in a given area, usually expressed as the number of inhabitants per square kilometer (km^2) or per square mile (mi^2).
Determine the location of Green Open Space needs based on the distribution of Urban Heat Island in Jakarta	Determine location needs for GOS	Land Surface Temperature (LST)	The temperature of the top layer of soil, which can be affected by various factors such as solar radiation, humidity, vegetation, and human activities.
		Land Use Land Cover (LULC)	Land Use Land Cover in Jakarta, includes various activities such as agriculture, housing, industry, forestry, and infrastructure.
		Vegetation	A collection of plants that grow in a certain area. Examples of vegetation are tropical rainforests, grasslands, and tundra.
		Population Density	The number of people living in a given area, usually expressed as the number of inhabitants per square kilometer (km^2) or per square mile (mi^2).

Source: Author Analysis, 2024

These variables of second objective will then be analyzed using the weighted overlay tool in ArcGIS. Following are the variables class parameters and the description of each class in determining priority location to fulfill the need of green open space, where this parameter was adapting from previous research related.

Table 14 Variable Class Parameter

Variables	Class	Classification	Category
LST	1	< 21 °C	Very Cold
	2	21 °C – 24 °C	Cold
	3	24 °C – 28 °C	Cool
	4	28 °C – 32 °C	Hot
	5	> 32 °C	Very Hot
LULC (Land Use Land Cover)	1	Waterbodies	
	2	Vegetation	
	3	Agriculture	
	4	Vacant Land	
	5	Built-up	
Vegetation (NDVI)	5	< - 0.0206 to – 0.0266	Non-Vegetation
	4	- 0.026 to 0.192	Very Low Vegetation
	3	0.192 to 0.294	Low Vegetation
	2	0.294 to 0.573	Moderate Vegetation
	1	> 0.573	High Vegetation
Population Density	1	< 340 People/km2	Very Low
	2	340 – 500 People/km2	Low
	3	510 – 1000 People/km2	Moderate
	4	1001 – 5000 People/km2	High Density
	5	> 5001 People/km2	Very High Density

Class	Description
5	Very Priority
4	Priority
3	Moderate Priority
2	Less Priority
1	Not Priority

Source: (Ahirwar et al., 2020; Himayah et al., 2020; Made et al., n.d.; Mukesh Kumar et al., 2018; Peraturan Menteri Kehutanan Nomor P.32/Menhut-II/2009, n.d.)

3.4 Population and Sample

The population in this study is the entire Jakarta area which has differences in land use and land surface temperature in each location. Sampling in this research was carried out using non-probability sampling techniques. Non-probability sampling is a sampling technique that does not provide an equal opportunity for each element (member) of the population to be selected as a member of the sample (Sugiyono, 2011) In non-probability sampling techniques, there are several sampling techniques used, one of which is Purposive Sampling which is used in this research. Sampling was carried out using a purposive sampling technique based on considerations in accordance with the aims and objectives of the research. In purposive sampling, it is necessary to identify samples or parties who have influence through stakeholder analysis techniques. The first objective of this research is stakeholders who have relevance in determining the weighting of variables which are the main causes of UHI in Jakarta. The stakeholders in question are:

Table 15 Type of Stakeholder

No	Type of Stakeholder	Stakeholder Name
1.	Government	Department of Human Settlements, Spatial Planning and Defence of DKI Jakarta Province (DCKTRP DKI Jakarta)
		Department of Parks and City Forests, DKI Jakarta Province
2.	Academic	Academics that expert on GOS and UHI
3.	Private sector/Community Organisation	Industry/Private parties/Company/ Community Organisation in term of Green Open Space and Urban Heat Island

Source: Author Analysis, 2024

3.5 Data Collection Method

Data collection carried out in this research consisted of primary data collection methods and secondary data collection.

3.5.1 Primary Data

The primary data collection method is a method that uses survey techniques directly to obtain research data. The primary survey aims to obtain opinions from relevant stakeholders in the existence of Green Open Space that affected UHI in Jakarta. The primary survey in this research uses interview related to answering research targets. The interview conducted in this research is structured, the questions in the research are written. Structured interviews are used during AHP analysis to analyse the weight of factors to determine the main causes of UHI in Jakarta. The following is a table of primary data collection along with data sources:

Table 16 Primary Data

No	Type of variable	Data Source	Technique
1.	Variable weight of the factors causing urban heat island in Jakarta	Stakeholder Assessment	Interview
2.	Variables for Determining the Need for Green Open Space Locations Based on the Distribution of Urban Heat Islands in Jakarta	Stakeholder Assessment	Interview

Source: Author Analysis, 2024

3.5.2 Secondary Data

The secondary data collection method is used to obtain secondary data, namely data that has been collected by a person/body/organization without the need for researchers to carry out field observations. This data can be in the form of archived data documents. Secondary data collection was carried out through agency and literature surveys. This research will use the agency survey, it is a secondary data collection method carried out through several agencies that are relevant to the research discussion, namely the Department of Human Settlements, Spatial Planning and Defence of DKI Jakarta Province (DCKTRP DKI Jakarta), BPS DKI Jakarta, and various other sources.

Table 17 Secondary Data

No.	Type of Data	Data Source	Technique
1.	• Land Surface Temperature (LST), • Vegetation Index (NDVI),	Satellite Image LANDSAT 8	Remote Sensing
2.	• Land Use Land Cover, • The existence of GOS, • Topography.	Department of Human Settlements, Spatial Planning and Defence of DKI Jakarta Province (DCKTRP DKI Jakarta)	Agency Survey
3.	• Air Temperature • Rainfall	Meteorology Climatology and Geophysics Council (BMKG)	Agency Survey
4.	Population Growth	BPS DKI Jakarta	Agency Survey

Source: Author Analysis, 2024

3.6 Data Analysis Technique

The data analysis technique in this research is used to achieve predetermined targets and the goal as a basis for drawing conclusions and answering research questions, namely what the main factors are causing UHI in Jakarta based on the results of weighting and prioritization of green open space locations in Jakarta to combat UHI.

Table 18 Data Analysis Method

No.	Data Input	Analysis	Technique	Output
1.	Determine the variable weight of the factors causing Urban Heat Island and its distribution in Jakarta	Interview	AHP method	• Priority factors cause UHI in Jakarta • Map of UHI distribution
2.	Determine the need of Green Open Space locations based on the distribution of Urban Heat Island in Jakarta	• Interview • Satellite Image Landsat 8 • Variable to determine the need locations of GOS	• Remote Sensing • GIS Overlay	• Map of location needed for GOS in Jakarta City

Source: Author Analysis, 2024

3.6.1 Weighting Analysis and Determination of Priority Scale for factors causing UHI and its distribution in Jakarta using Analytical Hierarchy Process (AHP)

A. Analytical Hierarchy Process (AHP)

The AHP (Analytic Hierarchy Process) method is a structured technique for organizing and analysing complex decisions. AHP is one of Multi Criteria decision making method that was originally developed by Prof. Thomas L. Saaty. It breaks down a decision into a hierarchy of sub-criteria, allowing for a more detailed and systematic evaluation of the factors involved. This analysis aims to determine the weight to answer the most influential factors in the occurrence of urban heat islands in Jakarta, which then results from this analysis to help determine priorities for green open space locations.

AHP is often used as a problem-solving method compared to other methods for the following reasons:

a. Hierarchical structure, because of the selected criteria, down to the deepest sub-criteria.
b. Considering validity up to the tolerance limit for inconsistencies in various criteria and alternatives chosen by decision makers.
c. Considering the durability of decision-making sensitivity analysis output.

To carry out AHP analysis, there are 3 principles in it (Supriardi, 2018). Those are including:

1. Identification of the problem and Decomposition

Create a hierarchical structure starting with the main goal. With this principle a complex problem structure is divided into parts hierarchically. Goals are defined from general to specific. In its simplest form, the structure will compare objectives, criteria and alternative levels. This research aims to analyse the weight of factors causing UHI that occurs in Jakarta and their distribution. The next criteria in this research are variables that are factors in the occurrence of UHI.

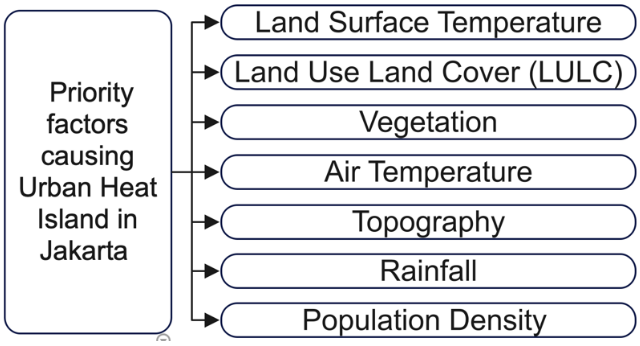


Figure 5 AHP Flow Variable Identification for 1st Objective

Source: Author Analysis, 2024

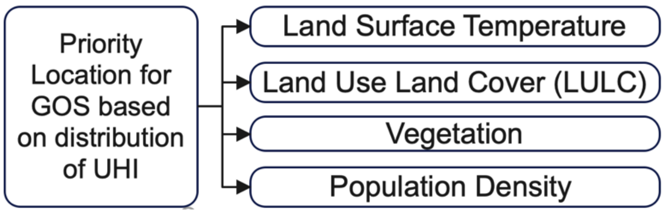


Figure 6 AHP Flow Variable Identification for 2nd Objective

Source: Author Analysis, 2024

2. Comparative Judgement

This technique will be used to construct pairwise comparisons of all currently available elements to create a scale of the elements' relative value. A numerical rating scale is produced by the assessment process. Priorities are obtained through the combination of pairwise comparisons in matrix form.

Table 19 Pairwise Comparison Scale

Numerical Value	Definition	Description
1	Equal importance of both element	Two elements contribute equally
3	Moderate importance of one element over another	Experience and judgment favor one element over another
5	Strong importance of one element over another	An element is strongly favored
7	Very Strong importance of one element over another	An element is very strongly dominant
9	Extreme importance of one element over another	An element is favored by at least on order of magnitude
2, 4, 6, 8	Intermediate value between two adjacent judgment	Used to compromise between two judgments

Source: (Supriadi, 2018)

3. Priority Synthesis

Priority synthesis involves multiplying local priorities by the pertinent upper-level criteria's priorities and adding the results to each element at the level that the criteria affect. The outcome, sometimes referred to as a global priority, is a combination that is used to weight the local priorities of the pieces that meet the lowest criterion. Using an application like Expert Choice on a computer can help with this procedure.

4. Consistency Ratio Test

Consistency ratio is one of the metrics measured in AHP. It will be conducted if CR ≤ 10%, according to the consistency index. Continuity It is anticipated that near-perfect outcomes will lead to almost accurate conclusions. Less than or equal to 10% is the expected consistency ratio, even though perfection is hard to attain (Vargas & St, 2022).

The results of this comparison are then used to calculate the weight of each factor, which is used to find out which variables are the main factors in the occurrence of urban heat islands in Jakarta which can help in determining priority locations for green open space. For example, if the analysis shows that vegetation density is the most important factor in reducing urban heat island effects, then locations with high vegetation density would be prioritized for green open spaces. Similarly, if the analysis indicates that urban heat island intensity is the most critical factor, then areas with the highest urban heat island intensity would be prioritized for green open spaces. By using the AHP method to analyze green open space and prioritize locations for reducing the urban heat island effect, urban planners and managers can make more informed decisions about where to invest in green spaces to maximize their cooling impact on the urban environment.

B. Urban Heat Island Distribution in Jakarta

After weighting was carried out using the AHP method, results were obtained that can show the factors that influence the occurrence of Urban Heat Island in Jakarta. Next, analysed the distribution of Urban Heat Island using Google Earth Engine (GEE) by entering a code script to process the map analysis. This stage requires Landsat 8 data, which is then analysed to calculate the area size based on the UHI classification.

The first stage begins with defining the variables and their functions by determining the date of the analysis period. The UHI analysis in this research will use the 2023 period from January 1st to December 31st. Next, apply the 'mask' variable to filter clouds or remove clouds in the study area, which in this research is the city of Jakarta. After that, the UHI calculation is carried out according to the existing formula by entering the LST value, LST standard deviation and LST mean. Then the map can be visualized.

3.6.2 Analysis of Determining the Need for Green Open Space Locations Using Weighted Overlay

To answer 2nd objective, the variables used will be analyst with AHP from stakeholder perspective. The weighted overlay method in ArcGIS will be used to determine location needed for GOS. This will involve selecting class parameters based on the most widely used standards and guidelines used by previous studies regarding urban heat island distribution indicators, identifying suitable locations, and entering the weighted values obtained from stakeholders from the AHP result.

Five classifications will be used to determine the priority levels: very priority, priority, moderate priority, less priority, and not priority. Furthermore, the intersect tool in ArcGIS must be used to check current land use based on current sub-activities to guarantee that the location needed is appropriate for constructing GOS in Jakarta. This approach will confirm whether the area can be developed as green open space and assist in identifying the kind of green space that is appropriate for development. The sort of green open space to be produced can be changed, for instance, if the zone's primary use is residential or office. This is brought on by dense living quarters and limited open space in urban areas.

3.7 Research Framework

Following is the figure of research framework of this study.

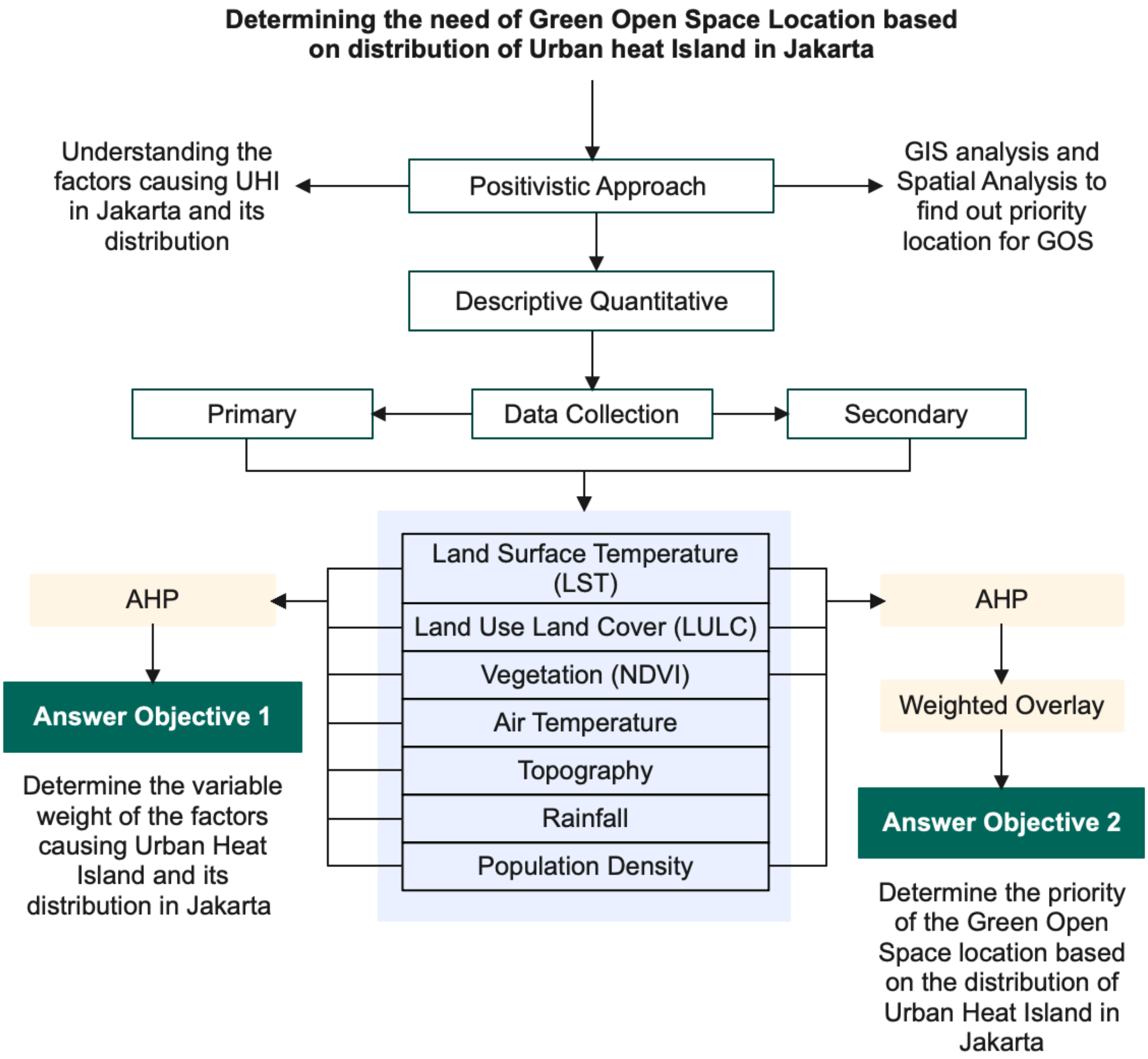


Figure 7 Research Framework

Source: Author Analysis, 2024

CHAPTER IV
Result and Discussion

4.1 Overview of Study Area

4.1.1 Geographical and Administrative of the study area

DKI Jakarta Province is situated between 6º12′ South Latitude and 106º48′ East Longitude. The city of Jakarta is a lowland area with an average elevation of +7 meters above sea level and features several relatively large canals. DKI Jakarta comprises 1 district, 5 municipalities, and 44 sub-districts. This research will examine the City of Jakarta and municipalities in Jakarta as a study area with a total area of five Jakarta cities, namely 650,257 km2 and administrative boundaries as follows:

Table 20 Administration Area of Jakarta

No.	City	District	Total Area (Km2)
1.	**South Jakarta**	Cilandak	**144,942**
		Jagakarsa	
		Kebayoran Baru	
		Kebayoran Lama	
		Mampang Prapatan	
		Pancoran	
		Pasar Minggu	
		Pesanggrahan	
		Setiabudi	
		Tebet	
2.	**East Jakarta**	Cakung	**185,538**
		Cipayunng	
		Ciracas	
		Duren Sawit	
		Jatinegara	
		Kramat Jati	
		Makasar	
		Matraman	
		Pasar Rebo	
		Pulo Gadung	
3.	**Central Jakarta**	Cempaka Putih	**47,565**
		Gambir	
		Johar Baru	
		Kemayoran	
		Menteng	
		Sawah Besar	

No.	City	District	Total Area (Km2)
		Senen	
		Tanah Abang	
4.	**West Jakarta**	Cengkareng	**125,000**
		Grogol Petamburan	
		Taman Sari	
		Tambora	
		Kebon Jeruk	
		Kalideres	
		Palmerah	
		Kembangan	
5.	**North Jakarta**	Cillincing	**147,212**
		Kelapa Gading	
		Koja	
		Pademangan	
		Penjaringan	
		Tanjung Priok	
Total		**44**	**650,257**

Source: BPS, 2024

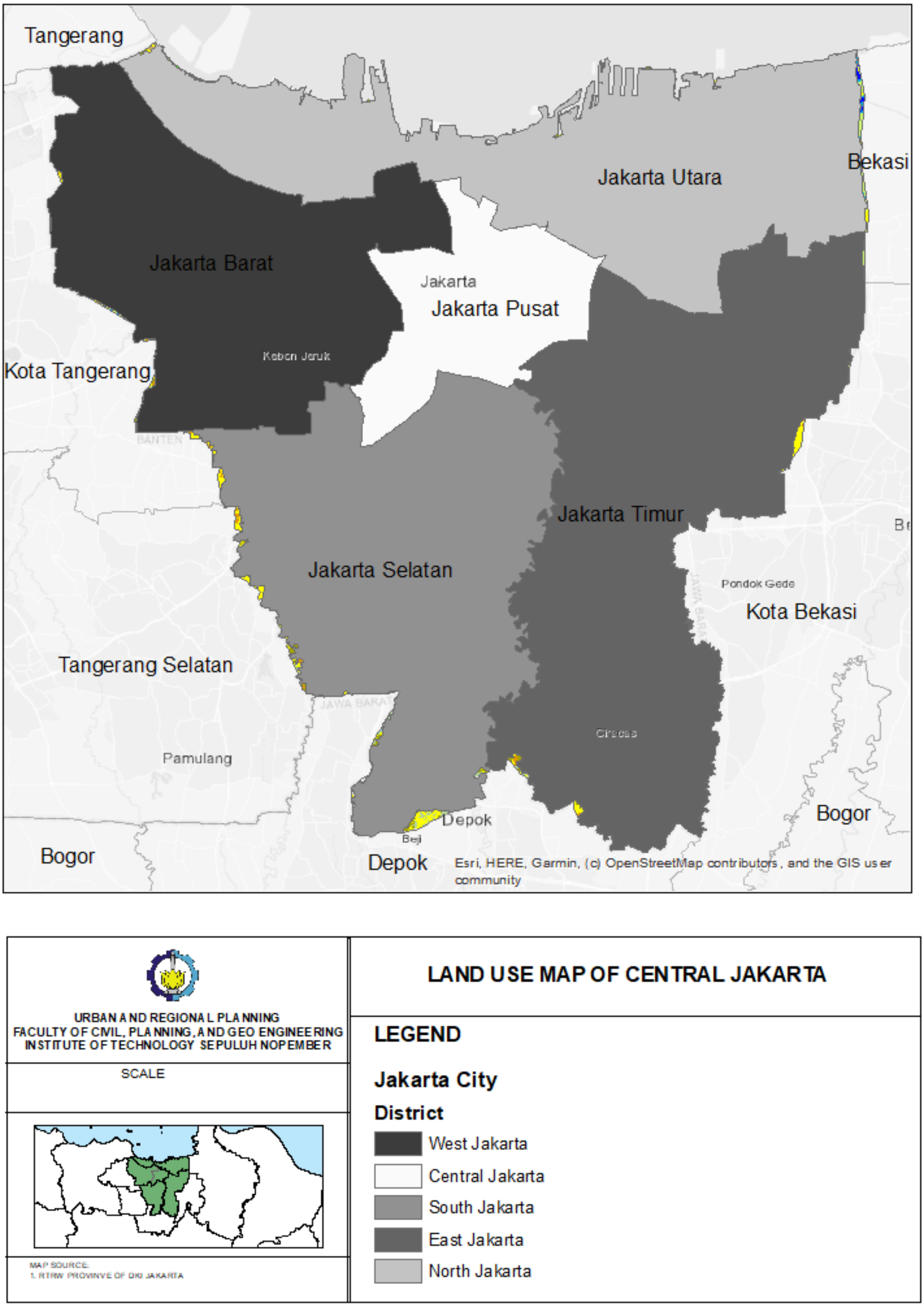


Figure 8 Administrative Boundary Map of Jakarta

Source: Author Analysis, 2024

4.1.2 Topography

The topography of Jakarta is divided into multiple categories based on their height classes, according to the analysis. The lowlands that are between 0 and 10 metres above sea level, as well as the sloping category that is between 5 and 50 metres above sea level, make up most of the Jakarta's topography. This group includes mostly areas near the sea, such as the northern area of Jakarta. However, steep hills dominate Jakarta's southern area. The analysis of the topographic map of Jakarta City is presented in the table and results below.

Table 21 Category of Topography Jakarta

No	Height (m)	Category	Total Area (km2)
1	1 - 10	Lowland/Flat	561,422,984
2	11 - 30	Slope	34,847,777
3	> 30	Steep Hills	188,692

Source: Author Analysis, 2024

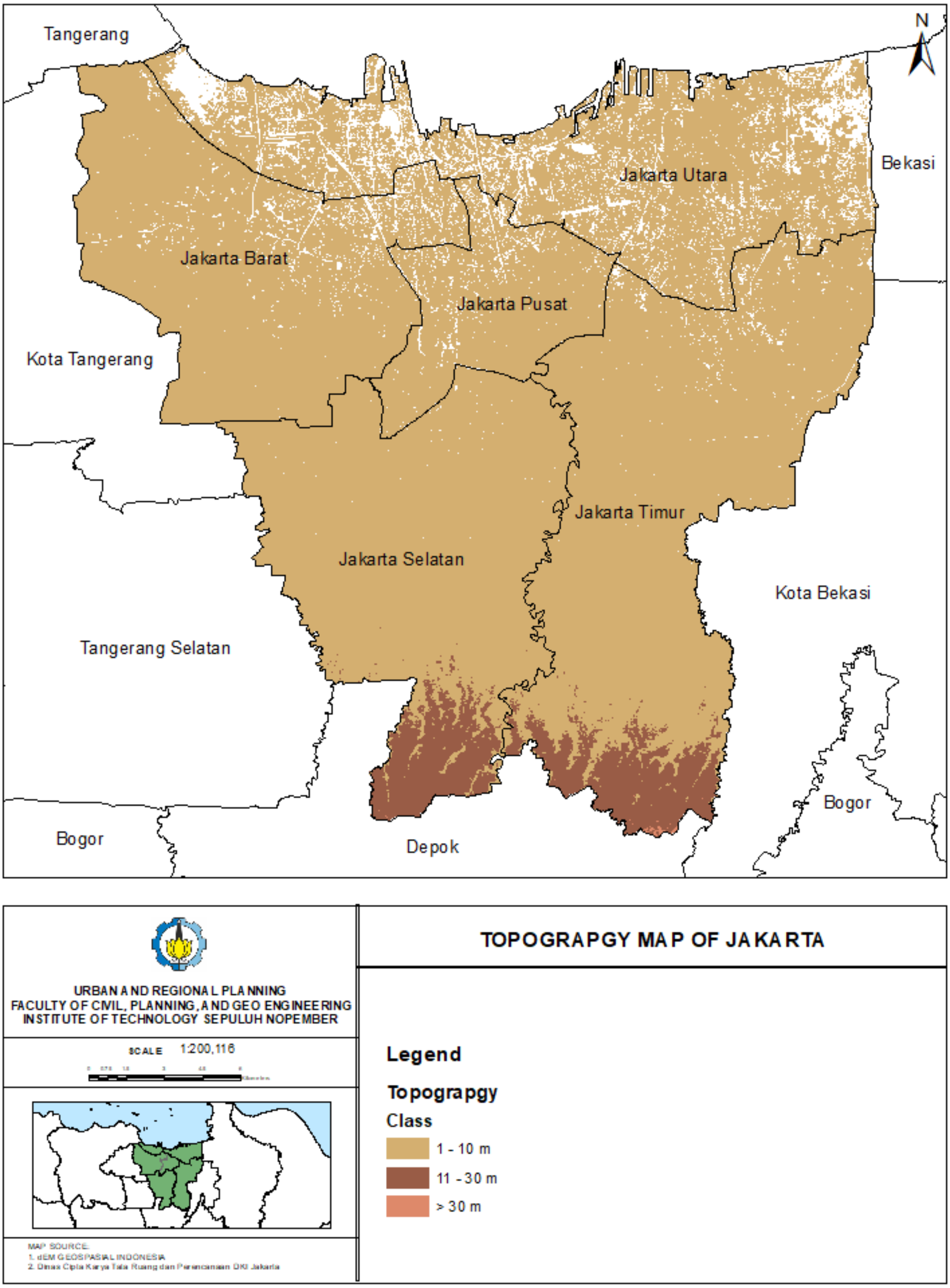


Figure 9 Topography Map

Source: Author Analysis, 2024

4.1.3 Rainfall

Data from the BMKG data are required to generate a rainfall analysis. The Tanjung Priok Meteorological Station and the Kemayoran Meteorological Station are the two meteorological stations located in Jakarta. The table below shows that October has the lowest rainfall value at both sites, whereas February has the highest intensity.

Table 22 Rainfall Intensity per Month

Rainfall 2024	Number of precipitation (mm/month)	
Month	**TJ. Priok Station**	**Kemayoran Station**
January	268.2	170.9
February	**496.1**	**561.3**
March	246.7	236
April	76.9	167.5
May	117.7	106.2
June	90.6	127.2
July	11.7	5.3
August	0	1.8
September	2.7	0
October	**0**	**0**
November	204.1	156.2
December	7	43.3
Total	**1521.7**	**1575.7**
Rainfall Average	**126.808333**	**131.308333**

Source: BMKG, 2024

Following that, an analysis of the average annual rainfall for 2023 was conducted using data from the Tanjung Priok station, which yielded 126.8 mm/year, and the Kemayoran station, which yielded 131.3 mm/year. With an average of 1500 to 2000 mm/year, Jakarta's rainfall goes into the moderate category according to the BMKG rainfall category mm/year. The classes, average precipitation, and rainfall categories that emerged from map analysis are explained in the table that follows. Here are the findings of the table and map.

Table 23 Result of the Rainfall Average in Jakarta 2024

Class of Rainfall	Rainfall Average	Category
3	1,521- 1,575	Moderate

Source: BMKG, 2024

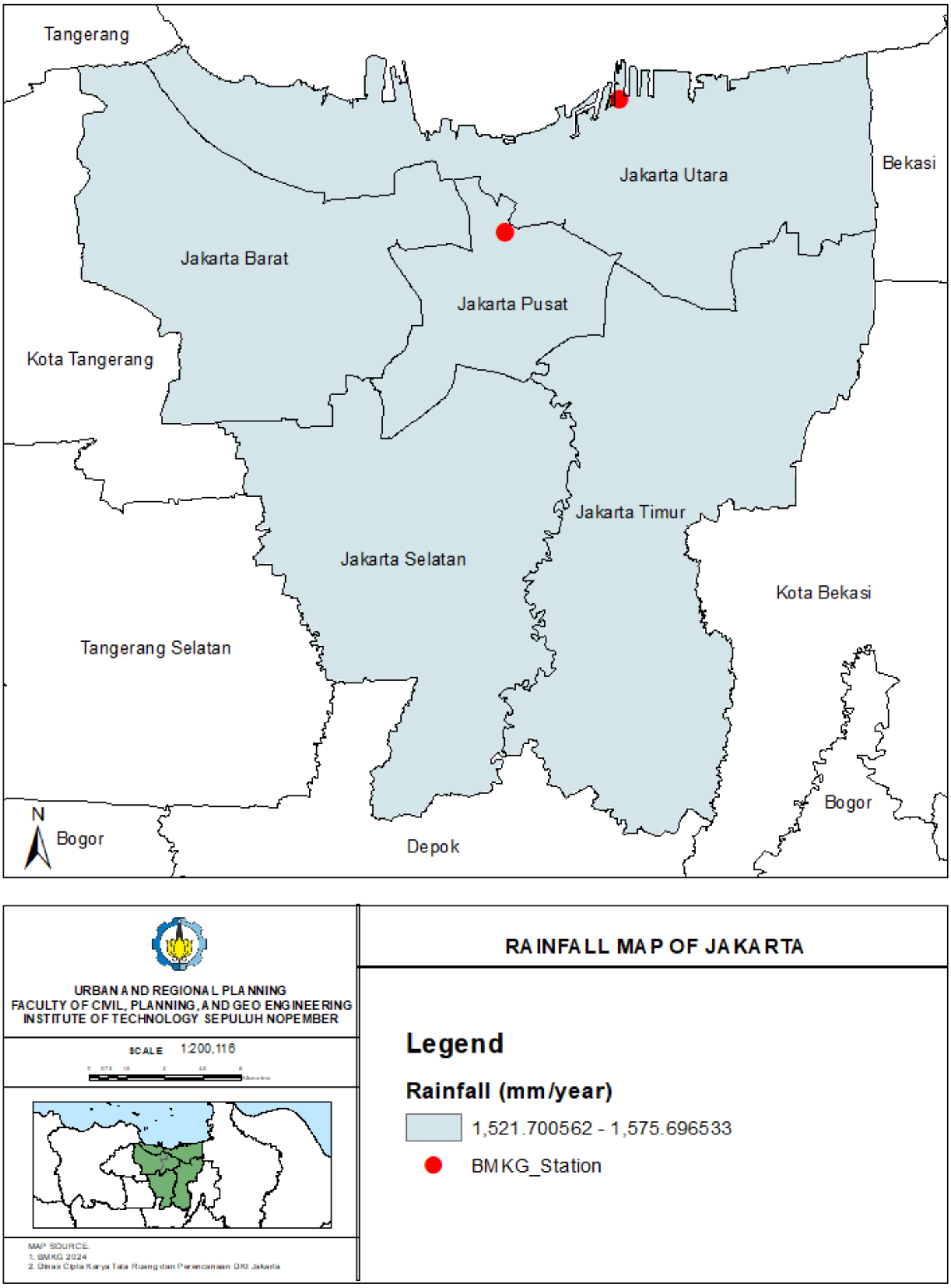


Figure 10 Rainfall Map

Source: Author Analysis, 2024

4.1.4 Air Temperature

There are two Meteorological, Climatic, and Geophysical Agency Stations (BMKG) in Jakarta City: Tanjung Priok Station and Kemayoran Station. The table below shows how the temperature and humidity index at these two stations in Jakarta differ from one another.

Table 24 Observation of Climate Elements at Tanjung Priok Maritime Meteorological Station by Month in DKI Jakarta Province, 2023

Month	Temperature (°C)		
	Min	Average	Max
January	23.4	28.3	33.7
February	23	27.6	33.4
March	24	28.2	32.8
April	25.4	29.4	34.7
May	22.4	29.8	34.8
June	23.5	29.4	34.3
July	**21.2**	**29.2**	**34.3**
August	25.4	29.3	34.2
September	23.2	29.6	36.8
October	**27**	**30.4**	**37.2**
November	24.4	28	35.4
December	24.8	29.8	34.4

Source: BMKG, 2024

Table 25 Observation of Climate Elements at Kemayoran Meteorological Station by Month in DKI Jakarta Province, 2023

Month	Temperature (°C)		
	Min	Average	Max
January	23.6	28.3	34.8
February	23.2	27.4	33.6
March	23.4	27.9	33.8
April	24.6	29.2	34.8
May	25.8	29.5	34.6
June	24.6	29.2	34.4
July	24.6	29	34.6
August	24	29.2	34.8
September	24.2	29.4	36.8
October	25	30.2	36.6
November	24.4	29.5	35.6
December	24.8	29.5	35.6

Source: BMKG, 2024

Based on data from BMKG, Tanjung Priok is the station that needs to be used for map analysis to analyse the air temperature in Jakarta. Tanjung Priok Station, which is in the North Jakarta region, provides relevant data for analysing the city's weather and air temperature. Sea surface temperature and air humidity data, which are crucial for assessing Jakarta's weather and air quality, are among the more precise and comprehensive data available from this station. While Kemayoran Station provides pertinent data as well, Tanjung Priok provides more precise and detailed data for the examination of Jakarta's air temperature map.

As a result, Tanjung Priok Station data will be used in this study's air temperature map analysis. Average temperature data, with a minimum temperature of 21.2 °C and a high temperature of 37.2 °C, will be analysed and processed in ArcGIS. The analysis's findings indicate that Jakarta's water is generally 29 °C on average with normal temperature as the classification. Following is the map of air temperature in Jakarta.

Table 26 Classification Temperature Average in Indonesia

No	Temperature Average (°C)	Classification
1	20 – 24	Low
2	25 – 30	Normal
3	31 - 35	High

Source:(Adeanti & Harist, 2018)

Table 27 Temperature Result in Jakarta

Class	Temperature Average in Jakarta (°C)	Classification
2	29 °C	Normal Temperature

Source: Author Analysis, 2024

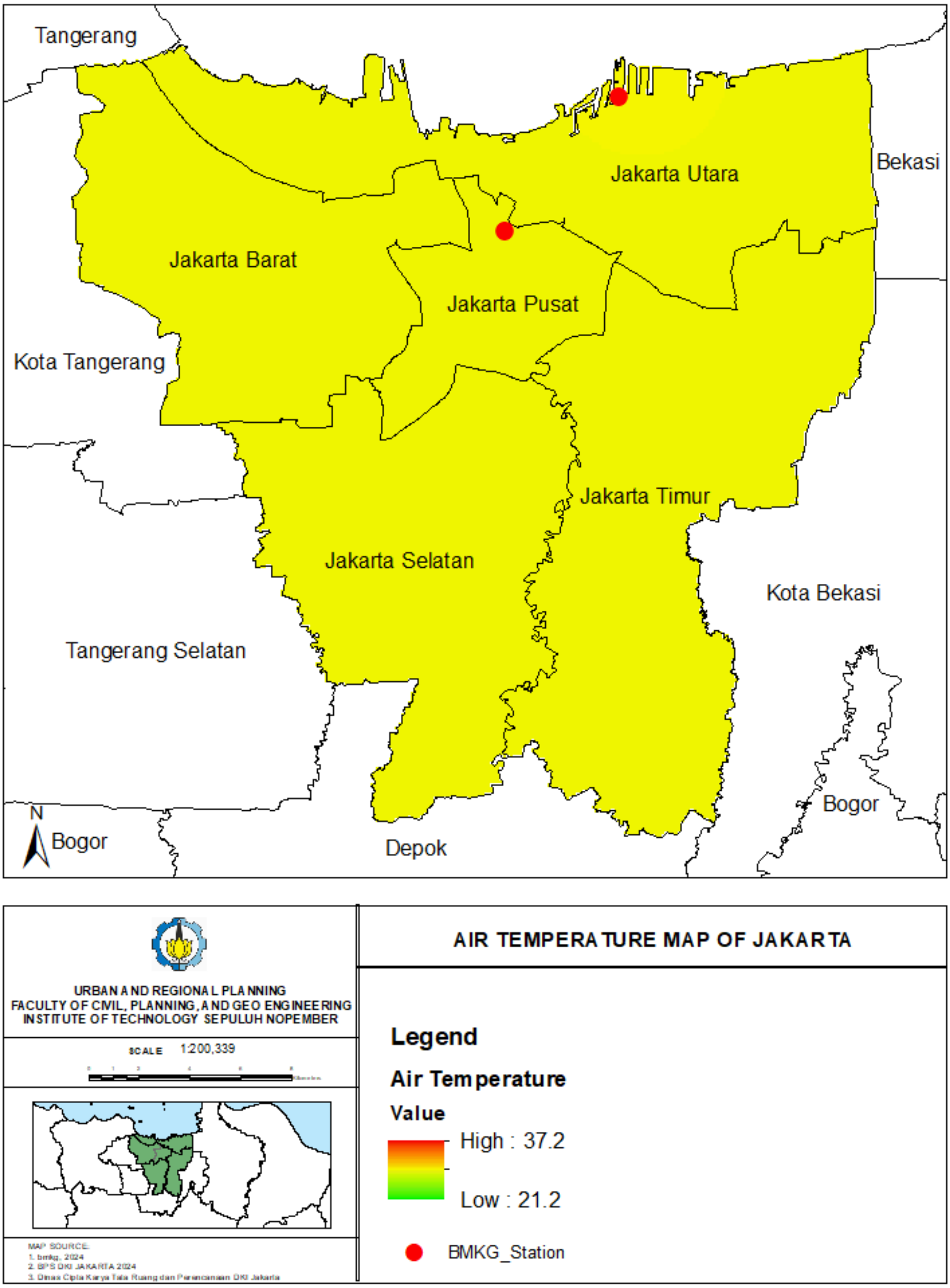


Figure 11 Air Temperature Map

Source: Author Analysis, 2024

4.1.5 Population Density

Jakarta has a population density of about 10,656,137 people per km2, according to BPS Jakarta 2024. With 3,086,010 people per km2, East Jakarta has the most population, while Central Jakarta has the lowest, with 1,044,297 people per km. Based on dividing the entire population by the total area, the population density of each city is shown, with Jakarta having a very high density. It can be seen on the table of the parameter population density that the amount of > 5001 people/km2 is categorized by very high density. Comprehensive data about Jakarta City's population is shown in the table below.

Table 28 Parameter Class of Population Density

No	Population Density (people/km2)	Category
1.	< 340	Very Low
2.	340 – 500	Low
3.	510 – 1000	Moderate
4.	1001 – 5000	High Density
5.	> 5001	Very High Density

Source: (Made et al., n.d.)

Table 29 Population in Jakarta

No	Jakarta City	Total area	Population (people/km2)	Population density (/km2)	Category
1	South Jakarta	144,942	2,230,653	15,390	Very High Density
2	East Jakarta	185,538	3,086,010	16,633	
3	Central Jakarta	47,565	1,044,297	21,955	
4	West Jakarta	125,000	2,479,571	19,837	
5	North Jakarta	147,212	1,815,606	12,333	
Total		**650,257**	**10,656,137**	**16.3875775**	

Source: BPS DKI Jakarta, 2024

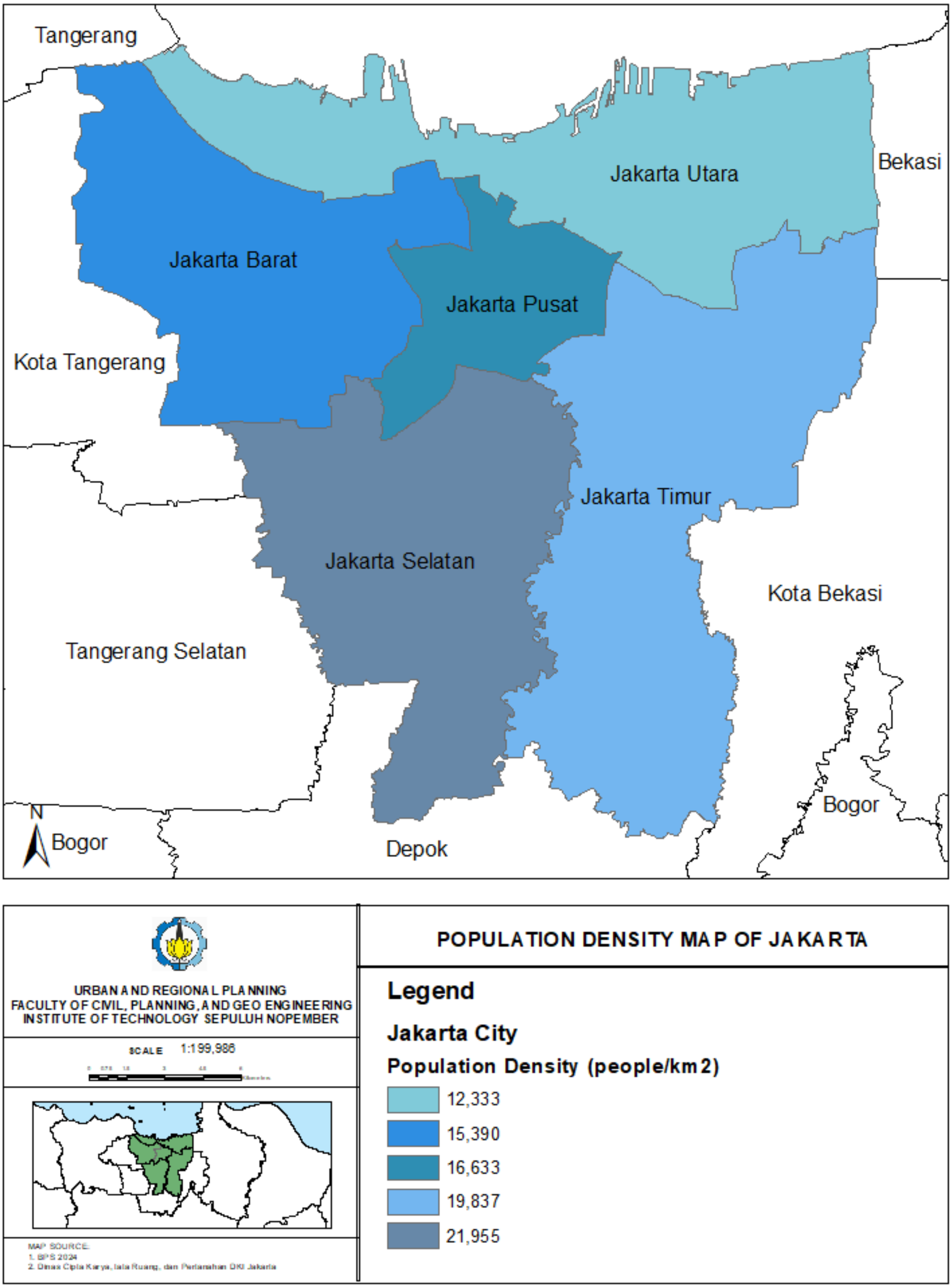


Figure 12 Population Density Map

Source: Author Analysis, 2024

4.1.6 Land Use Land Cover (LULC)

According to data from the DKI Jakarta Cipta Karya Spatial Planning and Planning Service, residential areas cover the majority of Jakarta City's land use, followed by trade and services, and office. Since this area is the capital and the heart of the Indonesian economy, land use is impacted by the bustling activity and mobilisation of land transportation. A table, chart, and map showing Jakarta's land use are shown below.

Table 30 Land Use Classification in Jakarta

No	Land Use	Area (sq.m)
1	Building	22,977,634
2	Socio-Cultural - Museum - Art Gallery - Meeting Hall	1,405,044
3	Lake	1,550,831
4	Horticulture and Greenhouses	3,309,023
5	Urban Forest	906,003
6	Protected Forest	1,862,184
7	Industry	31,862,871
8	Transportation Area - Terminal - Special and Public Airports - Stations - Seaports - Helicopter landing - Pool for Bus, Microbus, Taxi - Transportation Shuttle	4,780,433
9	Religious Facilities - Mosque - Church - Temple - Vihara - Pagoda	4,404,855
10	Garden	613,297
11	Health Facilities - Pharmacy - Medical Hall - Maternity Hospital - Midwife Practice - Clinic - Clinic - Public Hospital	3,167,105
12	Field	1,368,664
13	Greenland	36,213,201
14	Empty Land	36,394,975

No	Land Use	Area (sq.m)
15	Grave	4,918,549
16	Educational Facilities - Kindergarten - elementary school - Junior high school - Senior high school - College/University - Tutoring - course	16,298,554
17	Trade and Service - Market - Supermarket - Shops - Service Seller	54,530,151
18	Office	25,604,809
19	**Settlement**	**289,182,349**
20	Defence Area	8,854,675
21	Community Network Center	246,963
22	Research Center	282,869
23	Swamp	4,099,957
24	Rice field	10,860,134
25	River	38,106
26	TPS-3R	338,652
27	Park	2,361,966
28	Neighbourhood Playground	905,875
29	Recreational Park - Recreational Park - Camping Park	3,883,557
30	Pond	4,451,771
31	Reservoir	2,419,033

Source: Dinas Cipta Karya Tata Ruang dan Perencanaan DKI Jakarta, 2024

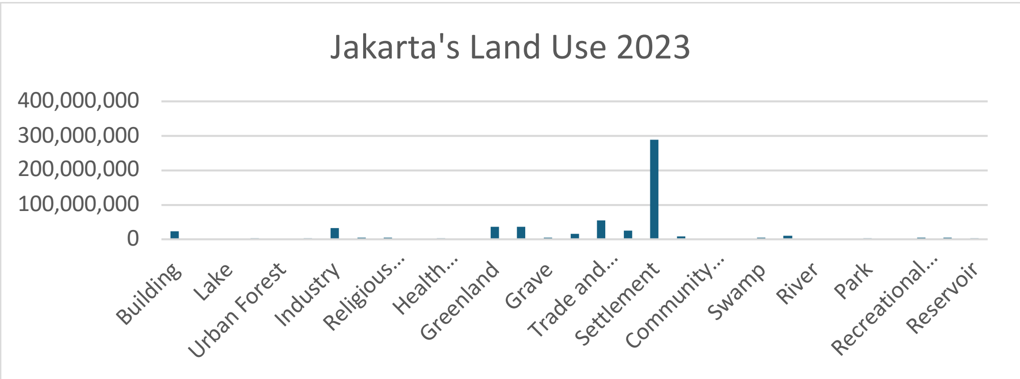


Figure 13 Land Use Chart

Source: Author Analysis, 2024

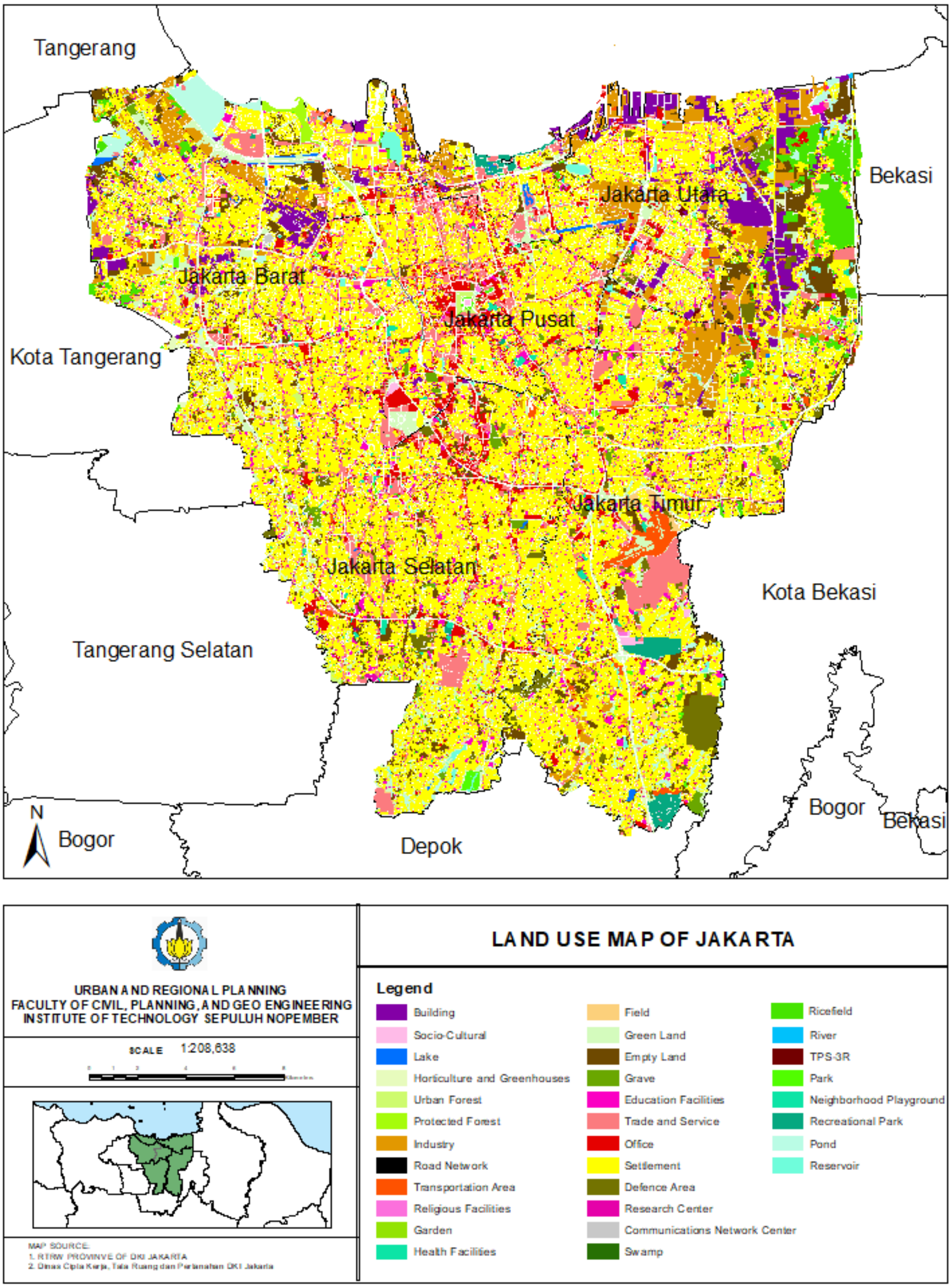


Figure 14 Land Use Map

Source: Author Analysis, 2024

In term of Land Cover, four classes were used to categorise the land cover analysis: built-up area, agricultural, green area, and waterbodies. where built-up areas make up most of the Jakarta's land cover. Built-up areas typically experience higher temperatures due to the absorption and storage of heat by construction materials such as concrete and asphalt. Local temperatures rise as a result, particularly at night when heat is released back into space. Agricultural land carries out the evapotranspiration process, which cools the air, and absorbs less heat than built-up areas, its typically has lower temperatures. Based on the findings of the map study, agricultural land can be considered as the priority location for the placement of green open spaces through the utilisation of fields and vacant space.

Greenland areas are so effective at lowering temperatures. This green land cover's position can be considered when comparing existing green areas with it to determine the priority of green space sites. In the meantime, water bodies can maintain a constant temperature due to their large heat capacity. Temperature changes can be decreased by water's ability to absorb heat during the day and release it gradually at night.

Table 31 Land Cover Jakarta

No.	Classification	Area (sq.m)	Category
1.	Built-up Area	463,944,936	- Building - Socio-cultural - Industry - Transportation area - Religious - Health - Educational - Trade and service - Office - Settlement - Defence area - Community network center - Research center,
2.	Agricultural Land	16,151,121	- Horticultural - Rice field.
3.	Green Area	5,105,134	- Urban forest - Protected forest - Garden - Greenland - Grave - City Park - Neighbourhood playground - Recreational Park.
4.	Waterbodies	12,559,701	- Lake - Swamp

No.	Classification	Area (sq.m)	Category
			- River - Pond - Reservoir
5.	Vacant Land	36,394,976	- Empty land - Field

Source: Author Analysis, 2024

Class	Classification
1	Waterbodies
2	Vegetation
3	Agriculture
4	Vacant Land
5	Built-up

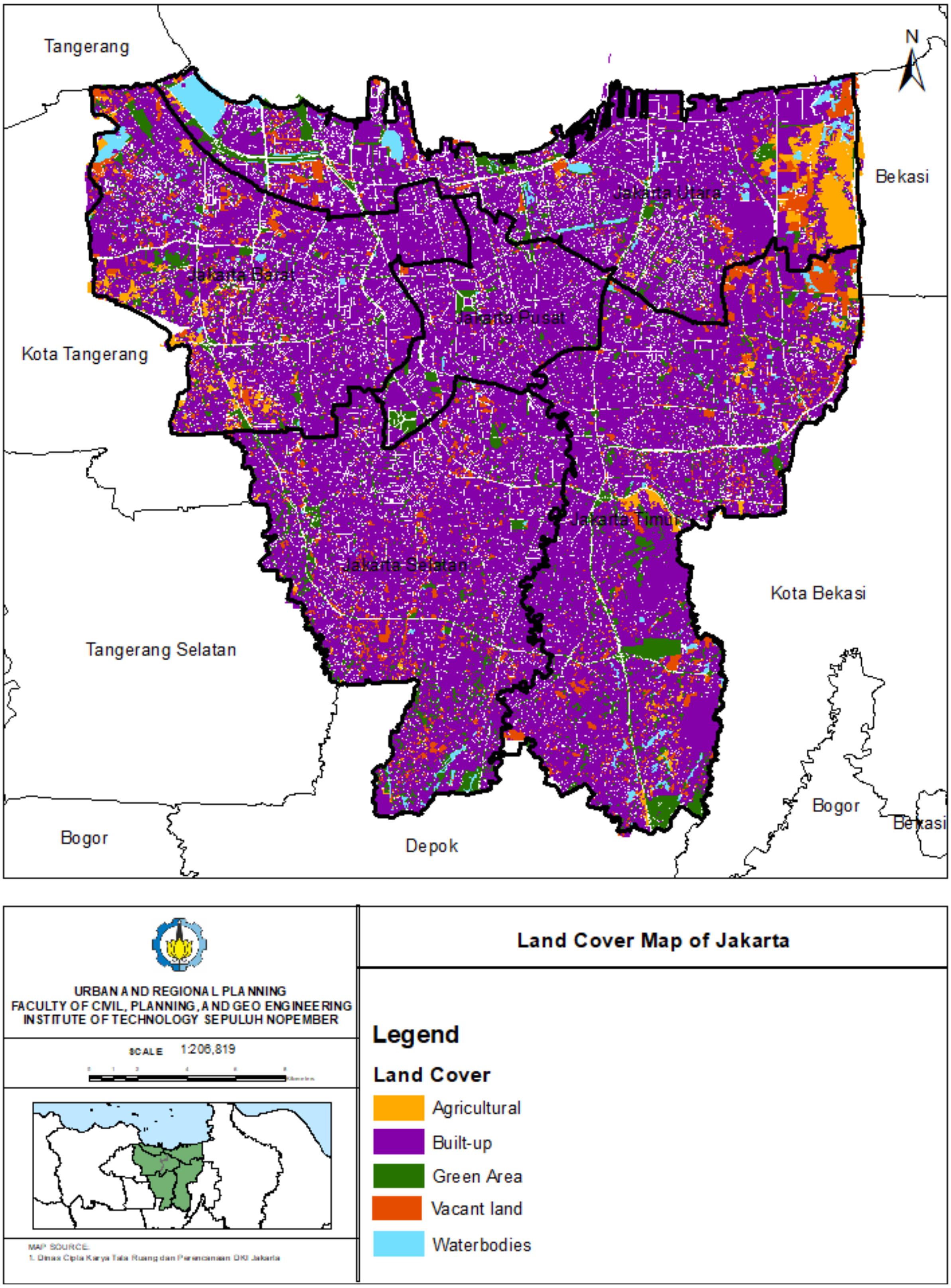


Figure 15 Land Cover Map

Source: Author Analysis, 2024

4.1.7 Vegetation

City of Jakarta tend to have lower levels of vegetation compared to suburban areas or greener areas. Several factors that can influence the condition of vegetation in the City of Jakarta include Population density, air pollution, especially from vehicle pollution, limited land for building Green Open Space which causes air temperatures to increase and results in an Urban Heat Island, as well as city development/land use that occurs in Jakarta City. Jakarta's NDVI is divided into three classes: non-vegetation, very low vegetation, and low vegetation, based on the findings of a map study using Google Earth Engine. In this research area, where the non-vegetation class is dominant. A contributing factor in this is Jakarta's mostly built-up land, which is made up of settlement, Commercial area, and Office. The Following is the NDVI analysis result.

Table 32 NDVI Category Result

No	Value	Category	Area (km2)
1	-0.3035 to -0.054	Non-Vegetation	201,485,238
2	- 0.054 to 0.022	Very Low Vegetation	11,163,673
3	0.022 to 0.262	Low Vegetation	43,920,881

Source: Author Analysis, 2024

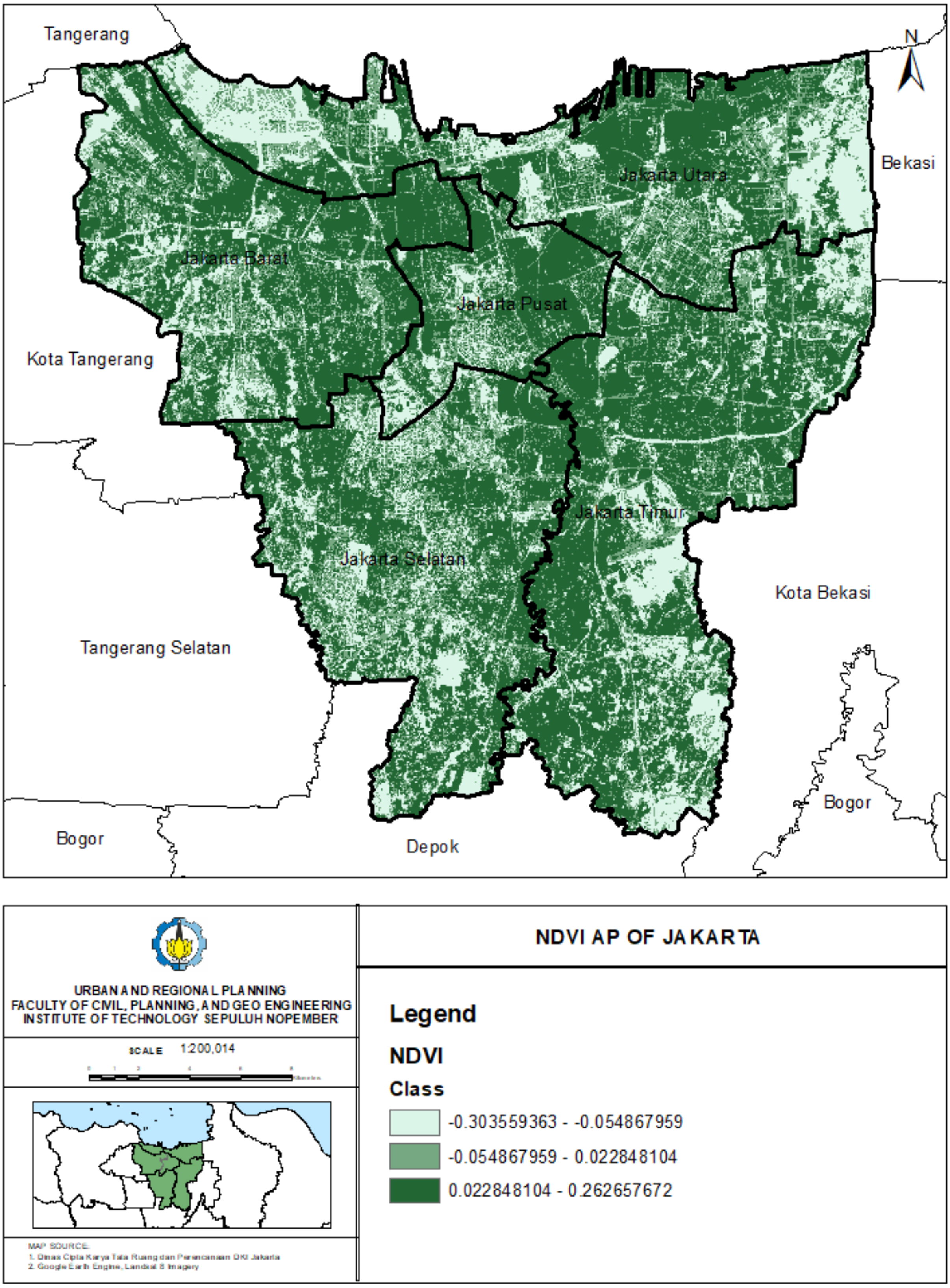


Figure 16 NDVI Map

Source: Author Analysis, 2024

4.1.8 Land Surface Temperature (LST)

Landsat 8 band 10 was used in Google Earth Engine to conduct this research. Furthermore, air temperature data from the BMKG Tanjung Priok station in Jakarta during 2023 were utilised to calculate surface temperatures. This data included a minimum of 21.2 ºC and a maximum of 37.2 ºC. According to the analysis's findings, Jakarta has the lowest LST value 30.4 ºC and the highest > 32 ºC based on the parameter class. Given the current LST specifications, the LST category in Jakarta is dominated by hot and extremely hot temperatures, with an average surface temperature of over 32 ºC.

The LST value which is very different from the results of the Jakarta air temperature analysis occurs due to several factors, namely, land cover, weather conditions, solar intensity, and others (Sivaul & Biorestia, 2023). Built-up land can increase surface temperature due to the thermal insulation effect which can inhibit evaporation and heat transfer, so that surface temperature increases. Weather conditions can increase surface temperature which is related to the intensity of the sun reaching the surface. Following is the table of LST Classification in Jakarta.

Table 33 Land Surface Temperature Class

No	LST (°C) In Jakarta	Category	Total Area	Area Percentage
1	30.4 – 32	Hot	395,586	0.06%
2	> 32	Very Hot	645,728,419	99.94%

Source: Author Analysis, 2024

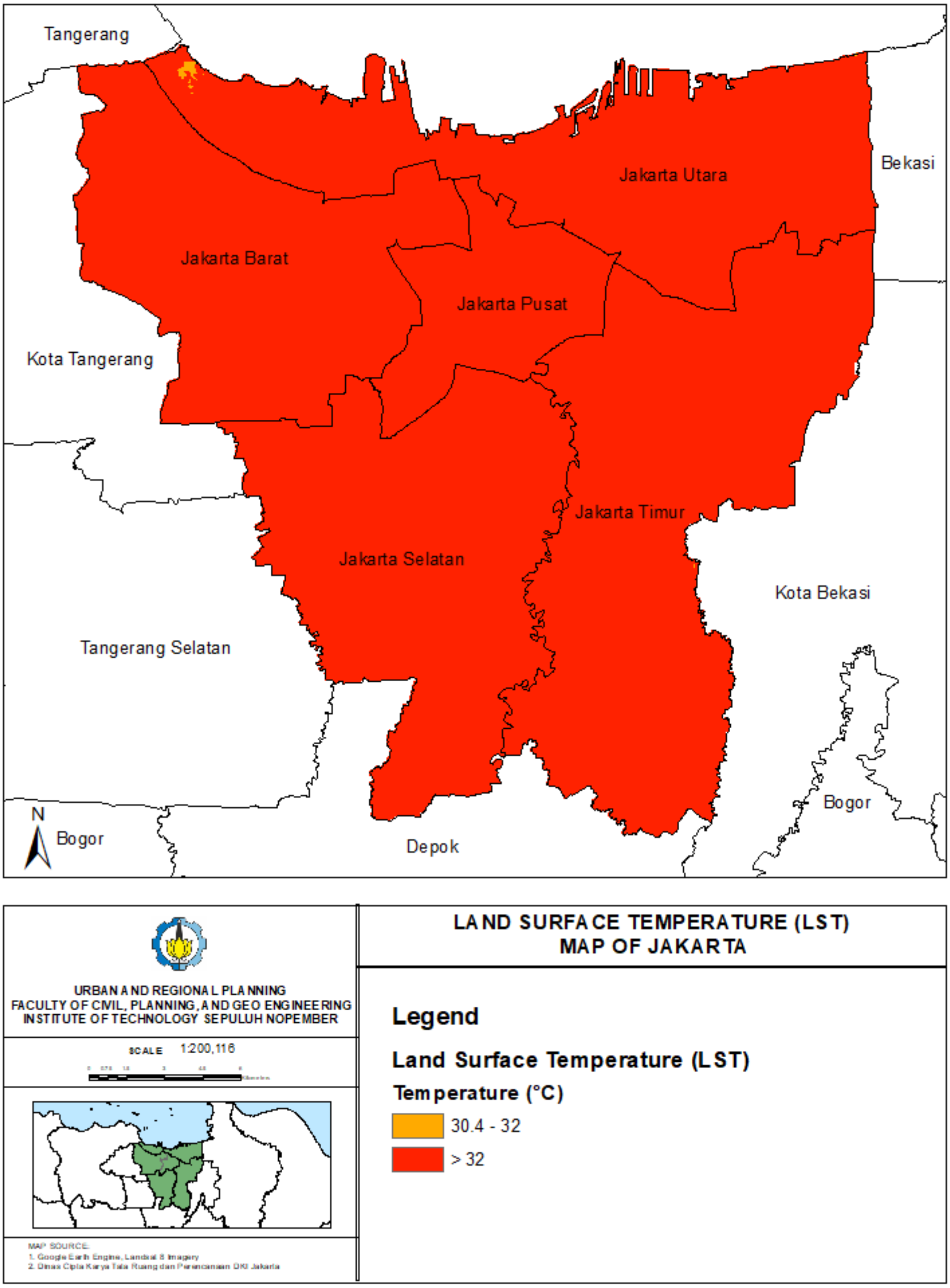


Figure 17 Land Surface Temperature Map

Source: Author Analysis, 2024

4.1.9 Road Network and Waterbodies

The city of Jakarta is filled with busy activities, therefore, there is a lot of road infrastructure. Roads and water bodies have a role in increasing heat in cities and the existence of GOS. Where the existence of a road network, especially in Jakarta, is heavily traveled by people carrying out daily activities, coupled with the dense use of private and public transportation, as well as the materials used such as asphalt can cause an increase in temperature (Mohajerani et al., 2017). Additionally, bodies of water themselves help reduce heat because water can absorb heat (Agustine et al., 2023). The following is a map of the road network and water bodies in the city of Jakarta .

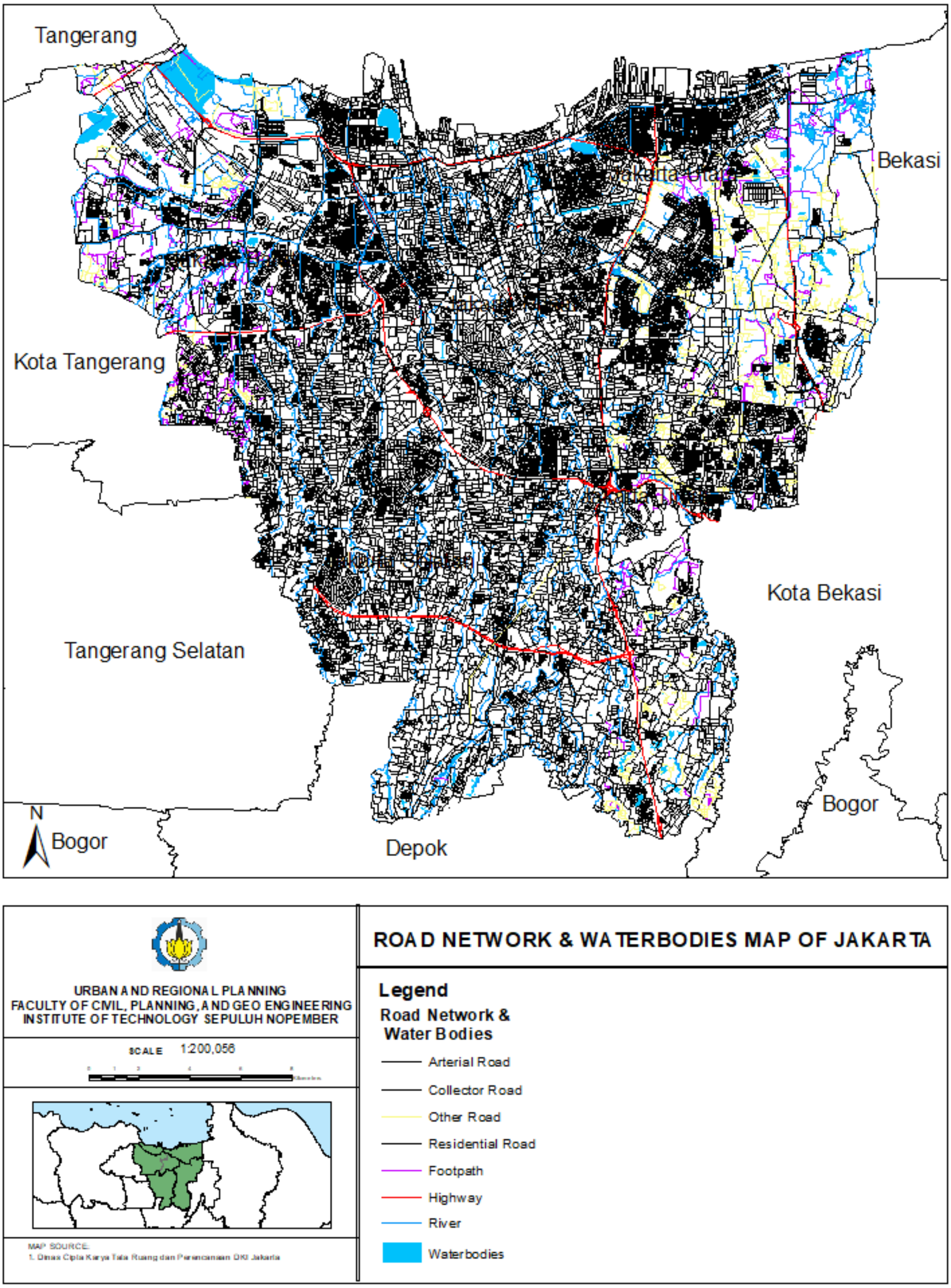


Figure 18 Road Network and Waterbodies Map

Source: Author Analysis, 2024

4.2 General Overview of Green Open Space in Jakarta

4.2.1 Condition of Green Open Space in Jakarta

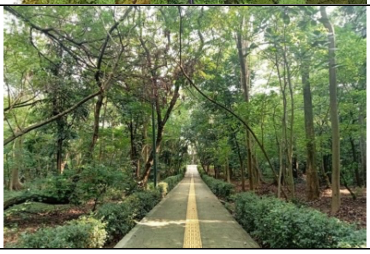
According to information from the DKI Jakarta City Parks and Forest Service, just 5% of Jakarta's total land area is currently made up of green open space. There is an urgent requirement to make improvements. The government's developing and rehabilitation of multiple open green spaces in Jakarta has also contributed to the current state of these areas. According to the data analysis results, Jakarta's GOS current area is 7,596,863 square metres. The following table provides numerous instances of GOS that are currently in exist in every region of Jakarta.

Table 34 Jakarta's Green Open Space

City	Green area (m2)
Kota Jakarta Pusat	334,222
Kota Jakarta Selatan	1,758,337
Kota Jakarta Utara	1,601,663
Kota Jakarta Barat	1,204,585
Kota Jakarta Timur	2,698,055
Total	**7,596,862**

Source: Dinas Pertamanan dan Hutan Kota DKI Jakarta, 2024

Table 35 GOS in Jakarta

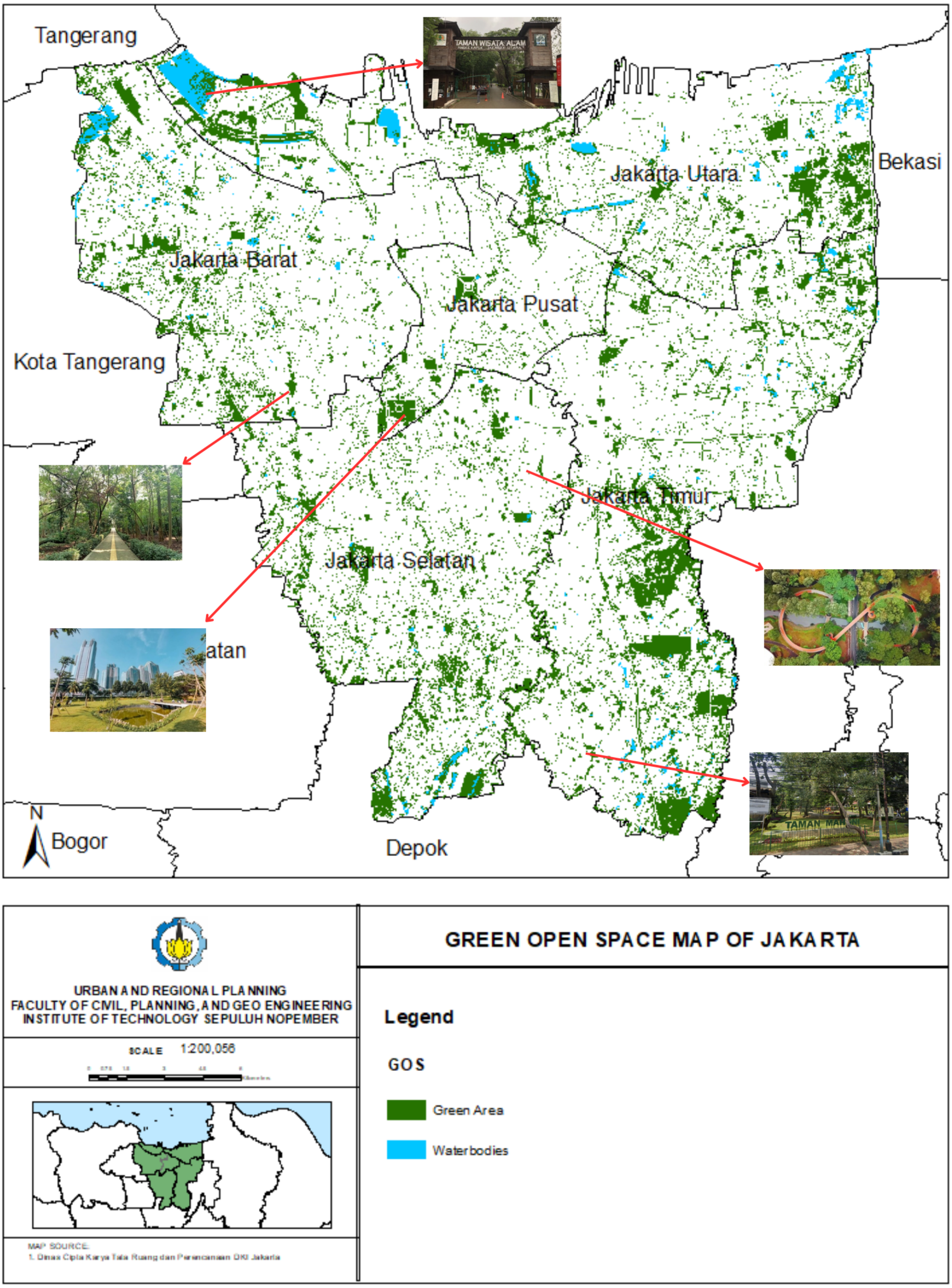
Location	Description	GOS Image
Central Jakarta: Jl. Jenderal Sudirman, RT.1/RW.3, Gelora, Kecamatan Tanah Abang, Kota Jakarta Pusat, Daerah Khusus Ibukota Jakarta 10270	Hutan Kota GBK	
South Jakarta: Jl. Tebet Barat Raya, RT.1/RW.10, Tebet Bar., Kec. Tebet, Kota Jakarta Selatan, Daerah Khusus Ibukota Jakarta 12820	Tebet Eco Park	
West Jakarta: Jl. H. Kelik, RT.8/RW.6, Srengseng, Kec. Kembangan, Kota Jakarta Barat, Daerah Khusus Ibukota Jakarta 11630	Hutan Kota Srengseng	

Location	Description	GOS Image
East Jakarta: RW.9, Kelapa Dua Wetan, Ciracas, East Jakarta City, Jakarta 13730	Taman Mahoni	
North Jakarta: Jl. Garden House, Kamal Muara, Kec. Penjaringan, Jakarta Utara, Daerah Khusus Ibukota Jakarta 14470	Taman Wisata Alam Angke	

Source: Author Analysis, 2024

Jakarta has a wide variety of urban forests and city parks based on the presence of green open spaces. Meanwhile, falls short of 30 % of the GOS standards as stated in Minister of Public Works Regulation No. 5/PRT/M/2008. Furthermore, GOS is essential for mitigating the urban heat island effect and enhancing human health and overall well-being. Therefore, the government will benefit from this research by being able to develop green open space in high-need areas and give them top priority for development.

The green open space ought to be conveniently located in the neighbourhood; it can be near homes, workplaces, or gathering spots, and it should be simple to access. Many of these places are easily accessible and near to water and highways, according to analysts. Wherein water bodies aid in maintaining GOS and roads facilitate access to it. The road network, waterbodies, and GOS presence map are shown below.


Tangerang
TAMAN WISATA ALAM
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Kota Tangerang
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URBAN AND REGIONAL PLANNING
FACULTY OF CIVIL, PLANNING, AND GEO ENGINEERING
INSTITUTE OF TECHNOLOGY SEPULUH NOPEMBER
SCALE 1:200,056
GREEN OPEN SPACE MAP OF JAKARTA
Legend
GOS
Green Area
Waterbodies
MAP SOURCE:
1. Dinas Cipta Karya Tata Ruang dan Perencanaan DKI Jakarta

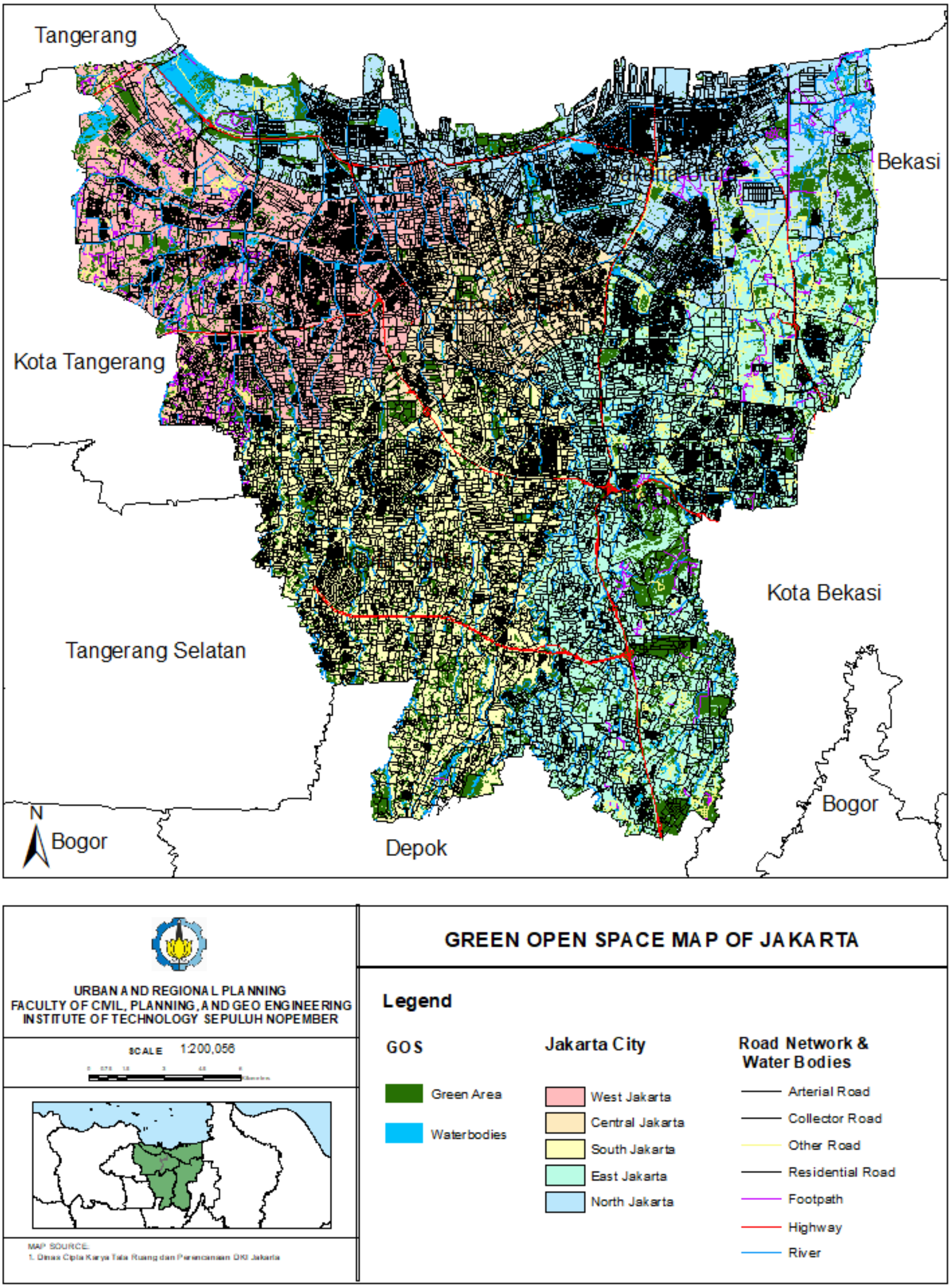


Figure 19 Green Open Space Map

Source: Author Analysis, 2024

4.3 Weighting Analysis and Determination of Priority Scale for Factors Causing Urban Heat Island in Jakarta

The Analytics Hierarchy Process (AHP) is employed in the study to determine the priority scale and weighting of the components that are the primary contributors of Jakarta's Urban Heat Island. where a comparison of all the variables is made. In the illustration below, the hierarchy is as follows:

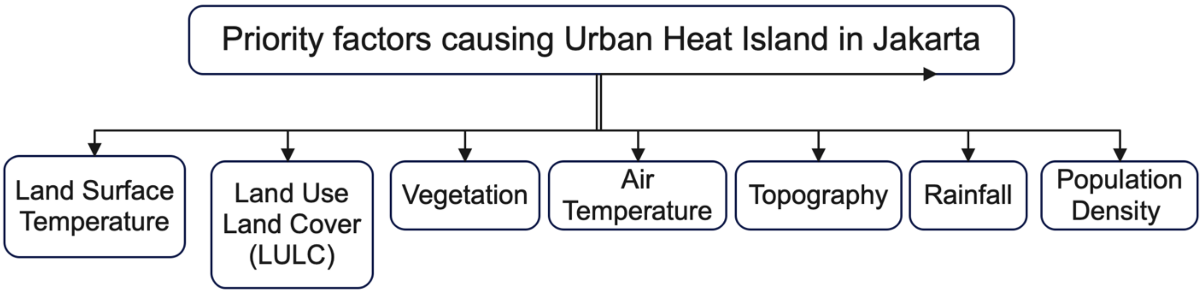


Figure 20 Hierarchical Structure Factors that are the main cause of the Urban Heat Island in Jakarta

Source: Author Analysis, 2024

The Expert Choice application programme, a tool to assist decision makers, was utilised to carry out the AHP approach of ranking the elements contributing to urban heat islands. Stakeholders provide the weighted scale along with expert assessments. Participants in this study included academics, community organisations, the DKI Jakarta City Parks and Forest Service, the Department of Human Settlements, and Spatial Planning and Land. These are the analysis's findings.

4.3.1 Main Factors causing UHI in Jakarta

Based on the DCKTRP stakeholder the results shown, the highest factor obtained was the variable LULC with a weight of 37.1 % and the lowest weight was topography with 2.8 %.

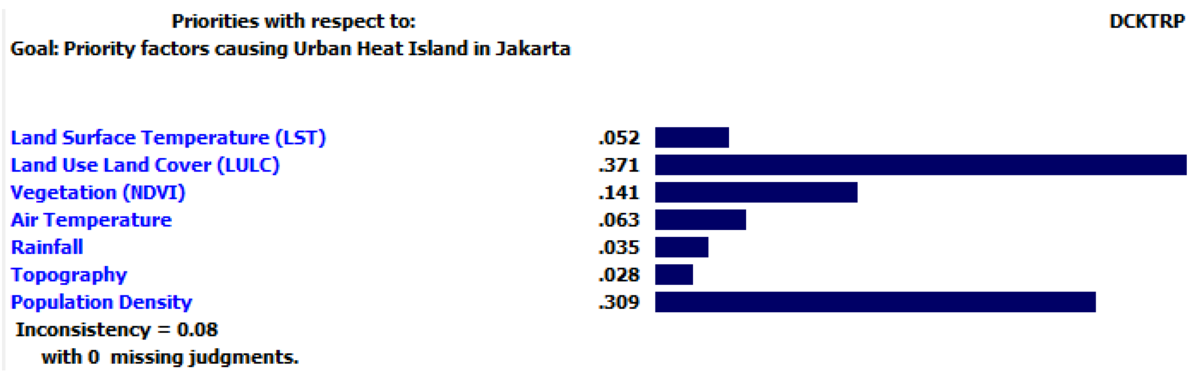


Figure 21 Stakeholder DCKTRP AHP Result 1st Objective

Source: Author Analysis, 2024

Based on the DKI Jakarta City Park and Forest Department stakeholder, the result shown the highest factor obtained was the variable LULC with a weight of 51.1 % and the lowest weight were land surface temperature (LST) and air temperature with both value 2.6 %.

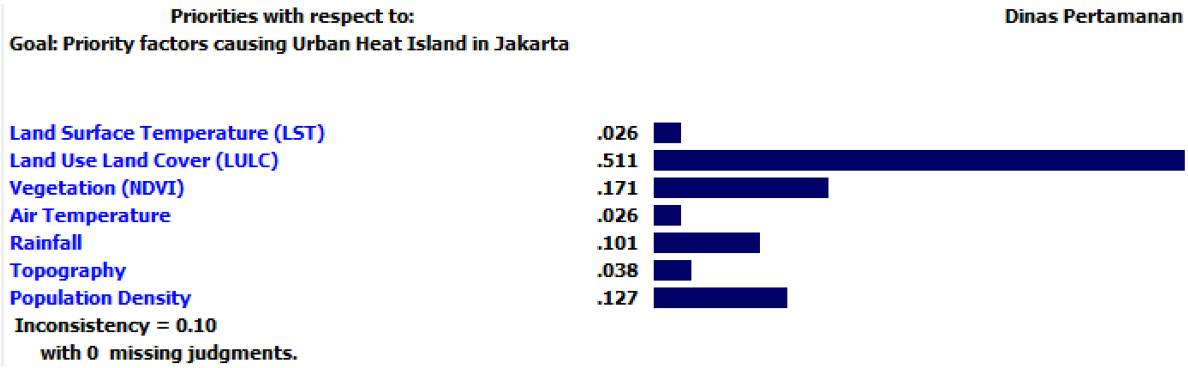


Figure 22 Stakeholder DKI Jakarta City Park and Forest Department AHP Result 1st Objective

Source: Author Analysis, 2024

Based on the Academic stakeholder from Trisakti University, the result shown the highest factor obtained was the variable LULC with a weight of 33 % and the lowest weight was air temperature with 3.3 %.

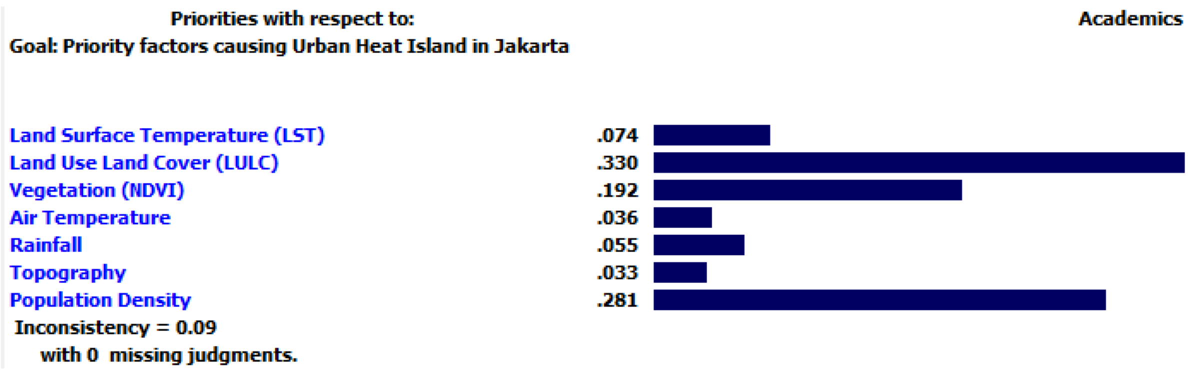


Figure 23 Stakeholder Academics AHP Result 1st Objective

Source: Author Analysis, 2024

Based on the Community Organization stakeholder from Rujak Center for Urban Studies, the result shown the highest factor obtained was the variable LULC with a weight of 34.9 % and the lowest weight was rainfall with 3.3 %.

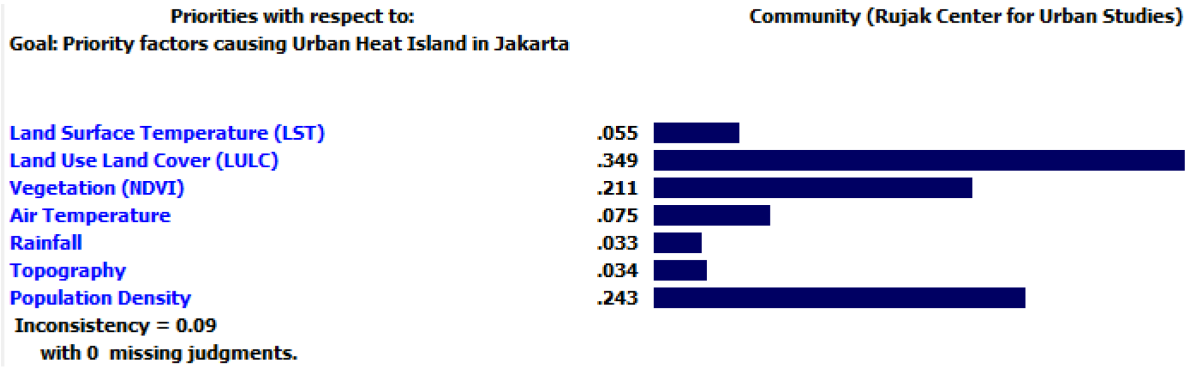


Figure 24 Stakeholder Community Organization AHP Result 1st Objective

Source: Author Analysis, 2024

The weightings for all stakeholders are combined after each stakeholder's weighting has been determined. According to the combined results, the following variables were identified as significant contributors to Jakarta's urban heat island phenomenon: The first variable that has the biggest influence is LULC with value of 38.3 %. The second place is vegetation with the weight value of 14.7 %. The third place is population density with value of 13.5 %, These two variables are related to LULC where the presence of vegetation is always decreasing due to land conversion due to population density continuing to increase in the city of Jakarta.

The fourth place is land surface temperature (LST) with 12 %, the fifth-place air temperature 8.5 %, both are at this level because they are influenced by variables at the previous top level, for example city density because human activity increases heat emissions in cities (Chapman et al., 2017). The Sixth is rainfall 7.7 % and based on the results of previous research, rainfall does not have a direct influence on the occurrence of the urban heat island phenomenon (Sidek, 2012). Lastly, the seventh place as last variable is topography with 5.2 %, Based on studies from (Farhan, 2022), UHI in the lowlands is not affected by topography.

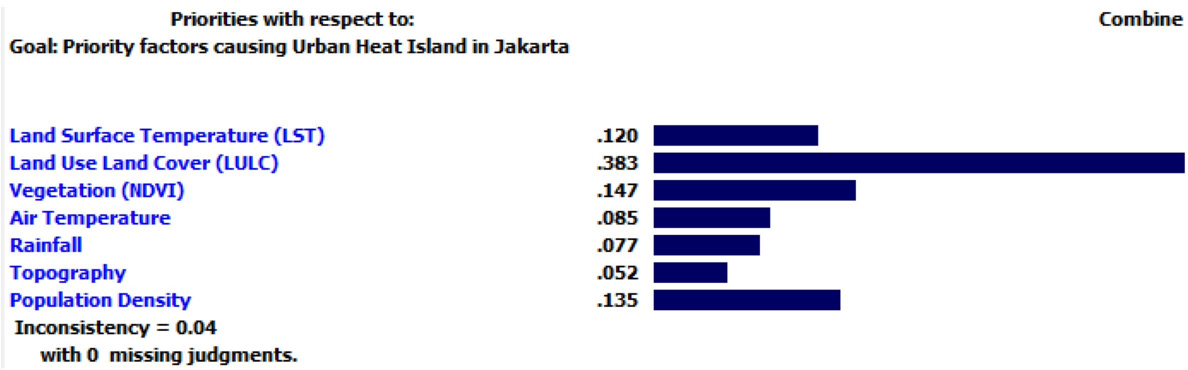


Figure 25 Stakeholder AHP Result Combine 1st Objective

Source: Author Analysis, 2024

The result also shown the inconsistency value is 0.04, which means that if the inconsistency value is below 10% or 0.1 then the comparison matrix is acceptable. The following output, which is shown in the image below, is the outcome of processing the combined weighted data.

4.3.2 UHI Distribution in Jakarta

The Urban Heat Island Distribution map is analyzed using Google Earth Engine as a tool. Based on references from (Rizki et al., 2024), the Urban Heat Island Map in Jakarta is required calculated using the NDVI and LST data. After analyzing the LST distribution with the NDVI value, the LST value, LST mean = 42.8945219, and LST standard deviation = 2.8169136 are obtained. The following formula is then used to calculate it using the ArcGIS raster calculator tools.

$$UHI = \frac{LST - 42.8945219}{2.8169136}$$

The table below shows the outcome of the urban heat island class. Jakarta's average UHI rating falls into class 5, meaning that it ranges > 32°C, with a 67.12% area percentage. The lowest class, which makes up 32.88% of the Jakarta region, experiences temperatures between 30.4°C to 32°C. According to the analysis from ArcGIS, it shown that most of each district in Jakarta City is majority covered by UHI class 5. It is concluded that the entire city of Jakarta has been exposed to urban heat island (UHI) conditions, where the average temperature or even at the lowest point of temperature in the city, has risen above the threshold temperature parameters that are frequently employed by researchers, including (Fardani & Yosliansyah, 2022; Himayah et al., 2020; Rania et al., 2023). Following is the table classification of UHI class.

Table 36 UHI Class in Jakarta

No	Temperature Threshold (°C)	Category
1	< 21	Very Cold
2	21 – 24	Cold
3	24 – 28	Cool
4	28 – 32	Hot
5	> 32	Very Hot

UHI Class	UHI Temperature (°C)	Area (km2)	Area Percentage
4	30.4 – 32	213,489	32.88%
5	> 32	435,884	67.12%

Source: Author Analysis, 2024

Table 37 UHI Class for each District in Jakarta

City	Total Area	UHI Class Total Area (km2)	
		4	5
West Jakarta	125,164,062	37,918,029	**87,246,033**
Central Jakarta	47,897,666	19,737,355	**28,160,311**
South Jakarta	144,949,988	42,264,111	**102,685,877**
East Jakarta	184,666,932	49,659,659	**135,007,273**
North Jakarta	140,180,720	59,572,488	**80,608,232**

Source: Author Analysis, 2024

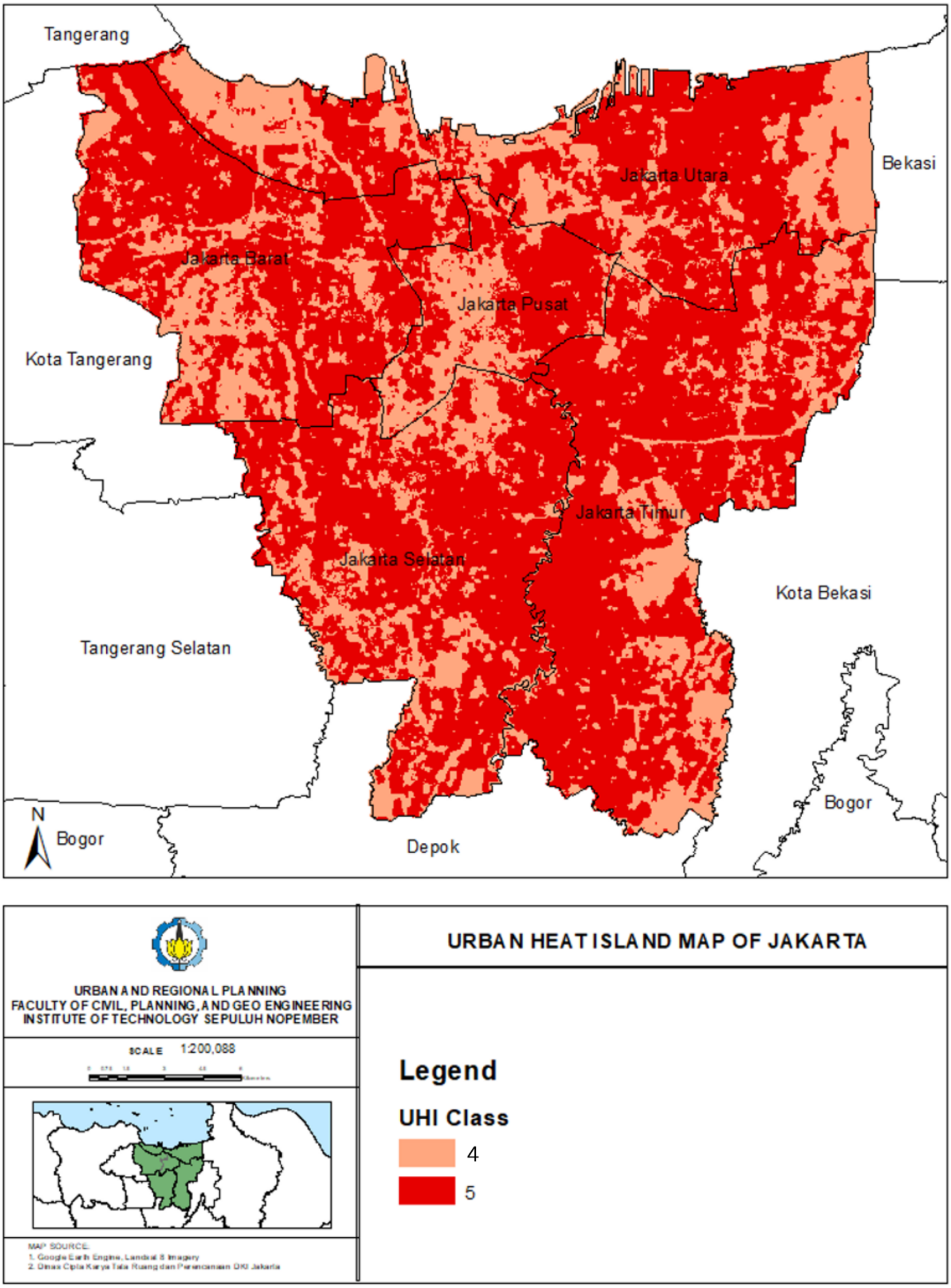


Figure 26 Urban Heat Island Map

Source: Author Analysis, 2024

4.4 Analysis of Determination the need of Green Open Space Location in Jakarta

4.4.1 Variables in Determining the need of GOS Location

To address the second goal, which is to determine Jakarta's green open space location needed based on the distribution of urban heat islands. The variables selected in term of this second objective such as Land Use Land Cover (LULC), Land Surface Temperature (LST), Vegetation, and Population Density. The following are reasons that strengthen why this variable is suitable for use in answering the second objective.

LULC (land use land cover) has a very high influence in determining the location development of GOS. Due to the urban areas has limited open space, deciding on the appropriate type of green open space is important. For instance, implementing the GOS type in the form of green roofs or green walls which have the potential to reduce temperatures with a cooling system from the roof and UHI mitigation (Balany et al., 2020). Additionally, non-built-up areas can be further developed as planting sites for vegetation, while built-up areas can be designated as development areas (Umar et al., 2022), This is because vegetation (NDVI) can absorb higher temperatures.

The presence of green spaces and population density are correlated. According to research findings, population density in Jakarta led to a rise in demand for land for housing, which in turn resulted in the conversion of agricultural land to residential use. This is the reason that residential areas with high population density are the primary settings for green open spaces. Subsequently, the examination of the land surface temperature (LST) in the City of Jakarta revealed that the high LST category predominates throughout nearly the whole Jakarta region. Thus, high temperatures are caused by Jakarta's predominately built-up land cover and lack of GOS.

4.4.2 AHP of each Variables

After determining the variables, AHP is carried out from the results of stakeholder interviews in determining the needed locations for green open space in Jakarta. Where the result can be seen as follow.

First stakeholder from DCKTRP, where the result shown that LULC is an important variable in determining the need of GOS locations with 41.2% weighted value. While the least factors are vegetation with 6.9% weighted value.

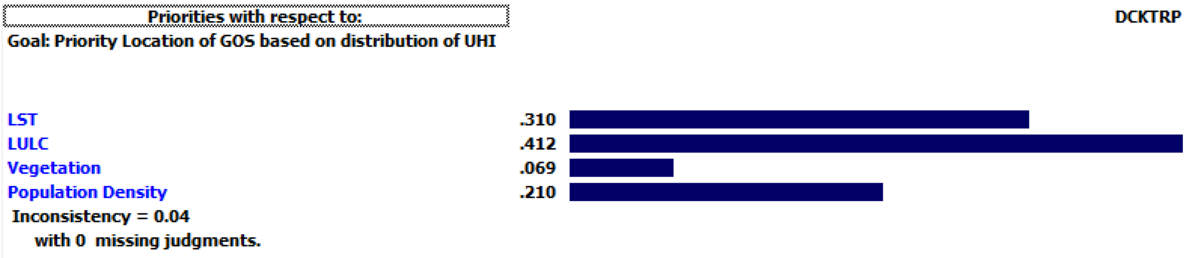


Figure 27 DCKTRP AHP Result for 2nd Objective

Source: Author Analysis, 2024

Based on the DKI Jakarta City Park and Forest Department stakeholder, the result shown the highest factor obtained was the variable LULC with a weight of 42.6% and the lowest weight were vegetation with value 6.5 %.

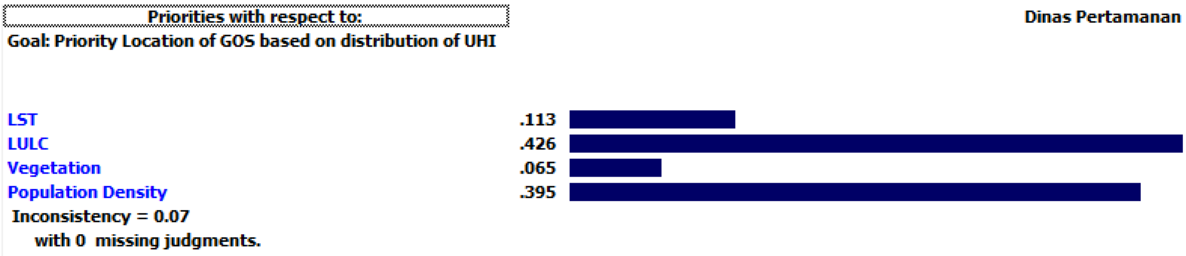


Figure 28 DKI Jakarta City Park and Forest Department AHP Result for 2nd Objective

Source: Author Analysis, 2024

Following the AHP result from Academic stakeholder, the population density with 47.5 % value is the first factor that must be consider in determining the need locations. However, LST is the least factor with 9% weighted value.

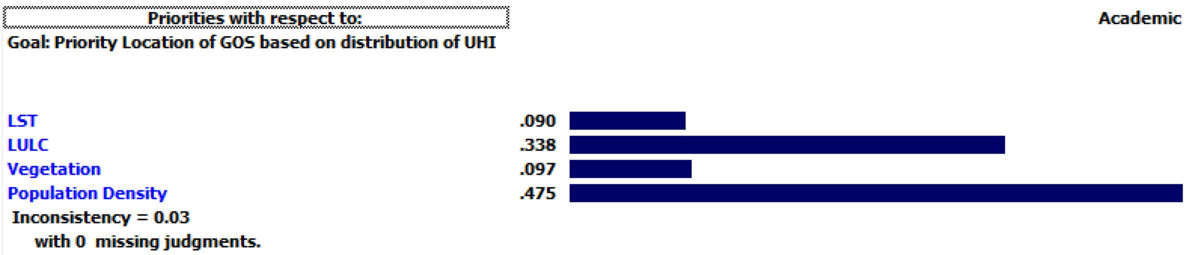


Figure 29 Academic AHP Result for 2nd Objective

Source: Author Analysis, 2024

The RujakrCUS (Rujak Center of Urban Studies) state that LULC as the first factor with 42.3% weighted value, while LST is the last with 7.3% value as the factor of determining the need location of GOS in Jakarta.

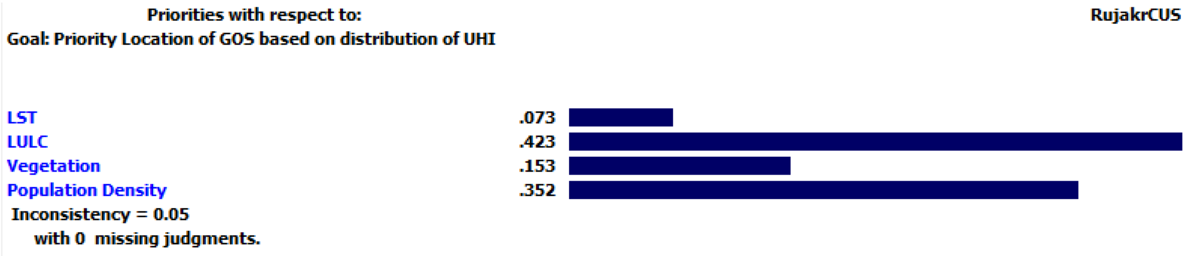


Figure 30 Community Organization AHP Result for 2nd Objective

Source: Author Analysis, 2024

Finally, the result from all stakeholders will be combined to get the weighted value of each variable. Where it shown that, LULC is on the first hierarchy in term of determining the need location of Green Open Space with 42.7%, following by population density with 33.3%, LST with 13.2% value, and vegetation with 10.8% of weighted value.

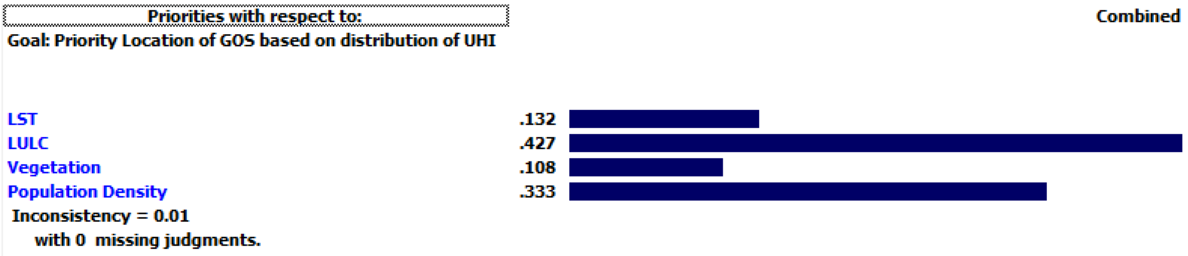


Figure 31 AHP Result Combine for 2nd Objective

Source: Author Analysis, 2024

As shown in the table below, the next step is to prepare the class parameters and weightings for each variable. Finally, after analysis, the shapefile data is transformed into raster format and weighted using a weighted overlay. Enter all the weighting value and location priority rank class parameter results after that. The analysis's findings for identifying GOS locations needed are as follows.

Table 38 Weighted Variable 1st Objective Classification Result

Variables	Class Rank	Classification	Category	AHP Weighted Value
LST	4	30.4 °C – 32 °C	Hot	42.7 %
	5	> 32 °C	Very Hot	
LULC	1	Waterbodies		33.3 %
	2	Vegetation		
	3	Agriculture		
	4	Vacant Land		
	5	Built-up		
Vegetation (NDVI)	5	-0.3035 to -0.054	Non-Vegetation	13.2 %
	4	- 0.054 to 0.022	Very Low Vegetation	
	3	0.022 to 0.262	Low Vegetation	
Population Density	5	> 5001 people/km2	Very High Density	10.8 %

Class	Description
5	Very Priority
4	Priority
3	Moderate Priority
2	Less Priority
1	Not Priority

Source: (Pantalone, 2010; Pokhrel, 2019) *, Author Analysis 2024*

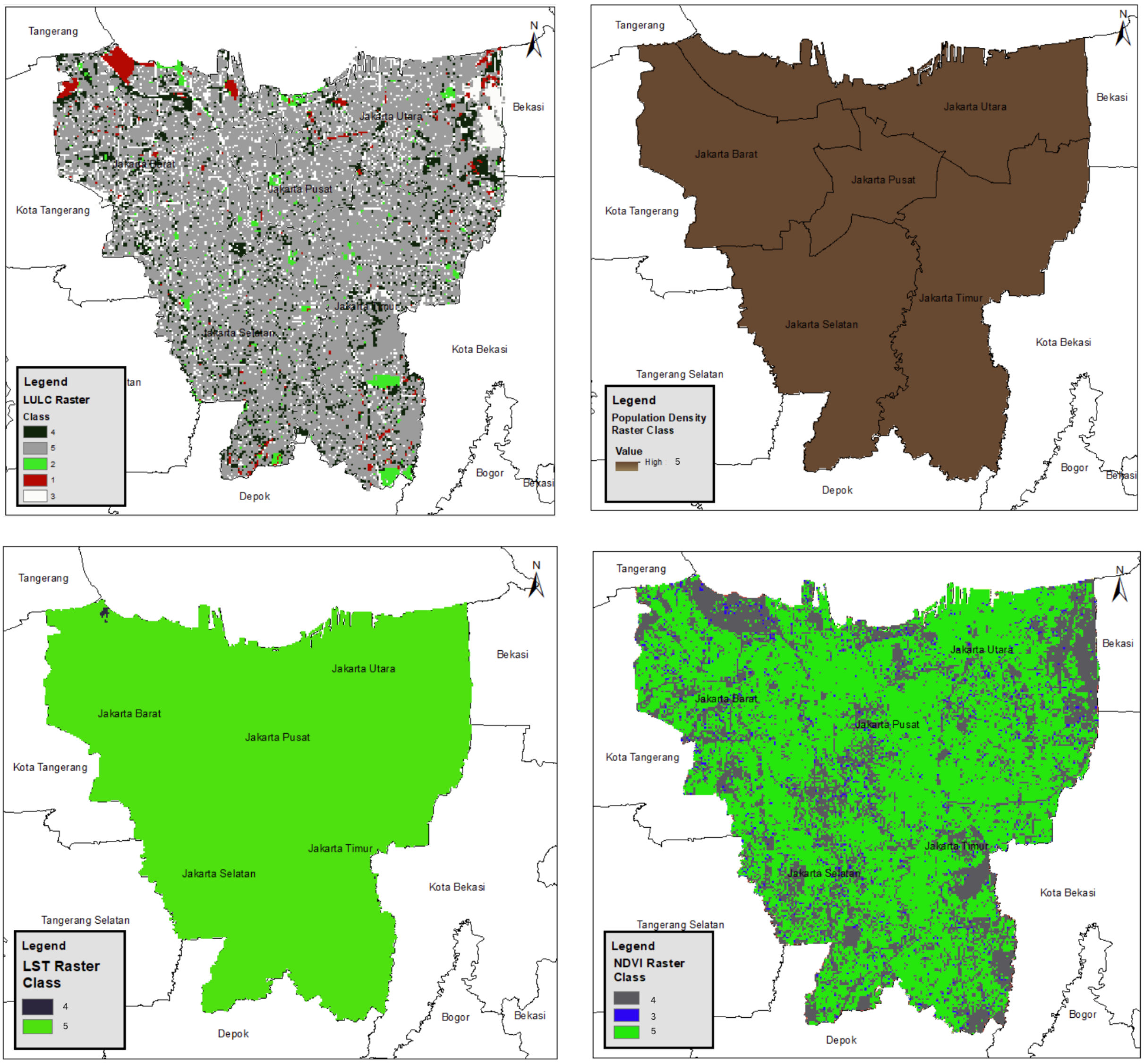


Figure 32 Raster Map each Variables

Source: Author Analysis, 2024

Five priority classes for the needs of green open space in Jakarta were identified based on the findings of the priority analysis of the locations of green open spaces. According to the result, class 1 as the not priority is covered by waterbodies, Road Network, and Green Area that has been exist in Jakarta. Class 2 as the less priority, class 3 as the priority class, class 4 as very priority area, and the city of Jakarta falls into class 5, which is extremely important and indicates that there is not much green open space in the city. One fact is that just 5% of DKI Jakarta's entire need for green open space has been covered by Jakarta's green open space. This shows the overall area of priority regions for each class as well as the outcomes of the weighted overlay map analysis. Following is the map of the need of GOS Location in Jakarta.

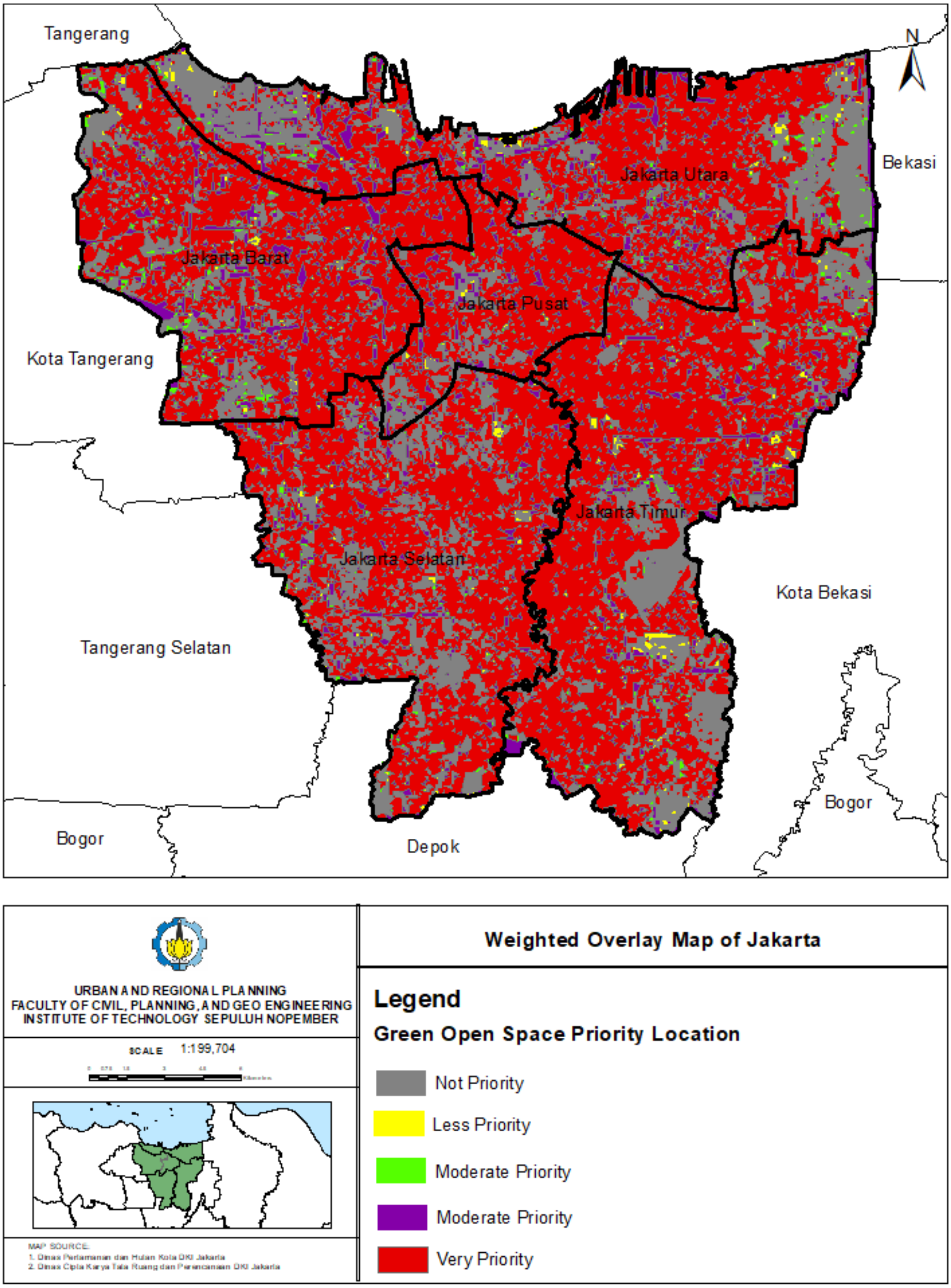


Figure 33 Green Open Space Priority Location Map

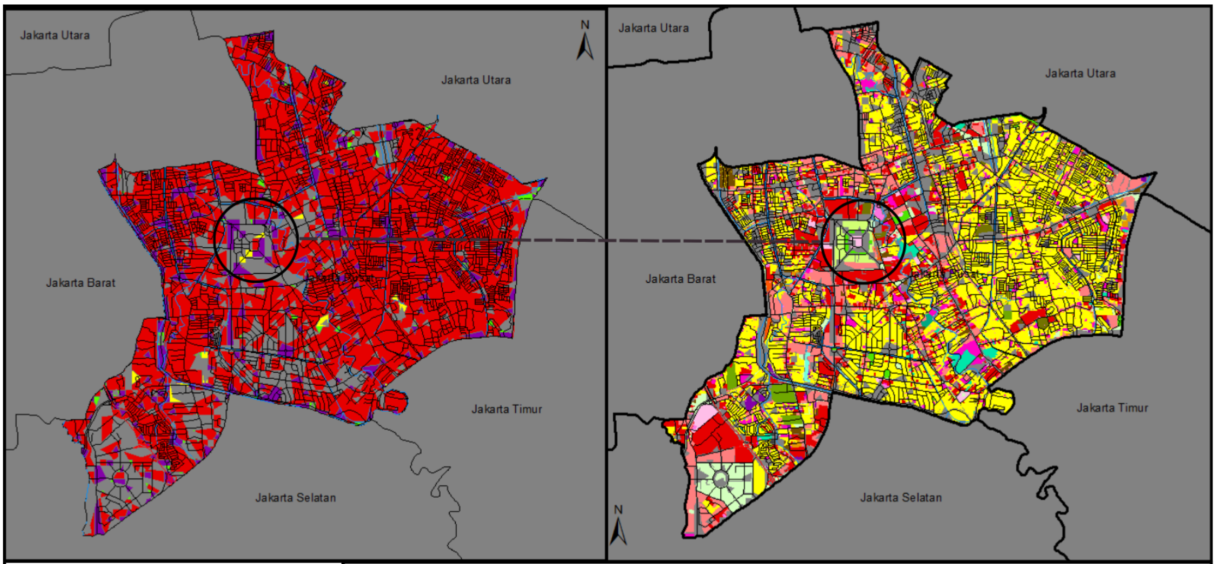
Source: Author Analysis, 2024

4.4.3 Validation of GOS locations with the land use and UHI map in Jakarta

To determine the proper kind of designation such as additions or planting for dense GOS development in Jakarta, land use must be validated using the intersect tool in ArcGIS by combining the outcomes of the weighted overlay of GOS location priorities with existing land use data.

The priority classes of GOS locations and the current land use in each of Jakarta's districts—West Jakarta, South Jakarta, North Jakarta, East Jakarta, and Central Jakarta—are contrasted in the map below. Class 1 as the not priority area to build the GOS is covered by road network, waterbodies, and green area. Class 2 as the less priority area is the area near to the existing of Green Open space in Jakarta. Class 3 as the moderate priority is covered by some of the transportation area and multipurpose building. Class 4 as the priority area is vacant land. Lastly, class 5 as the very priority area is covered by the settlement, office, building or all the built-up area.

The validation's outcomes can be used to identify which places in each district of Jakarta are ideal for the development of green open space. instance, intersecting land use maps can be useful in identifying the kind of GOS that can be constructed. For instance, green lanes can be used to create in roads and waterbodies in the GOS type. Green areas that already exist can be further developed to increase the need for GOS in Jakarta. Because landed green open spaces cannot be constructed due to limited land as residential districts or other densely populated places, green infrastructure can be applied to the upper stories of buildings in the form of parks, green walls, or green roofs.



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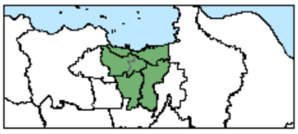


MAP SOURCE:
1. Dinas Pertamanan dan Hutan Kota DKI Jakarta
2. Dinas Cipta Karya Tata Ruang dan Pertanahan DKI Jakarta

GOS Priority Location and Land Use Map of Central Jakarta

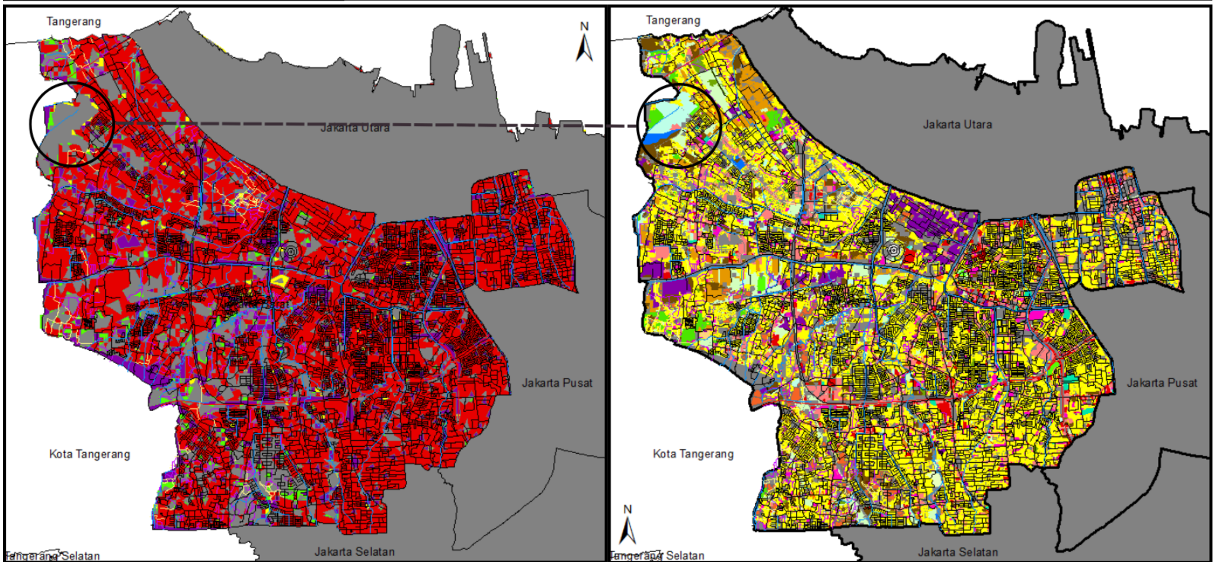
Legend

Priority Location Class
- Not Priority
- Less Priority
- Moderate Priority
- Moderate Priority
- Very Priority

Road
- Arterial Road
- Collector Road
- Other Road
- Local Road
- Footpath
- Highway

River
- River

Land Use
- Building
- Socio-Cultural
- Lake
- Horticulture and Greenhouses
- Urban Forest
- Protected Forest
- Industry
- Road Network
- Transportation Area
- Religious Facilities
- Garden
- Health Facilities
- Field
- Green Land
- Empty Land
- Grave
- Education Facilities
- Trade and Service
- Office
- Settlement
- Defence Area
- Research Center
- Communications Network Center
- Swamp
- Ricefield
- River
- TPS-3R
- Park
- Neighborhood Playground
- Recreational Park
- Pond
- Reservoir



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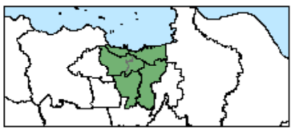
SCALE 1:92,326



MAP SOURCE:
1. Dinas Pertamanan dan Hutan Kota DKI Jakarta
2. Dinas Cipta Karya Tata Ruang dan Pertanahan DKI Jakarta

GOS Priority Location and Land Use Map of West Jakarta

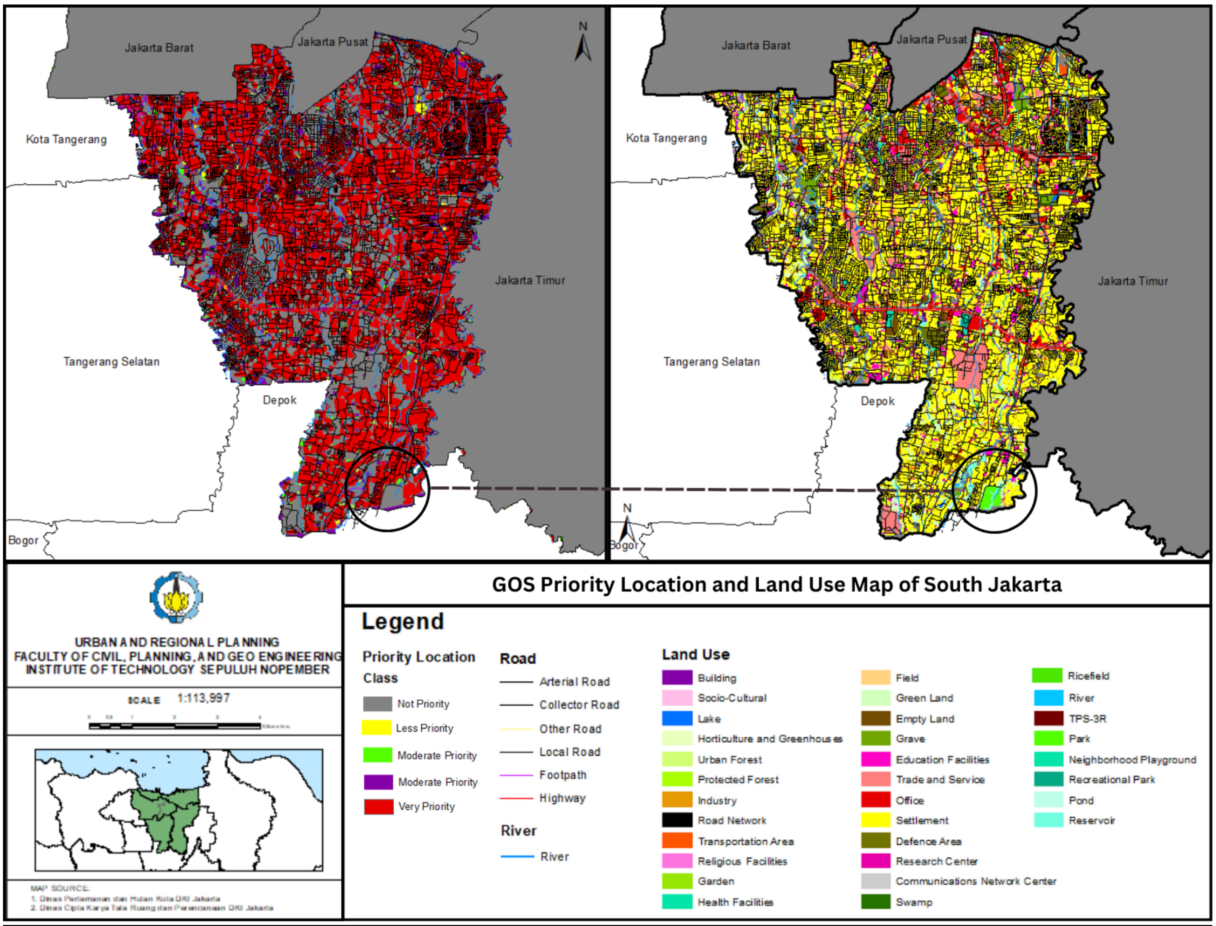
Legend

Priority Location Class
- Not Priority
- Less Priority
- Moderate Priority
- Moderate Priority
- Very Priority

Road
- Arterial Road
- Collector Road
- Other Road
- Local Road
- Footpath
- Highway

River
- River

Land Use
- Building
- Socio-Cultural
- Lake
- Horticulture and Greenhouses
- Urban Forest
- Protected Forest
- Industry
- Road Network
- Transportation Area
- Religious Facilities
- Garden
- Health Facilities
- Field
- Green Land
- Empty Land
- Grave
- Education Facilities
- Trade and Service
- Office
- Settlement
- Defence Area
- Research Center
- Communications Network Center
- Swamp
- Ricefield
- River
- TPS-3R
- Park
- Neighborhood Playground
- Recreational Park
- Pond
- Reservoir



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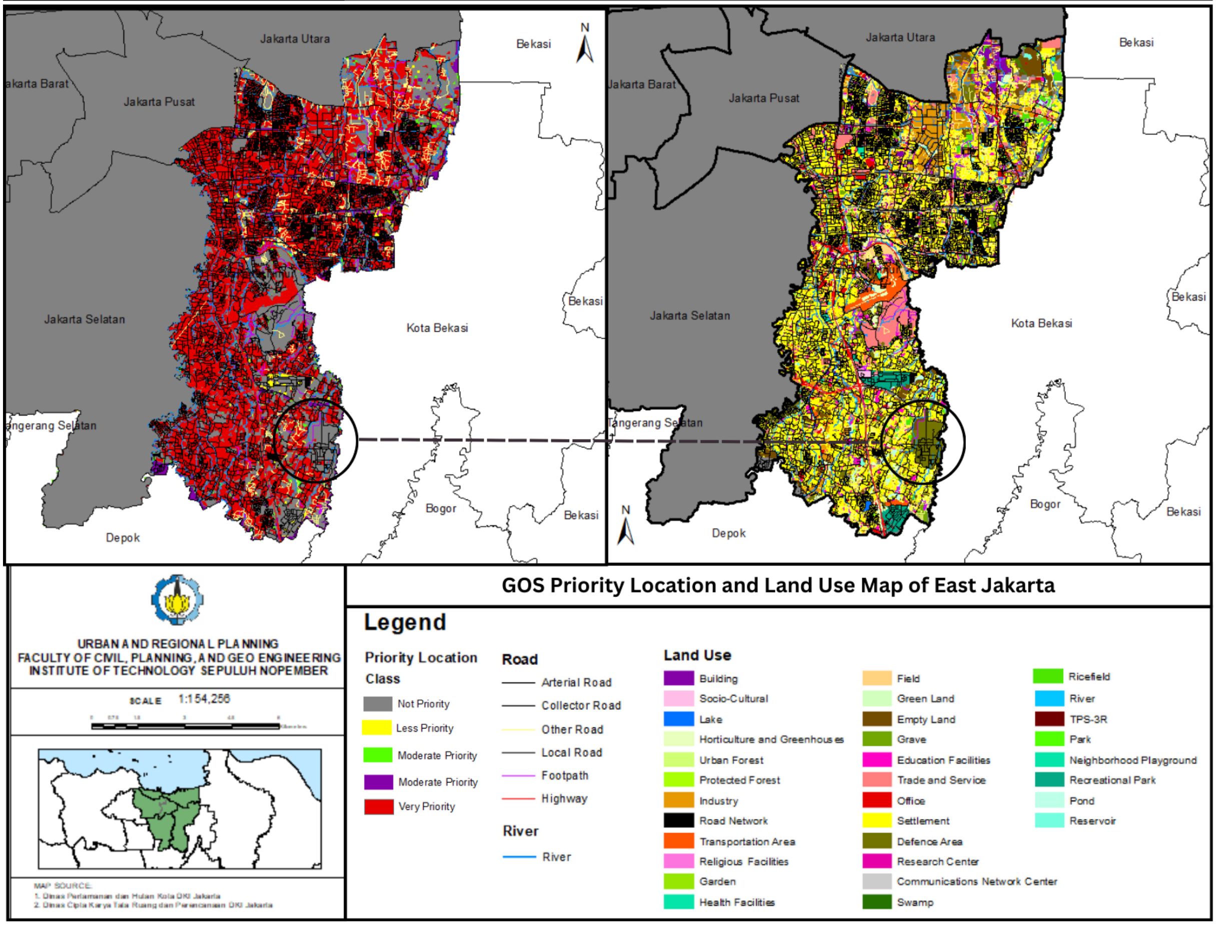
SCALE 1:113,997
GOS Priority Location and Land Use Map of South Jakarta
Legend
Priority Location Class
Not Priority
Less Priority
Moderate Priority
Moderate Priority
Very Priority
Road
Arterial Road
Collector Road
Other Road
Local Road
Footpath
Highway
River
River
Land Use
Building
Socio-Cultural
Lake
Horticulture and Greenhouses
Urban Forest
Protected Forest
Industry
Road Network
Transportation Area
Religious Facilities
Garden
Health Facilities
Field
Green Land
Empty Land
Grave
Education Facilities
Trade and Service
Office
Settlement
Defence Area
Research Center
Communications Network Center
Swamp
Ricefield
River
TPS-3R
Park
Neighborhood Playground
Recreational Park
Pond
Reservoir



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SCALE 1:154,256
GOS Priority Location and Land Use Map of East Jakarta
Legend
Priority Location Class
Not Priority
Less Priority
Moderate Priority
Moderate Priority
Very Priority
Road
Arterial Road
Collector Road
Other Road
Local Road
Footpath
Highway
River
River
Land Use
Building
Socio-Cultural
Lake
Horticulture and Greenhouses
Urban Forest
Protected Forest
Industry
Road Network
Transportation Area
Religious Facilities
Garden
Health Facilities
Field
Green Land
Empty Land
Grave
Education Facilities
Trade and Service
Office
Settlement
Defence Area
Research Center
Communications Network Center
Swamp
Ricefield
River
TPS-3R
Park
Neighborhood Playground
Recreational Park
Pond
Reservoir

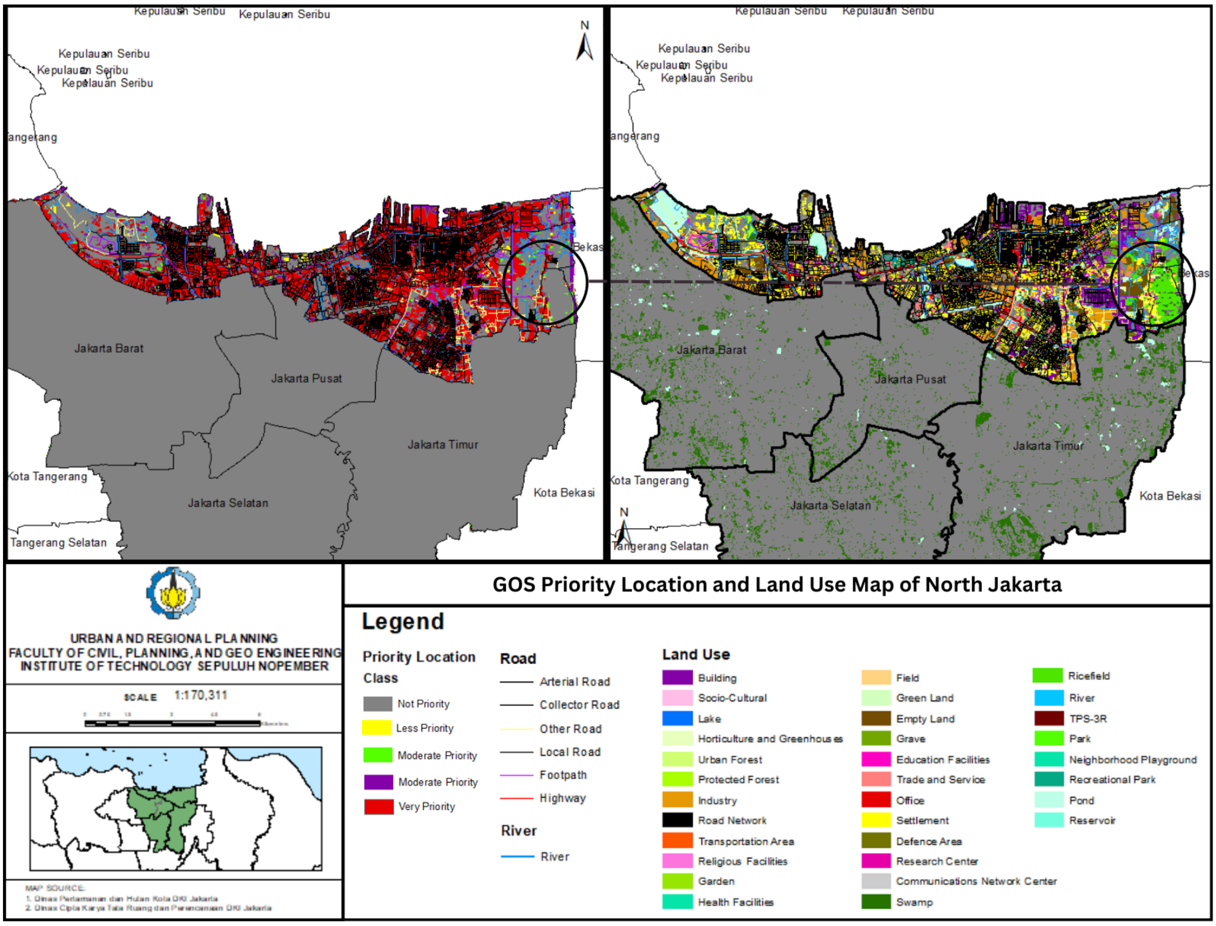

Figure 34 GOS Priority Location Map Each District in Jakarta

Source: Author Analysis, 2024

Finally, the comparison between the UHI distribution map and the need of GOS locations map in Jakarta shows that areas with high UHI levels correspond to zones that have a very high priority for RTH. Following is the map comparison both

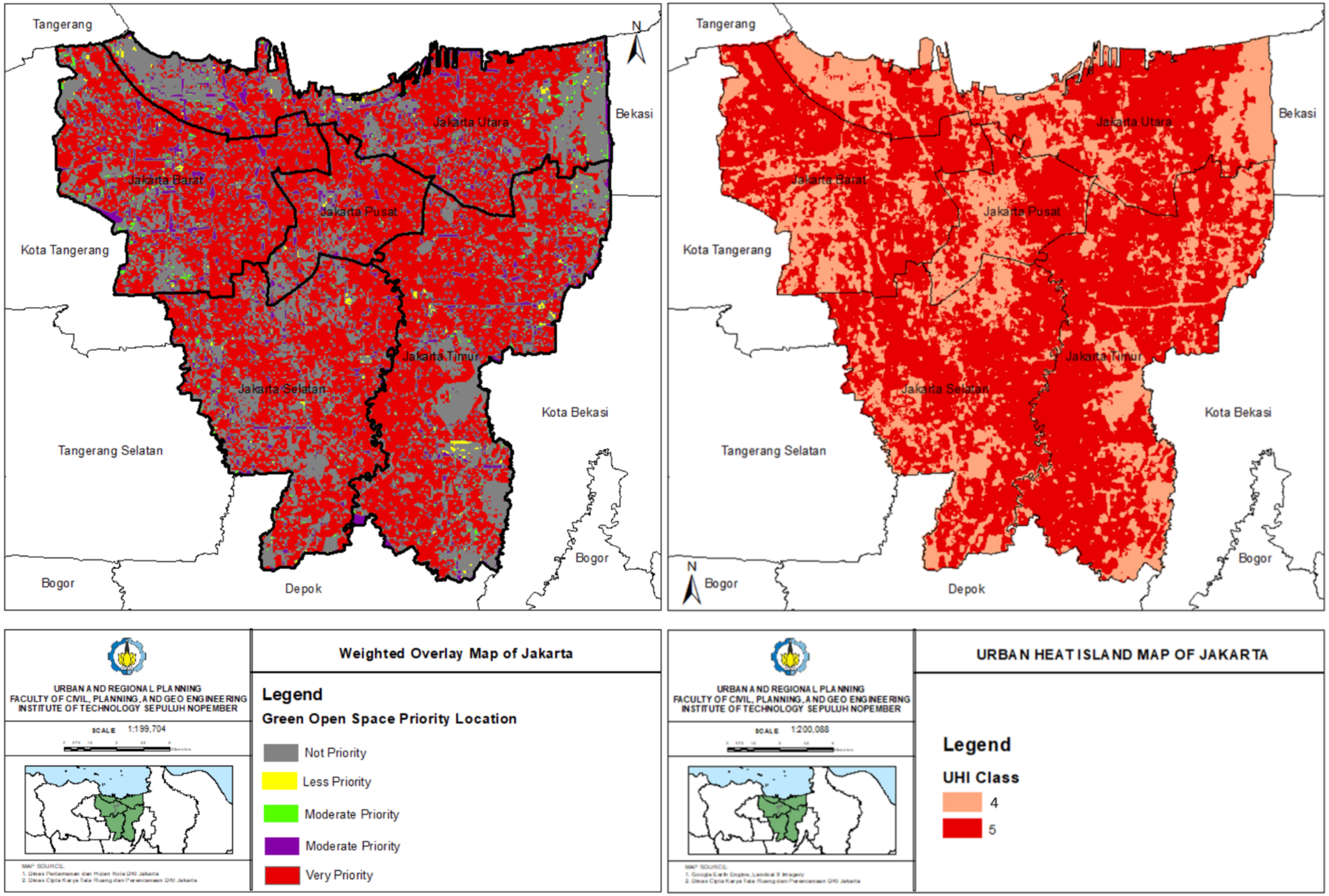

Figure 35 Comparison Map of the need of GOS Location and UHI distribution in Jakarta

Source: Author Analysis, 2024

CHAPTER V
CONCLUSION

5.1 Conclusion

The aim of this research is to determine the need of green open spaces locations based on the distribution of urban heat islands in Jakarta. This study obtains weighting values and spatial analysis using the Analytic Hierarchy Process (AHP) method based on responses from a subset of stakeholders regarding the variables contributing to urban heat islands in Jakarta. By collecting this data, the author hopes to learn more about the variables that lead to UHI occurrence in Jakarta and identify priority location to fulfill the needs of GOS that should be built based on UHI distribution. These are the two objectives that have been created. From this research, the following conclusions can be drawn, based on the outcomes of the analysis conducted in the previous discussion:

1. The first objective is to identify the factors that most affect Jakarta's urban heat islands phenomenon. These outcomes were derived from the weighting results of the comparisons between the variables that each stakeholder had previously evaluated. The following is the hierarchy of variable levels as UHI causes in this study and the weighted value:
    1. Land Use Land Cover (LULC), 38%
    2. Vegetation, 14.7%
    3. Population Density, 13.5%
    4. Land Surface Temperature (LST), 12%
    5. Air Temperature, 8.5%
    6. Rainfall, 7.7%
    7. Topography, 5.2%
2. Based on data collected between 2023-01-01 to 2023-12-31, the examination of Jakarta's urban heat island distribution maps reveals that UHI falls into classes 4 and 5. Class 4, which represents the hot category with an area reaching 32.88%, is classified between 30.4°C and 32°C. Class 5, which classifies temperatures higher than 32°C, indicates that the Jakarta City region is predominantly in the extremely hot category, accounting for 67.12% of the total area. It can be concluded that Jakarta's UHI is already very high, and that the city's residents may experience life-threatening heat waves.
3. The hierarchy variable level as the factors that must be consider in determining the priority location of GOS in Jakarta based on distribution of UHI, namely:
    1. Land Use Land Cover (LULC), 42.7%

2. Population Density, 33.3%
3. Land Surface Temperature (LST), 13.2%
4. Vegetation, 10.8%

4. Using ArcGIS's weighted overlay tools, the weighting results and class of each variable are utilized in the study to determine the need of GOS locations for the second objective. This study yielded five priority classes: very priority class, priority class, moderate priority class, less priority class, and not priority. The results of the need location of GOS map were then validated using the intersect tool with the current land use map. Class 1 as the not priority area to build the GOS is covered by road network, waterbodies, and green area. Class 2 as the less priority area is the area near to the existing of Green Open space in Jakarta. Class 3 as the moderate priority is covered by some of the transportation area and multipurpose building. Class 4 as the priority area is vacant land. Lastly, the land use has been utilized for residential, multipurpose building, office, commercial, and other uses for the highest priority class for the development of GOS in Jakarta. So that the validation results with this land use map can help determine the detailed location and type of GOS that can be developed in Jakarta.

5.2 Recommendation

The distribution of urban heat islands in Jakarta is used in this study to determine the need of green open spaces locations. Future researchers can use the following recommendations as a guide to fill in the gaps in this research, as there is still more that can be done to supplement its findings.

1. Jakarta has a very high UHI distribution, indicating that city planners must take action to implement sustainable city design to reduce UHI. In addition, several other variables are still considered when assessing the components that cause UHI in Jakarta, according to previous research. Variables such as Temperature Humidity Index (THI) can be added by future researchers. Based on relative humidity and air temperature, THI can be utilized to evaluate the degree of thermal comfort in each space.
2. To support the development and fulfill the need of GOS in Jakarta, further research on the precise area points that can be developed, and their sizes must be conducted to determine the GOS location priority. Further factors for this goal can also be thought of as those utilized by earlier studies, such as buffers from the current GOS site, buffers from waterbodies, and buffers from roads (Aryaguna et al., 2022). This will allow for a more thorough and comprehensive examination for determining GOS priority areas. The socio-

economic perspective can be considered while deciding the location. Higher socioeconomic groups typically have greater access to green spaces because they can afford to construct and maintain the infrastructure needed to sustain them, according to research from (Ufaira et al., 2023).

BIBLIOGRAPHY

Abdi, Z., Alizadeh, H., Mohammadi, S., & Sabouri, S. (2023). Analysis of urban form typology using urban heat island indicators: Case study of Ferdous neighborhood of Tabriz. *Frontiers in Ecology and Evolution*, *10*. https://doi.org/10.3389/fevo.2022.1065538

Abdulateef, M. F., & A. S. Al-Alwan, H. (2022). The effectiveness of urban green infrastructure in reducing surface urban heat island: Baghdad city as a case study. *Ain Shams Engineering Journal*, *13*(1). https://doi.org/10.1016/j.asej.2021.06.012

Adeanti, M., & Harist, M. C. (2018). *ANALISIS_SPASIAL_KERAPATAN_BANGUNAN_DAN_PENGARUHNY*.

Agustine, V., Putra, D. D., & Rilansari, V. (2023). Blue-Green Infrastructure for Jakarta's Sustainable Planning and Resilience. *IOP Conference Series: Earth and Environmental Science*, *1211*(1), 012018. https://doi.org/10.1088/1755-1315/1211/1/012018

Ahirwar, S., Malik, M. S., Ahirwar, R., & Shukla, J. P. (2020). Application of Remote Sensing and GIS for Groundwater Recharge Potential Zone Mapping in Upper Betwa Watershed. *Journal of the Geological Society of India*, *95*(3), 308–314. https://doi.org/10.1007/s12594-020-1430-3

Arifah, N., & Susetyo, C. (2018). Penentuan Prioritas Ruang Terbuka Hijau berdasarkan Efek Urban Heat Island di Wilayah Surabaya Timur. *JURNAL TEKNIK ITS Vol. 7, No. 2, (2018) ISSN: 2337-3539 (2301-9271 Print)*, *Vol.7*.

Aryaguna, P. A., Gaffara, G. R., Sari, D. A. K., & Arianto, A. (2022). Green Open Space Priority Modelling Using GIS Analysis In West Jakarta. *Indonesian Journal of Geography*, *54*(2), 263–271. https://doi.org/10.22146/ijg.68184

Balany, F., Ng, A. W. M., Muttil, N., Muthukumaran, S., & Wong, M. S. (2020). Green infrastructure as an urban heat island mitigation strategy—a review. In *Water (Switzerland)* (Vol. 12, Issue 12). MDPI AG. https://doi.org/10.3390/w12123577

Bermana, I. (n.d.). *KLASIFIKASI GEOMORFOLOGI UNTUK PEMETAAN GEOLOGI YANG TELAH DIBAKUKAN*.

Bokaie, M., Zarkesh, M. K., Arasteh, P. D., & Hosseini, A. (2016). Assessment of Urban Heat Island based on the relationship between land surface temperature and Land Use/ Land Cover in Tehran. *Sustainable Cities and Society*, *23*, 94–104. https://doi.org/10.1016/j.scs.2016.03.009

Chapman, S., Watson, J. E. M., Salazar, A., Thatcher, M., & McAlpine, C. A. (2017). The impact of urbanization and climate change on urban temperatures: a systematic review. In *Landscape Ecology* (Vol. 32, Issue 10, pp. 1921–1935). Springer Netherlands. https://doi.org/10.1007/s10980-017-0561-4

De Haas, W., Hassink, J., & Stuiver, M. (2021). The Role of Urban Green Space in Promoting Inclusion: Experiences From the Netherlands. In *Frontiers in Environmental Science* (Vol. 9). Frontiers Media S.A. https://doi.org/10.3389/fenvs.2021.618198

Fardani, I., & Yosliansyah, M. R. (2022). KAJIAN PENENTUAN PRIORITAS RUANG TERBUKA HIJAU BERDASARKAN FENOMENA URBAN HEAT ISLAND DI KOTA CIREBON. *Jurnal Sains Informasi Geografi*, *5*(2), 93. https://doi.org/10.31314/jsig.v5i2.1708

Farhan, M. A. (2022). *ANALISIS HUBUNGAN PERKEMBANGAN LAHAN TERBANGUN DENGAN URBAN HEAT ISLAND DI KOTA PADANG PADA TAHUN 2010, 2015 DAN 2020*.

Fortuniak, K. (2009). *Selected characteristics of the atmospheric turbulence over a central European city centre-spectral statistics SELECTED CHARACTERISTICS OF THE ATMOSPHERIC TURBULENCE OVER A CENTRAL EUROPEAN CITY CENTRE-INTEGRAL STATISTICS*. https://www.researchgate.net/publication/253228735

Ghofrani, Z., Sposito, V., & Faggian, R. (2017). A Comprehensive Review of Blue-Green Infrastructure Concepts. *International Journal of Environment and Sustainability*, *6*(1). https://doi.org/10.24102/ijes.v6i1.728

Gunawardena, K. R., Wells, M. J., & Kershaw, T. (2017). Utilising green and bluespace to mitigate urban heat island intensity. *Science of the Total Environment*, *584–585*, 1040–1055. https://doi.org/10.1016/j.scitotenv.2017.01.158

Himayah, S., Ridwana, R., & Ismail, A. (2020). Land surface temperature analysis based on land cover variations using satellite imagery. *IOP Conference Series: Earth and Environmental Science*, *500*(1). https://doi.org/10.1088/1755-1315/500/1/012019

Hu, L., & Li, Q. (2020). Greenspace, bluespace, and their interactive influence on urban thermal environments. *Environmental Research Letters*, *15*(3). https://doi.org/10.1088/1748-9326/ab6c30

Jabbar, H. K., Hamoodi, M. N., & Al-Hameedawi, A. N. (2023). Urban heat islands: a review of contributing factors, effects and data. *IOP Conference Series: Earth and Environmental Science*, *1129*(1). https://doi.org/10.1088/1755-1315/1129/1/012038

Jang, J., Lee, W., Choi, M., Kang, C., & Kim, H. (2020). Roles of urban heat anomaly and land-use/land-cover on the heat-related mortality in the national capital region of South Korea: A multi-districts time-series study. *Environment International*, *145*. https://doi.org/10.1016/j.envint.2020.106127

Januar, D., Suprayogi, A., & Prasetyo, Y. (2016). Studi Kasus : Wilayah Kota Semarang, Jawa Tengah. In *Jurnal Geodesi Undip Januari* (Vol. 5, Issue 1).

Kardinal Jusuf, S., Wong, N. H., Hagen, E., Anggoro, R., & Hong, Y. (2007). The influence of land use on the urban heat island in Singapore. *Habitat International*, *31*(2), 232–242. https://doi.org/10.1016/j.habitatint.2007.02.006

Li, X., Stringer, L. C., & Dallimer, M. (2022). The Impacts of Urbanisation and Climate Change on the Urban Thermal Environment in Africa. In *Climate* (Vol. 10, Issue 11). MDPI. https://doi.org/10.3390/cli10110164

Liu, Y., & Yamauchi, F. (2014). Population density, migration, and the returns to human capital and land: Insights from Indonesia. *Food Policy*, *48*, 182–193. https://doi.org/10.1016/j.foodpol.2014.05.003

Lyapin, A., & Druzhinina, I. (2019). Greenways as a new type of urban green construction at the foreign architectural practice. *IOP Conference Series: Materials Science and Engineering*, *667*(1). https://doi.org/10.1088/1757-899X/667/1/012059

Made, I., Widyarsana, W., Damanhuri, E., Ulhusna, N., & Agustina, E. (n.d.). *A Preliminary Study: Identification of Stream Waste Quantity and Composition in Bali Province, Indonesia*. https://doi.org/10.1051/e3sconf/20

Mahdiyah, U., Akbar, A. A., & Romiyanto, R. (2023). Efektivitas Ruang Terbuka Hijau (RTH) sebagai Daerah Resapan Air dan Penyimpanan Karbon di Kota Pontianak. *Jurnal Ilmu Lingkungan*, *21*(3), 553–564. https://doi.org/10.14710/jil.21.3.553-564

Maleknia, R., Akbari, H., Soosani, J., & Karami, O. (2013). Site selection for local forest park using analytic hierarchy process and geographic information system (case study: Badreh County. In *Article in International Journal of Sciences Basic and Applied Research*. https://www.researchgate.net/publication/269410424

Marsawal, D. A., Zubair, H., & Soma, A. S. (2021). Green Open Space Planning in Improving the Quality of Space in the Mamuju Urban Area. *International Journal Papier Public Review*, *2*(3), 29–41. https://doi.org/10.47667/ijppr.v2i3.99

Menberg, K., Bayer, P., Zosseder, K., Rumohr, S., & Blum, P. (2013). Subsurface urban heat islands in German cities. *Science of the Total Environment*, *442*, 123–133. https://doi.org/10.1016/j.scitotenv.2012.10.043

Mohajerani, A., Bakaric, J., & Jeffrey-Bailey, T. (2017). The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete. In *Journal of Environmental Management* (Vol. 197, pp. 522–538). Academic Press. https://doi.org/10.1016/j.jenvman.2017.03.095

Mukesh Kumar, M. K., Keshav Kumar Sharma, K. K. S., Deepak Lal, D. L., Atul, A., Ashhad Imam, A. I., & Shakti Suryavanshi, S. S. (2018). Identifying Prospective Areas for Groundwater Potential Zone in Allahabad City. *Journal of Environmental Nanotechnology*, *7*(4), 16–24. https://doi.org/10.13074/jent.2018.12.184336

Muzaky, H., & Jaelani, L. M. (2019). Analisis Pengaruh Tutupan Lahan terhadap Distribusi Suhu Permukaan: Kajian Urban Heat Island di Jakarta, Bandung dan Surabaya. *Jurnal Penginderaan Jauh Indonesia Agustus*, *01*(02). http://jurnal.mapin.or.id/index.php/jpji/issue/archive

National Landuse Database. (2006). *National Land Use Database: Land Use and Land Cover Classification*.

Nugroho, J. A., Sukojo, B. M., & Sari, I. L. (2010). *PEMETAAN DAERAH RAWAN LONGSOR DENGAN PENGINDERAAN JAUH DAN SISTEM INFORMASI GEOGRAFIS (STUDI KASUS : KAWASAN HUTAN LINDUNG KABUPATEN MOJOKERTO)*.

Oke, T. R. (1982). The energetic basis of the urban heat island. In *Quart. J. R. Met. Soc* (Vol. 108, Issue 455).

Okvat, H. A., & Zautra, A. J. (2011). Community Gardening: A Parsimonious Path to Individual, Community, and Environmental Resilience. *American Journal of Community Psychology*, *47*(3–4), 374–387. https://doi.org/10.1007/s10464-010-9404-z

Pantalone, S. (2010). *Creating the Urban Forest: Suitability Analysis for Green Space in the City of Boston*.

Peraturan Menteri Kehutanan Nomor P.32/Menhut-II/2009. (n.d.).

Pokhrel, S. (2019). Green space suitability evaluation for urban resilience: an analysis of kathmandu metropolitan city, nepal. *Environmental Research Communications*, *1*(10). https://doi.org/10.1088/2515-7620/ab4565

Puspita, I. B., & Saputra, F. A. (2019). Effect of Land Use Change to the Increasing Land-Based Emission and Urban Heat Island Phenomenon in Bandung City. *IOP Conference Series: Earth and Environmental Science*, *328*(1). https://doi.org/10.1088/1755-1315/328/1/012021

Putra, C. D., Ramadhani, A., & Fatimah, E. (2021). Increasing Urban Heat Island area in Jakarta and it’s relation to land use changes. *IOP Conference Series: Earth and Environmental Science*, *737*(1). https://doi.org/10.1088/1755-1315/737/1/012002

Qiu, G. Y., Zou, Z., Li, X., Li, H., Guo, Q., Yan, C., & Tan, S. (2017). Experimental studies on the effects of green space and evapotranspiration on urban heat island in a subtropical megacity in China. *Habitat International*, *68*, 30–42. https://doi.org/10.1016/j.habitatint.2017.07.009

Rahman, M. N., Rony, M. R. H., Jannat, F. A., Pal, S. C., Islam, M. S., Alam, E., & Islam, A. R. M. T. (2022). Impact of Urbanization on Urban Heat Island Intensity in Major Districts of Bangladesh Using Remote Sensing and Geo-Spatial Tools. *Climate*, *10*(1). https://doi.org/10.3390/cli10010003

Rania, P., Rini, I., Ari, D., & Yudono, A. (2023). PENILAIAN TINGKAT KENYAMANAN IKLIM MIKRO BERDASARKAN TEMPERATURE HUMIDITY INDEX KOTA PASURUAN. In *Planning for Urban Region and Environment* (Vol. 12, Issue 1).

Rizki, A. R., Tumuyu, S. S., & Rushayati, S. B. (2024). The Impact of Urban Green Space on The Urban Heat Island Phenomenon – A Study Case in East Jakarta, Indonesia. *Geoplanning*, *11*(1), 31–42. https://doi.org/10.14710/geoplanning.11.1.31-42

Rushayati, S. B., Prasetyo, L. B., Puspaningsih, N., & Rachmawati, E. (2016). Adaptation Strategy Toward Urban Heat Island at Tropical Urban Area. *Procedia Environmental Sciences*, *33*, 221–229. https://doi.org/10.1016/j.proenv.2016.03.073

Saputra, A., Ibrahim, M. H., Shofirun, S., Saifuddin, A., & Furoida, K. (2022). Assessing urban heat island in Jakarta, Indonesia during the pandemic of Covid-19. *IOP Conference Series: Earth and Environmental Science*, *986*(1). https://doi.org/10.1088/1755-1315/986/1/012069

Schwarz, N., Lautenbach, S., & Seppelt, R. (2011). Exploring indicators for quantifying surface urban heat islands of European cities with MODIS land surface temperatures. *Remote Sensing of Environment*, *115*(12), 3175–3186. https://doi.org/10.1016/j.rse.2011.07.003

Semenzato, P., & Bortolini, L. (2023). Urban Heat Island Mitigation and Urban Green Spaces: Testing a Model in the City of Padova (Italy). *Land*, *12*(2). https://doi.org/10.3390/land12020476

Shah, A., Garg, A., & Mishra, V. (2021). Quantifying the local cooling effects of urban green spaces: Evidence from Bengaluru, India. *Landscape and Urban Planning*, *209*. https://doi.org/10.1016/j.landurbplan.2021.104043

Sidek, L. M. (2012). *THE RELATIONSHIP OF LOCALIZED RAINFALL VERSUS URBAN HEAT ISLAND (UHI) PARAMETERS AND AIR POLLUTION*. https://www.researchgate.net/publication/280922141

Siswanto, S., Nuryanto, D. E., Ferdiansyah, M. R., Prastiwi, A. D., Dewi, O. C., Gamal, A., & Dimyati, M. (2023). Spatio-temporal characteristics of urban heat Island of Jakarta metropolitan. *Remote Sensing Applications: Society and Environment*, *32*, 101062. https://doi.org/10.1016/j.rsase.2023.101062

Siswanto, S., van Oldenborgh, G. J., van der Schrier, G., Jilderda, R., & van den Hurk, B. (2016). Temperature, extreme precipitation, and diurnal rainfall changes in the urbanized Jakarta city during the past 130 years. *International Journal of Climatology*, *36*(9), 3207–3225. https://doi.org/10.1002/joc.4548

Sivaul, G., & Biorestia, F. (2023). *Pemantauan Land Surface Temperature (LST) dan Kaitannya dengan Tutupan Lahan (Studi Kasus: Kota Surabaya Tahun 2014-2022*.

Sugiyono. (2011). *Sugiyono, 2011*.

Supriardi, A. (2018). *Analytical Hierarchy Process (AHP)*.

Syafitri, R. A. W. D., Susetyo, C., & Setiawan, R. P. (2020). Planning for compact eco-cities: A spatial planning to prioritise green infrastructure development to mitigate urban heat island in Surabaya. *IOP Conference Series: Earth and Environmental Science*, *562*(1). https://doi.org/10.1088/1755-1315/562/1/012019

Tanuwidjaja, G., & Chang, B. G. (2017). Green Infrastructure Concept for JABODETABEKJUR Metropolitan Area. *IOP Conference Series: Earth and Environmental Science*, *79*(1). https://doi.org/10.1088/1755-1315/79/1/012024

Tao, M., Konopka, P., Ploeger, F., Riese, M., Müller, R., & Volk, C. M. (2015). Impact of stratospheric major warmings and the quasi-biennial oscillation on the variability of stratospheric water vapor. *Geophysical Research Letters*, *42*(11), 4599–4607. https://doi.org/10.1002/2015GL064443

Ufaira, R., Amir, S., Indraprahasta, G. S., & Nastiti, A. (2023). Living in a hot city: thermal justice through green open space provision. *Frontiers in Human Dynamics*, *5*. https://doi.org/10.3389/fhumd.2023.1237515

Vargas, L., & St, C. (2022). *The Analytic Hierarchy Process*. http://www.springer.com/series/6161

Wang, X., Zhang, Y., & Yu, D. (2023). Exploring the Relationships between Land Surface Temperature and Its Influencing Factors Using Multisource Spatial Big Data: A Case Study in Beijing, China. *Remote Sensing*, *15*(7). https://doi.org/10.3390/rs15071783

Wirayuda, I. K. A. K., Widayani, P., & Sekaranom, A. B. (2023). Urban Green Space Analysis and its Effect on the Surface Urban Heat Island Phenomenon in Denpasar City, Bali. *Forest and Society*, *7*(1), 150–168. https://doi.org/10.24259/fs.v7i1.24526

Xu, F., Otte, A., Ludewig, K., Donath, T. W., & Harvolk-Schöning, S. (2017). Land cover changes (1963-2010) and their environmental factors in the Upper Danube Floodplain. *Sustainability (Switzerland)*, *9*(6). https://doi.org/10.3390/su9060943

Xu, L., Cui, S., Tang, J., Nguyen, M., Liu, J., & Zhao, Y. (2019). Assessing the adaptive capacity of urban form to climate stress: A case study on an urban heat island. *Environmental Research Letters*, *14*(4). https://doi.org/10.1088/1748-9326/aafe27

Yunita, R., Wibowo, A., Supriatna, & Rais, A. F. (2022). Urban Heat Island Mitigation Strategy based on Local Climate Zone Classification using Landsat 8 satellite imagery. *IOP Conference Series: Earth and Environmental Science*, *1039*(1). https://doi.org/10.1088/1755-1315/1039/1/012013

Zhou, X., & Chen, H. (2018). Impact of urbanization-related land use land cover changes and urban morphology changes on the urban heat island phenomenon. *Science of the Total Environment*, *635*, 1467–1476. https://doi.org/10.1016/j.scitotenv.2018.04.091

APPENDIX

Appendix 1. Survey Design

No	Objective	Data	Data Collection	Data Sources	Method	Technique	Output
1	Determine the variable weight of the factors causing Urban Heat Island and its distribution in Jakarta.	Land Surface Temperature (LST)	Primary Data	Stakeholders related: 1. Government Agency - Dinas Cipta Karya Tata Ruang dan Pertanahan DKI Jakarta - Dinas Pertamanan dan Hutan Kota DKI Jakarta 2. Academics 3. Community Organization	Stakeholder Interview	AHP Method	•Priority factors cause UHI in Jakarta •Map of UHI distribution
		Land Use					
		Vegetation					
		Land Cover					
		Air Temperature					
		Topography					
		Rainfall					
		Population Density					
2	Determine the priority location of the Green Open Space location based on the distribution of Urban Heat Island in Jakarta.	Land Surface Temperature (LST)	Primary and Secondary Data	RemoteLandsat 8 Imagery	Remote Sensing	ARCGIS Weighted Overlay	• Map of priority location for GOS in Jakarta City
		Land Use		DCKTRP	Agency Survey		
		Vegetation		Landsat 8 Imagery	Remote Sensing		
		Land Cover		DCKTRP	Agency Survey		
		Air Temperature		BMKG and BPS Jakarta 2024	Agency Survey		
		Topography		DEM Indonesia Geospasial	Agency Survey		
		Rainfall		BMKG and BPS Jakarta 2024	Agency Survey		
		Population Density		BPS Jakarta 2024	Agency Survey		

Appendix 2. Questionnaire

KUESIONER PENELITIAN
ANALISIS KEBUTUHAN LOKASI RUANG TERBUKA HIJAU
BERDASARKAN PERSEBARAN *URBAN HEAT ISLAND* DI JAKARTA

Bapak/Ibu/Saudara/i yang saya hormati,

Sehubungan dengan penyusunan mata kuliah Tugas Akhir, saya **Faranissah Noer Azizah** selaku mahasiswa dari Departemen Perencanaan Wilayah dan Kota Institut Teknologi Sepuluh Nopember, memohon ketersediaan Bapak/Ibu/Saudara/i untuk menjadi responden dalam penelitian saya yang berjudul **"Analisis Kebutuhan Lokasi Ruang Terbuka Hijau berdasarkan distribusi *Urban Heat Island* di Jakarta".** Kuesioner ini bertujuan untuk untuk mengetahui pendapat Bapak/Ibu sebagai pihak pemerintah/masyarakat mengenai faktor utama yang mempengaruhi terjadinya *Urban Heat Island* di Jakarta. Hasil kuesioner akan dianalisis dengan menggunakan metode *Analytic Hierarchy Process* (AHP). Hasil dari kuesioner ini diharapkan mampu memberikan kriteria yang ideal dalam perumusan sebagai faktor penyebab *Urban Heat Island* di Jakarta.

Besar harapan saya, Bapak/Ibu/Saudara/i dapat memberikan informasi dan pendapat untuk penelitian ini. Atas ketersediaan Bapak/Ibu/Saudara/i, saya ucapkan terima kasih.

Hormat saya,

Faranissah Noer Azizah
NRP 5015201160
Departemen Perencanaan Wilayah dan Kota
Institut Teknologi Sepuluh Nopember

Narahubung: 0878 0016 6670 / faraazizah31@gmail.com

IDENTITAS RESPONDEN

Nama :

Instansi/Alamat :

Bidang/Jabatan :

PETUNJUK PENGISIAN

1. Kriteria atau elemen pada setiap level/tingkatan hirarki didefinisikan dan dibatasi oleh penyusunan kuesioner untuk menghindari asumsi yang terlalu luas dan terfokus.
2. Responden diminta untuk memberikan tanggapan/penilaian terhadap setiap perbandingan berpasangan berdasarkan pengalaman, pengetahuan, dan intuisi responden selama ini.
3. Tingkat kepentingan yang digunakan dalam kuesioner adalah sebagai berikut:

Intensitas Kepentingan atau Tingkat Preferensi	Definisi	Penjelasan
1	*Equal importance* (Kedua elemen sama penting)	Dua aktifitas (elemen) memeberikan kontribusi sama terhadap tujuan
3	*Moderate importance* (Elemen yang satu sedikit lebih penting dari yang lain)	Pengalaman dan penilaian memberikan nilai tidak jauh berbeda antara satu aktivitas (elemen) terhadap aktivitas (elemen) lainnya
5	*Strong importance* (Elemen yang satu lebih penting dari yang lain)	Pengalaman dan penilaian memberikan nilai kuat berbeda antara satu aktivitas (elemen) terhadap aktivitas lainnya
7	*Very Strong importance* (Elemen yang satu sangat lebih penting dari yang lain)	Satu aktivitas (elemen) sangat lebih disukai dibanding aktivitas (elemen) lainnya
9	*Extreme importance* (Elemen yang satu mutlak lebih penting dari yang lain)	Satu aktivitas (elemen) secara pasti menempati urutan tertinggi dalam tingkatan preferensi
2, 4, 6, 8	Nilai Kompromi atas nilai-nilai di atas (Nilai tengah antara dua pertimbangan yang berdekatan)	Penilaian Kompromi secara numeris dibutuhkan semenjak tidak ada kata yang tepat untuk menggambarkan tingkat preferensi

Contoh Manakah yang lebih penting dari kriteria penyebab faktor *Urban Heat Island* di bawah ini

Kriteria A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Kriteria B

Hal ini berarti bahwa Kriteria A sangat penting daripada Kriteria B pada penentuan faktor terjadinya *Urban Heat Island* di Jakarta. Dengan ini saya mengharapkan ketersediaan Bapak/Ibu/Saudara/i untuk menjawab daftar pertanyaan ini sesuai dengan pengalaman anda.

Kriteria

Berikut ini terdapat kriteria yang akan dibobotkan untuk mendapatkan kriteria sebagai penetu faktor utama penyebab *Urban Heat Island* di Jakarta. Kriteria ini disusun berdasarkan hasil sintesa pustaka yang telah dilakukan peneliti sebelumnya.

Variable	Keterangan
Suhu Permukaan Tanah (LST)	Suhu pada lapisan paling atas tanah, yang dapat dipengaruhi oleh berbagai faktor seperti radiasi matahari, kelembapan, vegetasi, dan aktivitas manusia.
Penggunaan Lahan Tutupan Lahan (LULC)	Penggunaan Lahan di Jakarta, mencakup berbagai aktivitas seperti pertanian, perumahan, industri, kehutanan, dan infrastruktur.
Vegetasi	Kumpulan tanaman yang tumbuh di suatu area tertentu. Contoh vegetasi adalah hutan hujan tropis, padang rumput, dan tundra.
Suhu Udara	Ukuran panas atau dinginnya atmosfer pada suatu lokasi dan waktu tertentu. Suhu udara dipengaruhi oleh berbagai faktor seperti radiasi matahari, ketinggian, dan kondisi cuaca. Contoh pengukuran suhu udara adalah 25°C pada siang hari di daerah tropis.
Curah Hujan	Jumlah air yang jatuh ke permukaan bumi dalam bentuk hujan, salju, hujan es, atau bentuk presipitasi lainnya. Curah hujan diukur dalam satuan milimeter (mm) atau inci (in) dan biasanya dicatat selama periode tertentu (harian, bulanan, tahunan).
Topografi	Karakteristik fisik permukaan tanah, termasuk bentuk, ketinggian, dan fitur-fitur geografis seperti gunung, bukit, lembah, dataran, dan sungai.
Kepadatan Penduduk	Jumlah orang yang tinggal di suatu area tertentu, biasanya dinyatakan dalam jumlah penduduk per kilometer persegi (km^2) atau per mil persegi (mi^2).

Kuesioner

Keterangan : Lingkarilah kriteria nilai sesuai dengan persepsi Bapak/Ibu mengenai tingkat kepentingan antar aspek berikut .

IDENTITAS RESPONDEN
Nama : Ihsan Syahara
Instansi/Alamat : Dinas Cipta Karya, Tata Ruang dan Pertanahan Provinsi DKI Jakarta
Bidang/Jabatan : Asisten Professional Staff

Variabel Prioritas Faktor Penyebab *Urban Heat Island* dan Sebarannya di Jakarta

Kriteria A	Skala Penilaian																	Kriteria B
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	LULC
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Vegetation
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Air Temperature
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Rainfall
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Topography
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Population Density
LULC	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
LULC	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Air Temperature
LULC	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rainfall
LULC	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Topography
LULC	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Population Density
Vegetation	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Air Temperature
Vegetation	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Rainfall
Vegetation	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Topography
Vegetation	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Population Density
Air Temperature	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Rainfall
Air Temperature	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Topography
Air Temperature	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	Population Density
Rainfall	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Topography
Rainfall	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Population Density
Topography	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	**8**	9	Population Density

Penentuan kebutuhan Lokasi Ruang Terbuka Hijau berdasarkan Distribusi Urban Heat Island di Jakarta

Kriteria A	Skala Penilaian																	Kriteria B
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	LULC
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
LULC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
LULC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
Vegetation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density

IDENTITAS RESPONDEN
Nama : Hendrianto
Instansi/Alamat : Dinas Pertamanan dan Hutan Kota DKI Jakarta
Bidang/Jabatan : Bidang Perencanaan Pertamanan dan Hutan Kota

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Variabel Prioritas Faktor Penyebab *Urban Heat Island* dan Sebarannya di Jakarta

Kriteria A	Skala Penilaian																	Kriteria B
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	**9**	LULC
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	**9**	Vegetation
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Air Temperature
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Rainfall
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Topography
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	**9**	Population Density
LULC	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
LULC	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Air Temperature
LULC	9	**8**	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rainfall
LULC	9	**8**	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Topography
LULC	9	8	7	**6**	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
Vegetation	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Air Temperature
Vegetation	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Rainfall
Vegetation	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Topography
Vegetation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Population Density
Air Temperature	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Rainfall
Air Temperature	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Topography
Air Temperature	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	Population Density
Rainfall	9	8	7	**6**	5	4	3	2	1	2	3	4	5	6	7	8	9	Topography
Rainfall	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Population Density
Topography	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Population Density

Penentuan kebutuhan Lokasi Ruang Terbuka Hijau berdasarkan Distribusi Urban Heat Island di Jakarta

Kriteria A	Skala Penilaian																	Kriteria B
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	LULC
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
LULC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
LULC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
Vegetation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density

IDENTITAS RESPONDEN
Nama : Endrawati Fatimah
Instansi/Alamat : Prodi PWK Jurusan Teknik Planologi, FALTL Universitas Trisakti Jl. Kyai Tapa 1 Grogol Jakarta 11440
Bidang/Jabatan : Dosen

Variabel Prioritas Faktor Penyebab *Urban Heat Island* dan Sebarannya di Jakarta

Kriteria A	Skala Penilaian																	Kriteria B
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	LULC
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Vegetation
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Air Temperature
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Rainfall
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Topography
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Population Density
LULC	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Vegetation
LULC	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Air Temperature
LULC	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rainfall
LULC	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Topography
LULC	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Population Density
Vegetation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Air Temperature
Vegetation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Rainfall
Vegetation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Topography
Vegetation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Population Density
Air Temperature	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Rainfall
Air Temperature	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Topography
Air Temperature	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Population Density
Rainfall	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Topography
Rainfall	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Population Density
Topography	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Population Density

Penentuan kebutuhan Lokasi Ruang Terbuka Hijau berdasarkan Distribusi Urban Heat Island di Jakarta

Kriteria A	Skala Penilaian																	Kriteria B
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	LULC
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
LULC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
LULC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
Vegetation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density

IDENTITAS RESPONDEN
Nama : Alvin Andrean
Instansi/Alamat : Rujak Center for Urban Studies
Bidang/Jabatan : Urban Planner Staff

Variabel Prioritas Faktor Penyebab *Urban Heat Island* dan Sebarannya di Jakarta

Kriteria A	Skala Penilaian																	Kriteria B
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	LULC
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Vegetation
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Air Temperature
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Rainfall
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Topography
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Population Density
LULC	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Vegetation
LULC	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Air Temperature
LULC	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Rainfall
LULC	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Topography
LULC	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Population Density
Vegetation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Air Temperature
Vegetation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Rainfall
Vegetation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Topography
Vegetation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Population Density
Air Temperature	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Rainfall
Air Temperature	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Topography
Air Temperature	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Population Density
Rainfall	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Topography
Rainfall	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Population Density
Topography	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Population Density

Penentuan kebutuhan Lokasi Ruang Terbuka Hijau berdasarkan Distribusi Urban Heat Island di Jakarta

Kriteria A	Skala Penilaian																	Kriteria B
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	LULC
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
Suhu Permumkaan Tanah (LST)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
LULC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Vegetation
LULC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density
Vegetation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Population Density

AUTHOR BIOGRRPHS

The author was born in Jakarta on May 31, 2002. After taking formal education and graduating from SMAN 1 Tambun Selatan, the author continued her education as an international student at the Department of Regional and City Planning, Institute Technology of Sepuluh Nopember. As an IUP student, the author participated in a student exchange program at Shibaura Institute Technology Japan in 2022. During the studies, the author actively participated in student program activities, organizations and volunteer activities such as the KMMI Short Course from the Ministry of Education and Culture 2021, as a reporter for the creation of the Urban Planning Magazine of HMPL ITS 9 editions, international forum and conference from the University of Technology Malaysia and SIT Japan events. Apart from that, the author completed an internship program from MSIB batch 5 at PT Chakra Giri Energi Indonesia as a research analyst in 2023. The author has high hopes for the usefulness of this final project, therefore, if you have constructive criticism/suggestions, don't hesitate to contact the author via email, faraazizah31@gmail.com.