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The best scenario for the development of public green open space zones in Malang, Indonesia

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Abstract

The establishment of green open spaces is closely correlated with the advancement of urban development, as they offer a multitude of benefits, including ecological, environmental, socio-cultural, and economic advantages. According to data from the Department of Public Works, Spatial Planning, Housing, and Settlement Areas of Malang City, public green open spaces have yet to be established in all settlements in Malang City. Consequently, the benefits of these spaces are not yet accessible to all residents. This research project focuses on the development of scenarios for the development of public green open spaces, authorized by the Malang City Government, which will enable the use of minimum facilities to serve as many people as possible. The research employed quantitative methods in data processing and analysis in order to select the optimal public green space zone development scenario. The spatial analysis was performed using ArcMap 10.4.1. Furthermore, this research employed the standard service radius set forth in the Regulation of the Minister of Agrarian and Spatial Planning/Head of the National Land Agency Number 14 of 2022 and the service coverage of the Neighborhood Unit concept. In Malang City, it was determined that the optimal scenario for potential land involves prioritizing the development of city parks, district parks, and sub-district parks in that order. Consequently, the aforementioned scenario would result in city parks, district parks, and sub-district parks collectively serving only 73.52, 43.17, and 33.49 percent of the population of Malang City, respectively.

Keywords: green open space; development scenario; resident service

1. Introduction

Some current environmental problems require the development of a healthy and sustainable urban environment (World Health Organization, 2017). Green open space (GOS) is closely related to the development process, as it offers a range of benefits, including ecological, environmental, socio-cultural, and economic advantages. One of the ecological benefits is a decrease in surface temperature in a 300 meter radius area from a minimum of 1ha green space areas (Liou et al., 2021). Besides, adequate size of green space and good accessibility can help in disaster prevention due to its environmental and social functions (Astell-Burt et al., 2014; Gozalo et al., 2019). Moreover, the maintenance and development of existing green spaces in areas of deficiency offer ecological and public health benefits (Knight et al., 2022). Specifically, it can reduce air pollution, retain surface water runoff, and reduce heat (Aram et al., 2019; Corbane et al., 2018; Davtalab et al., 2020; Han et al., 2021; Karthik et al., 2014; Khan et al., 2021; Priya & Senthil, 2021; Wu & Chen, 2023; Yang et al., 2022; Yuan, 2017). In terms of socio-cultural factors, green spaces can facilitate the growth of informal gatherings and social interactions, which are crucial for maintaining a healthy lifestyle. These interactions can help to reduce feelings of loneliness (Carmona, 2019; Jennings & Bamkole, 2019; Jeste et al., 2020;

Markevych et al., 2017; Mehta & Bosson, 2021; Paul et al., 2020; Van den Berg et al., 2019). Some studies have also highlighted the contribution of green spaces to human health, citing active contact with the natural environment as a key factor (Ekkel & de Vries, 2017; Soga et al., 2015). Meanwhile, economically, the existence of green spaces can improve the welfare of urban communities. One such benefit is the reduction of healthcare costs (Paul et al., 2020; Yang et al., 2022). In addition to reducing healthcare costs, green spaces attract tourists to visit (Mahendra, 2022). From an economic valuation perspective, green spaces play a role in mitigating climate change, with a value of IDR. 809,099,537.04 per year, as demonstrated in research conducted in Stabat City, suggesting the need for local governments to prioritize the maintenance and expansion of green spaces (Sulistiyono et al., 2022).

By 2050, it is estimated that approximately 68 percent of the world's population will live in cities (United Nations, 2018). This encourages urban development, which represents the most significant threat to existing green spaces, particularly the green spaces planned for the future (Biernacka & Kronenberg, 2018; Kronenberg, 2015). This is a concern for urban planners and policymakers in the planning of green spaces, which should be considered as one of the components to reduce negative impacts. Additionally, several studies imply that the benefits of green spaces may be greater for residents, particularly the ones in the surrounding areas (Ayala-Azcárraga et al., 2019; Tu et al., 2020). The proximity of green spaces to residences is of significant importance in encouraging individuals to engage in outdoor activities, which has a positive impact on social interaction and physical well-being (Wood et al., 2017). Consequently, in order to mitigate the impact and maximize the benefits, it is essential to provide accessible green spaces that can be utilized by all residents (Huck, 2023). Green spaces, particularly those that are accessible to all people, play a crucial role in the mental and physical well-being of communities, particularly those with low socioeconomic status (Astell-Burt et al., 2014; Ding et al., 2021; Lee et al., 2015; Markevych et al., 2017; Rigolon et al., 2018; Twohig-Bennett & Jones, 2018). The concept of freedom of access implies that the green space should be public and not private.

The accessibility of green spaces has been extensively discussed and researched in various locations, including Europe (Kabisch et al., 2016; Le Texier et al., 2018) and Asia (Du et al., 2020; Gong et al., 2016; Xu et al., 2019; Ye et al., 2018). Accessibility is a crucial aspect to consider for constructing a green space, as not all individuals can effortlessly access and utilize the functions of green spaces due to age, mobility, and gender-related limitations (Rahman & Zhang, 2018). Various methodologies and approaches have been employed to assess the accessibility of green spaces as an indicator of equitable distribution of services to settlements and residents. In a study by Du et al. (2020), the service radius was utilized to determine the accessibility of green space areas to buildings. The results indicated that the utilization of service radius in lieu of the actual condition of the road network may result in an overestimation of green space areas accessibility. This is corroborated by research from Xu et al. (2019) that employs Point of Interest (POI) as a proxy for buildings. However, subsequent analysis revealed that POI could not supplant the building size factor. In light of these findings, there is a clear need for the development of methods and approaches that consider the existing road network and are supported by population data. This will enable a more accurate assessment of green space area services to residents. Furthermore, the establishment of standards is also considered necessary by various researchers to analyze the accessibility of green space areas in a spatial and social context (Gupta et al., 2016; Maryanti et al., 2017).

The Indonesian government has also recognized the significance of green open space, resulting in the issuance of various regulations, including the most recent, the Regulation of the Minister of Agrarian and Spatial Planning/Head of the National Land Agency Number 14 of 2022 concerning Guidelines for the Provision and Utilization of Green Open Space. The regulation outlines the various types of green open space, including green open space zones, other zones that function as green open space, and green open space functioning space objects. The green open space zones are closely related to the provision of services to people living in settlements, as it has a service radius. The green open space zones encompass an urban forest, city park, district park, sub-district park, neighborhood association park, cemetery, and green lane. All of these types of green open spaces have a service radius, except for the green belt. The radius indicating the proximity of green open spaces can be a key indicator of their accessibility (World Health Organization, 2017). Generally, minimum standards are used in the development of green open spaces to ensure equitable distribution, although the approach still lacks specificity in terms of frequency, type, and radius (Kimpton, 2017). The Indonesian government's 2022 regulation has specifically addressed the frequency, type, and radius of green spaces, thereby ensuring that the development of green spaces in Indonesia will serve the entire population equitably. Further, the distribution of green spaces will undoubtedly have a positive impact on reducing particulate pollutants that can be inhaled by humans (Lu et al., 2019).

Malang City, designated as one of the National Activity Centers in East Java Province, is undergoing rapid development, particularly with the support of numerous universities that attract a diverse student population from across the country. This rapid growth has led to an increase in the city's population and a concomitant decline in environmental quality, as evidenced by rising surface temperatures (Hu & Qi, 2019). The rapid development of urban areas has been linked to adverse health outcomes for residents, with the environment playing a significant role in influencing human health (Temperli et al., 2017). Increasingly dense cities have been observed to reduce the area of green spaces and degrade their quality (Haaland & van Den Bosch, 2015; Nguyen & Chidthaisong, 2022). Furthermore, 59% of Malang City experiences the Urban Heat Island phenomenon, particularly in the city center (Kusumaningrum et al., 2022). This decline in quality is indicated in the Environmental Quality Index, where Malang City's air and water quality exhibit a downward trend. This is compounded by the lack of quantity of green spaces that are necessary to maintain the environmental quality of settlements and cities. The existing amount of green space in Malang City is only 1,045.31 hectares, which represents 9.5% of the city's total area. However, the city requires 2,256 hectares, or 20.4% of its area, to meet the recommended standard (Safrilia & Poerwoningsih, 2021). Therefore, it is evident that the Malang City Government must assume a more active role in the realization of green spaces. This is supported by the assumption of population growth and urbanization development, which indicates that the role of open space can be considered an effective factor in security and mental and physical health (Addas, 2018; Lestan et al., 2014; Ngom et al., 2016; Olwig, 2017). It is therefore imperative that the realization of open space be expedited, to prevent its development from being constrained to a few select areas and from being distributed in an uneven manner, as has been observed in the Lianhu, Beilin, and Xincheng districts of Xi'an City, China (Dang et al., 2021).

The Malang City Government has implemented a number of strategies to achieve the goal of green open space. One such strategy is the utilization of asset land and land acquisition for green open space, which is then followed by the establishment of public green open space through the Decree of the Mayor of Malang Number 188.45/139/35.73.112/2019, dated April 5, 2019. The letter pertains to the determination of city parks, city forests, and green lanes in Malang City, with an area of 28.77 ha, 9.31 ha, and 13.85 ha, respectively. When aggregated, the existing public green open space, with a total area of 51.93 ha, represents 0.47% of the Malang City area. According to data from the Malang City Public Works, Spatial Planning, Housing, and Settlement Areas Office, the public green open space has not reached all settlements in Malang City. In light of this and in consideration of the fact that cities are increasingly reducing open areas, it is necessary to develop green spaces by utilizing the minimum possible land while still being able to serve the residents of Malang City.

This research is concerned with the identification of scenarios for the development of public green open space authorized by the Malang City Government that can serve as many people as possible with the minimum facilities. Meanwhile, the subjects for this research include city parks, district parks, and sub-district parks. In the analysis process, the standard issued by the Ministry of Agrarian Affairs and Spatial Planning/Head of the National Land Agency of the Republic of Indonesia Number 14 of 2022 concerning the Provision and Utilization of Green Open Space with additional accessibility considerations are employed. The standard has not been widely utilized in research, particularly with regard to service radius, and the consideration of accessibility can more accurately depict the reach of green open space using the existing road network.

2. Method

This research employed quantitative methods in data processing and analysis to identify the optimal public green open space zone development scenario. This was accomplished through the use of ArcMap 10.4.1, which enabled the spatial selection of the most suitable scenario. This selection was based on the assumption that an area could only function as a city park, district park, or sub-district park. The stages involved in this process could broadly be classified as land potential assessment and scenario selection. The detailed stages of data processing and analysis are presented in Figure 1.

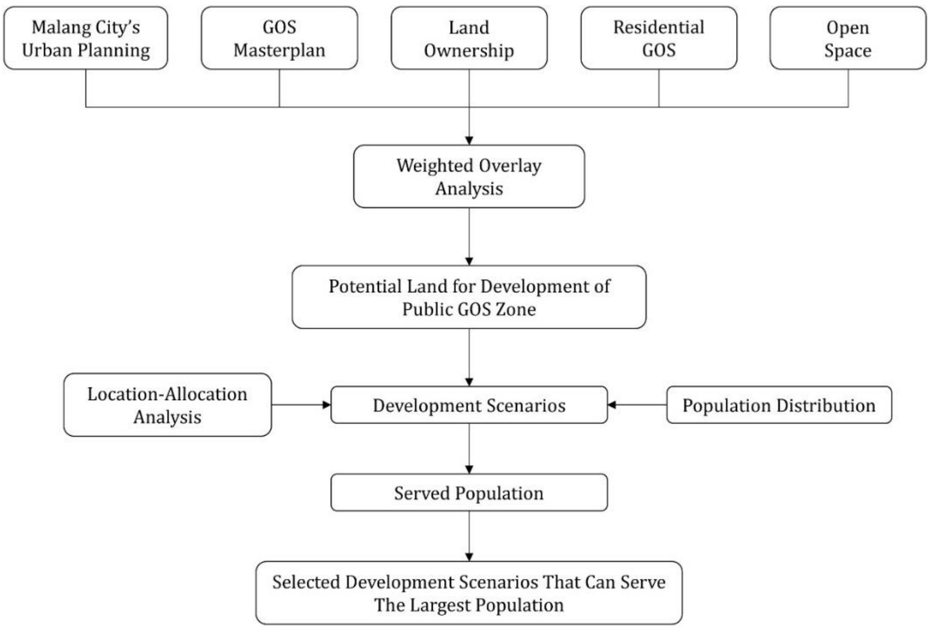

Figure 1. Stages of Data Processing and Analysis

In the assessment of land potential, data on spatial plans and land ownership were utilized in accordance with the direction in Regulation of the Minister of Agrarian and Spatial Planning/Head of the National Land Agency Number 14 of 2022. Additionally, open green areas were considered, given its open nature (Artandio et al., 2019). The spatial data was then assessed and weighed following expert opinion. In detail, the data used in the assessment of the potential for land to be designated as a public green open space zone is presented in Table 1.

Table 1. Data Processing for Assessment of Area Potential as Public Green Open Space

No	Data	Category	Source
1	Malang City's Urban Planning	Spatial Plan	Development Planning Agency at Sub-National Level, Malang, Indonesia
2	Green Open Space Masterplan		Environment Office of Malang, Indonesia
3	Land Ownership	Land Ownership	National Land Agency of Malang, Indonesia
4	Residential Green Open Space		Department of Public Works, Spatial Planning, Housing and Settlement Areas Malang, Indonesia
5	Open Space	Open Space	

In the second stage, the potential land for each type of public green open space zone development was used as the basis for developing development scenarios. This scenario prioritized the development of the area, whether as the city park, district park, or sub-district park, in order of priority. It also considered location-allocation analysis in selecting the minimum potential location that can serve a maximum number of residents. The distribution of the population served by the proposed green open spaces is based on the assumption of the number of residents in each residential building. The population served was calculated from the service radius of each selected potential green open space according to its type. The coverage standards used in the location-allocation analysis and the service radius of each type of public green space zone are presented in Table 2.

Table 2. Standard Radius and Service Area of Public Green Space Zone

No	Type	Service Area (m)	Category	Ideal Radius (m)
1	City Park	5,000	Highly distant	>3,000
2	District Park	2,500	Distant	1,200-3,000
3	Sub-district Park	700	Moderate	600-1,200

In the final stage of the analysis, the population served by each type of public green open space zone was calculated. The total population served by each type was then subtracted from the unserved population to assess the success of the development scenario. The scenario with the greatest value was then selected as the development of public green open space zones.

3. Results and Discussion

3.1. Research Location

The research was conducted in Malang City, East Java Province, Indonesia, in December 2023. The location is illustrated in Figure 2. Malang City is one of the cities in East Java Province, situated in the central part of the East Java province. Geographically, Malang City is located at coordinates 112°34' to 112°42' East Longitude and 7°54' to 8°04' South Latitude. Malang City is also situated within the boundaries of Malang Regency. Its northern border is shared with the Singosari and Karangploso districts, while its southern border is demarcated by Tajinan and Pakisaji districts. To the east, the city is bordered by Pakis and Tumpang districts, while its western border is marked by Wagir and Dau districts. Malang City is comprised of five districts: Blimbing, Klojen, Kedungkandang, Lowokwaru, and Sukun. These districts are further divided into 57 sub-districts.

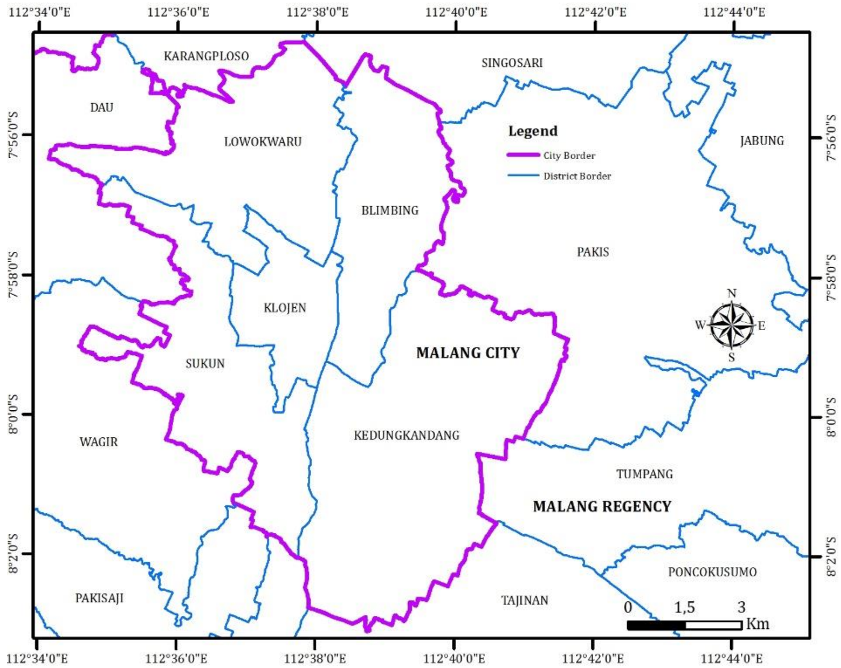

Figure 2. Maps of the Administrative Area of Malang City, Indonesia

3.2. Potential Land Realized as Public Green Space Zone

The Regulation of the Minister of Agrarian and Spatial Planning/Head of the National Land Agency elucidates that the identification stage of land potential should be conducted through the utilization of data pertaining to applicable spatial plans and databases of land and building assets owned by the government. An example of a spatial plan that has been legally enacted is the Regional Spatial Plan of Malang City Year 2022-2042, which is stipulated through Malang City Regional Regulation Number 6 Year 2022. In addition to this legally enacted plan, there is also a Master Plan for green open space in Malang City in 2020 issued by the Malang City Environment Office. In regard to land and building assets, the available data in Malang City is a map of land parcels issued by the Malang City National Land Agency Office. In addition to assets that have already been legally defined, there are also potential assets that could be derived from the transfer of housing infrastructure and public facilities to the Malang City Government. Table 3 presents land values based on spatial plan data, government assets, and open areas.

Table 3. Value of Land

No	Data	Value
1	Regional Spatial Plan of Malang City 2022	
	- Follow the plan	4
	- Permitted (I)	3
	- Conditional (B)	2
	- Not regulated	1
	- Not allowed (X)	0
2	GOS Masterplan	
	- Follow the plan	3
	- Other GOS zone plan	2
	- Other GOS plan typologies B and C	1
	- unplanned GOS plan	0
3	Status of Land	
	- Public (Right of Use)	2
	- Vacant	1
	- Private	0
4	Residential GOS	
	- Residential GOS	1
	- Non-Residential GOS	0
5	Open area	
	- Unbuilt	1
	- Built-up area	0

In the assessment of the Regional Spatial Plan of Malang City 2022, the spatial pattern plan was employed, and general zoning provisions were incorporated. In the Regional Spatial Plan of Malang City 2022, an area was assigned a score of 4 if it was planned according to the type of public green open space zone. Conversely, an area was assigned a score of 0 if it was not planned as a public green open space zone, and green open space development was not permitted. In the GOS Masterplan, a score of three was assigned to an area planned for a public green open space zone, while a score of zero was assigned to an unplanned area. A score of two was assigned to the planned area for other green open space zones, such as green lanes. Finally, a score of one was assigned to an area planned for green open space typologies B and C, such as fields. Moreover, in terms of land status, the highest value was assigned to areas owned by the government since they were public property. Conversely, the lowest value was attributed to areas owned by the community or private individuals. In the assessment based on Residential GOS, the area was given a score of 1 if it was planned for green open space and its existence was still in accordance with the plan. Similarly, areas that remain unbuilt were assigned a value of 1, while those developed areas were assigned a value of 0.

Furthermore, the land value was weighed to avoid subjectivity following the expert opinion. In the research, the weighting was assisted by 21 experts from the relevant fields to green open space, comprising 13 individuals from the State Civil Apparatus of Malang City Government, six academics, and one professional from the community. Table 4 presents the weight of expert opinion.

Table 4. Weighted Assessment of Land Potential Based on Experts

No	Data	Weigh (%)
1	Regional Spatial Plan of Malang City 2022	19.0
2	Green Open Space Masterplan	19.5
3	Status of the Land	23.2
4	Residential Green Open Space	21.3
5	Open Space	17.0
Total		100.0

The extent and distribution of community-serving green spaces are commonly determined through automated raster data processing from satellite imagery (Gupta et al., 2016; Le Texier et al., 2018; Rahman & Zhang, 2018; Xu et al., 2019). Some commonly utilized raster data sources include Google and local satellites, such as those employed in the Delhi and Brussels studies (Gupta et al., 2016; Le Texier et al., 2018). Nevertheless, automated processing is not always as accurate as manual digitization by researchers or other sources (Du et al., 2020; Gong et al., 2016; Kabisch et al., 2016; Ye et al., 2018). Manual digitization supported by field checks, especially regarding land use and land cover, will increase its accuracy. To achieve the most accurate analysis possible, map data from mapped green spaces, complemented by field surveys obtained from the Public works, spatial planning, housing, and settlement areas office of Malang City is used for the analysis.

Following the collective opinion of experts, the variable of government-owned land status is an important factor in the realization of green open space. Meanwhile, the other variables considered as second most important to the least important include the Regional Spatial Plan of Malang City 2022, conformity with the 2020 Green Open Space Masterplan, conformity with the Regional Spatial Plan of Malang City 2022, and open space. The results of the assessment, which involved overlay analysis and weighting, are presented in Figures 3, 4, and 5.

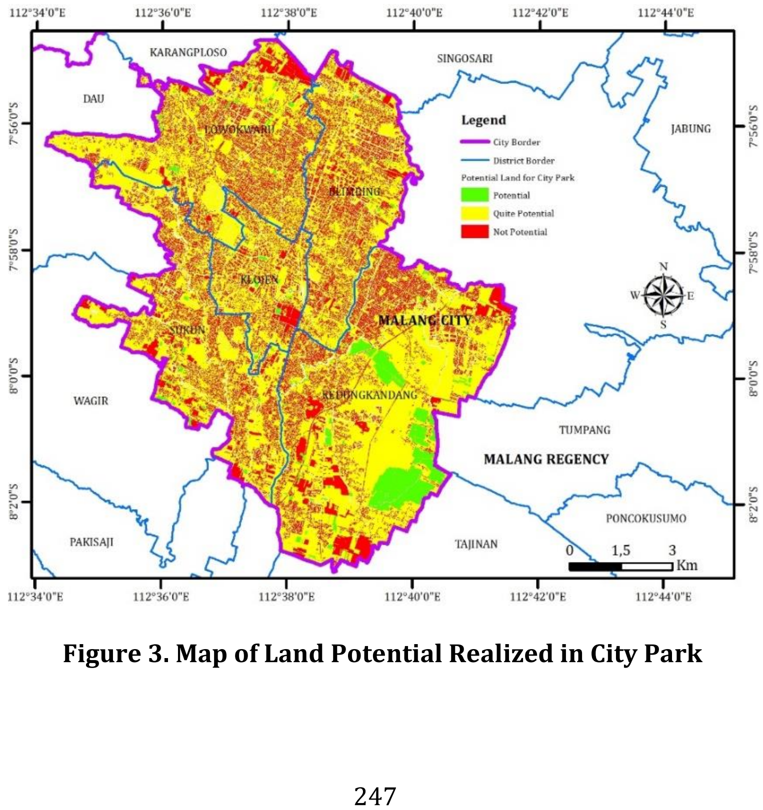

Figure 3. Map of Land Potential Realized in City Park

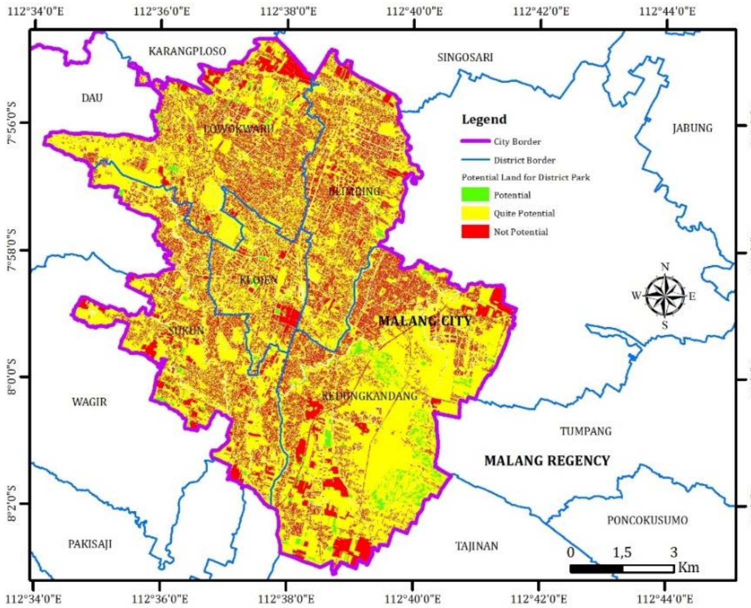

Figure 4. Map of Potential Land Realized as District Park

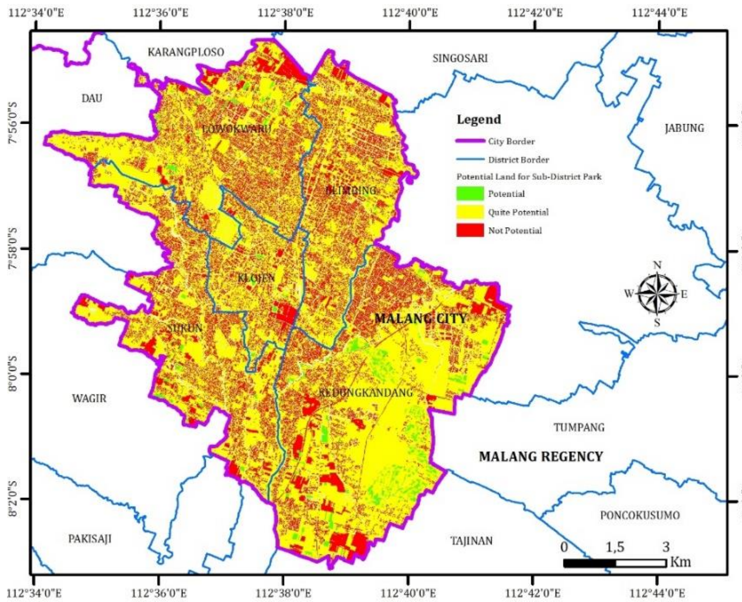

Figure 5. Map of Potential Land Realized as Sub-district Park

Figure 3 illustrates the potential for a large area to be realized as a city park on the southeast side or in Kedungkandang District, while the remaining area is scattered with a tendency to be more narrow in other sub-districts. Meanwhile, the distribution of potential and non-potential areas is evenly distributed throughout the Malang City area. Figure 4 shows that there is no dominant area of potential to be realized as a district park. The area presented in Figure 3 previously appeared to be large and unified. However, it has undergone a transformation, with the composition becoming partly potential and partly quite potential. Figure 3 also presents similar areas of potential and non-potential areas, which are evenly distributed throughout Malang City. This is also evident in Figure 5, which shows the absence of a large area to be realized as a potential sub-district park. Upon examination of the potential and quite potential areas to become city parks, district parks, and sub-district parks, they seem to overlap.

3.3. Distribution of Population

A number of studies conducted in various countries have employed residents as the target population for green open space services (Gong et al., 2016; Montealegre et al., 2022; Rahman & Zhang, 2018). This research builds upon this precedent by treating residents as the primary recipients of green open space services in accordance with the stipulations set forth in the Regulation of the Minister of Agrarian and Spatial Planning/Head of the National Land Agency Number 14 of 2022. Other studies have also targeted residents as the primary recipients of GOS services but have not utilized population data for various reasons. For instance, employed artificial building data in their research in Nanjing, China, due to the unavailability of comprehensive population data (Du et al., 2020). In a similar vein Le Texier et al. (2018) employed the distribution of residential buildings as a proxy for population data in Brussels. This approach is analogous to that employed by Ye et al. (2018), who utilized residential midpoints derived from a 300 x 300-meter grid division in their study of Macau. Additionally, a number of studies have examined the accessibility of green space services through the lens of urban points of interest (Xu et al., 2019). Based on the studies that have been compiled previously, it appears that the geographical population distribution approach is necessary for the development of green spaces as a service to the residents of Malang City.

The green open space services should aim for the population. Therefore, an analysis was performed to explore the distribution of settlements and population density in each urban village and subdistrict in Malang City. The garnered data included a map of the distribution of residential buildings and a map of administrative boundaries obtained from the 1:5,000 base map (Ministry of Public Works and Housing of the Republic of Indonesia, 2022) and the population of each sub-districts from the districts (Central Bureau of Statistics of Indonesia, 2022). The distribution of the population of Malang City is illustrated in Figure 6.

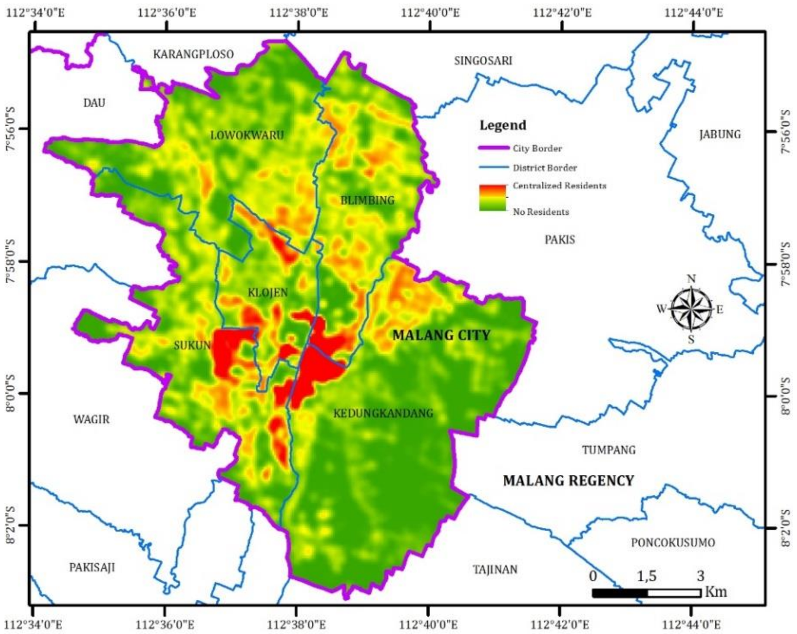

Figure 6. Distribution of Population in Malang City

Figure 6 employs data on population density and points of distribution of residential buildings to illustrate the distribution of the population of Malang City. This analysis reveals that the concentration of Malang City's population is concentrated in the eastern part of Sukun District, the southern part of Klojen District, the southern part of Blimbing District, and the western part of Kedungkandang District.

3.4. Development of Scenario for Public Green Open Space Zones

Previous studies employed disparate methodologies, standards, and analytical techniques to map accessibility as an indicator of green open space services. However, this study utilized the same analytical tool, ArcMap, throughout the entirety of the analysis. Researchers have favored this Esri-produced application due to its stability, ease of use, and capacity to perform a multitude of data processing and spatial analysis operations. Previous studies employed a distance approach (Du et al., 2020; Kabisch et al., 2016; Le Texier et al., 2018; Xu et al., 2019; Ye et al., 2018) or travel time to green spaces (Gupta et al., 2016). Some other studies employed both distance and travel time to the green space. The type of ArcMap tool employed in the analysis varies across studies, with some utilizing buffers or service radii and others employing network analysis, which more accurately depicts accessibility. This study employed a combined approach of distance to green spaces using radius and network analysis. This approach is appropriate to meet the requirements of the green open space service radius while still considering the existing road network conditions (Kusumaningrum et al., 2022). Additionally, under the development of green open space zones, the same area may have more than one function. Therefore, an analysis is needed to determine the best scenario for serving the majority of the population or, if possible, the entire population of the target service area. In the scenario development, potential land is used to be materialized into public green space zones based on the results of the analysis in the previous discussion.

The Regulation of the Minister of Agrarian and Spatial Planning or Head of the National Land Agency Number 14 of 2022 concerning the Provision and Utilization of Green Open Space stipulates a minimum area requirement for city, district, and sub-district parks. Accordingly, the data on potential areas to be developed into these parks must be screened. In the screening process, areas below the minimum area will be excluded from the potential land. The analysis in the previous section resulted in areas with minimum territory that could not be used as parks. These areas may obscure the area-based screening because they have the potential to connect several areas that are insufficient in terms of area. Areas that are insufficient in size can become sufficient when connected to each other. Consequently, prior to the screening process, it is essential to organize and segregate the areas into discrete units. The distribution of potential green open space zones that will emerge as a result of the digitization and screening adjustments is presented in Figure 7.

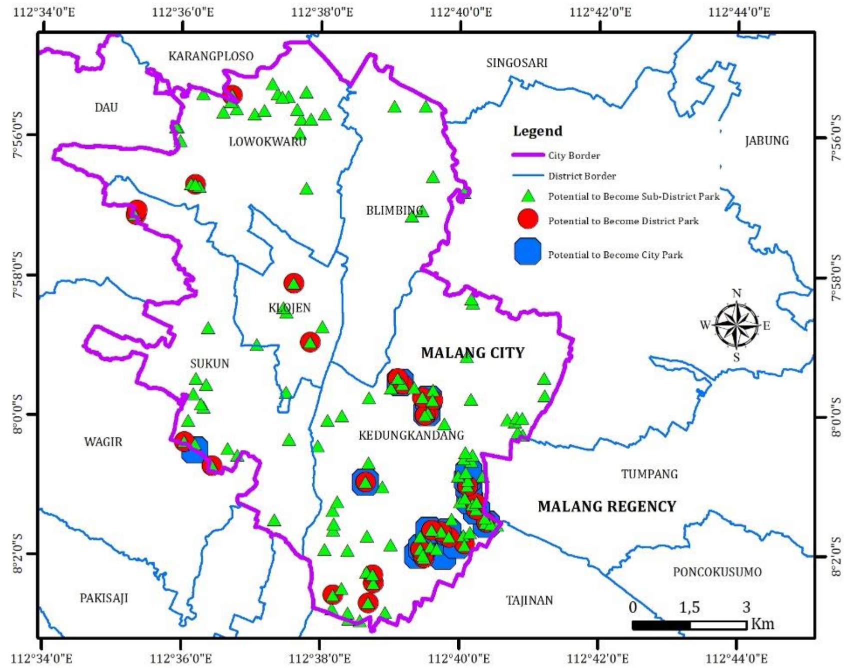

Figure 7. Map of Areas with Potential as Public Green Open Spaces

Figure 7 illustrates that not all districts in Malang City have the potential to be city, district, or sub-district parks. Districts with the greatest potential to be these three parks are Sukun and Kedungkandang. Other districts, such as Klojen and Lowokwaru, have the potential for district and sub-district parks. Meanwhile, Blimbing is the sole district with potential points for sub-district parks. Given the existence of different potential points in each district and the impossibility of an area functioning as more than one type of park, the development scenarios will be separated into three categories: those with all types of parks, those with 2 types of parks, and those with only one type of park. The scenarios to be simulated are presented in Table 4.

Table 4. Development Scenario

No	District	Scenario	Priority		
			1	2	3
1	Blimbing	A	Sub-district Park		
2	Klojen and Lowokwaru	A	District Park	Sub-district Park	
		B	Sub-district Park	District Park	
3	Kedungkandang and Sukun	A	City Park	District Park	Sub-district Park
		B	City Park	Sub-district Park	District Park
		C	District Park	City Park	Sub-district Park
		D	District Park	Sub-district Park	City Park
		E	Sub-district Park	City Park	District Park
		F	Sub-district Park	District Park	City Park

The scenario presented in Table 4 serves as the basis for selecting parks to be included in the service radius through location-allocation analysis. The selected parks are completed the service radius according to the provisions of each type. The service radius functions to calculate the population served based on the estimated population in each residential building within the service radius. The selected scenario is the one capable of serving the highest number of people. In particular, no development scenario simulation was carried out in the Blimbing district because it only has the potential for sub-district parks. The results of the simulation of potential land development scenarios that have been realized in public green space zones are presented in Table 5.

Table 5. Calculation for Scenario of Development of Public Green Open Space

No	District	Scenario	Number of Population		
			Served	Unserved	Total
			1	2	3 = 1-2
1	Klojen	A	144,506	77,086	67,419
		B	44,958	176,634	-131,677
2	Lowokwaru	A	196,379	166,511	29,869
		B	161,200	201,690	- 40,490
3	Kedungkandang and Sukun	A	1,086,416	735,970	350,446
		B	1,060,800	761,586	299,214
		C	896,092	926,294	-30,201
		D	896,092	926,294	-30,201
		E	957,977	864,409	93,568
		F	876,855	945,531	-68,675

The results of the calculations indicate that the development scenario A of the park in the Klojen and Lowokwaru districts presents a higher value than scenario B. In the Klojen district, scenario A is worth 67,419, while scenario B is worth -131,677. Scenario A has a value of 67,419, while scenario B has a value of -131,677. In the Lowokwaru district, scenarios A and B result in a value of 29,869 and -40,490, respectively. This analysis indicates that district parks are more effective in serving the population than sub-district parks. The calculation of population served indicates that the order of scenarios from highest to lowest value in the Kedungkandang and Sukun districts is as follows: scenarios A, B, E, C, D, and F. Following this finding, the selected development scenario for Kedungkandang and Sukun districts is to prioritize city parks, district parks, and sub-district parks in order. The obtained population serviceability using the optimal development scenario is presented in Table 6.

Table 6. Resident Serviceability Using the Best Public Green Space Zone Development Scenario

No	Types of Green Open Space	Number of Population		
		Served	Unserved	Total
1	City Park	689,517	248,359	937,876
2	Districts Park	404,850	533,026	937,876
3	Sub-districts Park	314,130	623,746	937,876

In reality, for each type of park, the selection of the optimal scenario still cannot serve the entire population of Malang City. At the city park level, only 689,517 out of 937,876 residents, or 73.52%, can be served. At the district park level, while all residents in the Klojen district have been served, when the data is aggregated to the city level, only 404,850 out of 937,876 residents (43.17%) are served by district parks. Similarly, at the sub-district park level, only 314,130 out of 937,876 residents, or 33.49%, are served. However, this park can serve the total residents of Bakalan Krajan, Kiduldalem, and Tunggulwulung sub-districts.

4. Conclusion

A spatial analysis of government land ownership and open areas, coupled with expert opinion, reveals that the majority of Malang City is suitable for the development of public green open space zones. Furthermore, there are areas that can be developed with multiple types of public green open space zones. However, due to the limitation of developing an area with a single type of public green open space zone, it is essential to identify a development scenario that can serve the greatest number of people. In Malang City, the optimal scenario for land potential involves prioritizing the development of city parks, district parks, and sub-district parks in sequence. However, these results still fall short of meeting the needs of the entire population of Malang City. Therefore, it is essential to consider the utilization of potential land, informed by scientific studies on the functionality of green open space.

Author Contributions

All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of Interest

Authors state no conflict of interest.

Data Availability Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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