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IMPLICATIONS OF SETTLEMENT EXPANSION ON THE AVAILABILITY OF GREEN OPEN SPACE IN MEDAN JOHOR DISTRICT

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ABSTRACT

Urbanization and population growth in Medan City have driven residential expansion that reduces the availability of public green open space in Medan Johor District. Within the regulatory framework of Law Number 26 of 2007, urban areas are required to provide at least 30% green open space (RTH) of the total area, consisting of 20% public RTH and 10% private RTH. This study aims to analyze the pattern and magnitude of residential expansion, its impact on public RTH availability, and the implications for environmental indicators and spatial services, focusing exclusively on the achievement of the 20% public RTH target. A quantitative approach with a descriptive-analytical method is applied through overlay analysis of 2015 and 2025 land use maps using Geographic Information Systems, complemented by demographic and spatial planning data. The findings show that residential land increased from 1,080.35 ha to 1,207.80 ha, while green open space declined from 596.08 ha to 432.15 ha, indicating a substantial reduction in public green space effectively serving the population. The proportion of total RTH decreased from 35.15% to 25.83% of the district area, which implicitly suggests that the share of public RTH falls below the mandated 20% target within the 30% policy framework. This decline has consequences for environmental quality, including reduced water infiltration capacity, higher surface temperature, and diminishing public space for social interaction, recreation, and sports. The results highlight the need to strengthen spatial regulation and land conversion control to restore and increase public RTH towards the 20% standard required by national spatial planning policy.

Introduction

The development of large cities in Indonesia shows a tendency to increase development pressure on space, especially in areas with high accessibility and developing economic functions (Astriani, 2016; Chasanah, 2023). Medan Johor District as one of the

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21 sub-districts in Medan City is experiencing an increase in the need for land for settlements and commercial activities that progressively convert vacant land and green open space that previously functioned as an ecological buffer for the area. The national regulatory framework through Law Number 26 of 2007 emphasizes the obligation to provide at least 30% green open space in urban areas, consisting of 20% public RTH and 10% private RTH, so that the portion of public RTH is the main indicator of the performance of green space services for the community.

Various studies show that settlement expansion is generally negatively associated with the availability of RTH, either through direct conversion of functions or fragmentation of green space. Previous research emphasizes the importance of RTH in supporting population welfare, environmental quality, and the sustainability of urban development, including through ecological, social, economic, and aesthetic functions (Muazro & Nuraini, 2024). A number of other studies highlight the weak implementation of spatial planning, pressure on the economic value of land, and low public awareness as driving factors for RTH shrinkage in urban areas (Chasanah, 2023; Astriani, 2016). However, most of the studies still focus on total RTH without specifically separating the performance and achievements of public RTH which is the direct responsibility of local governments.

In Medan Johor District, land use data in 2015 and 2025 showed an increase in settlement area from 1,080.35 ha to 1,207.80 ha, followed by a decrease in RTH area from 596.08 ha to 432.15 ha (Medan City Central Statistics Agency, 2015; 2025). This dynamic indicates the occurrence of land conversion pressures that have the potential to reduce the ability of regions to meet the target of 20% public RTH as regulated in the framework of 30% RTH for urban areas. The knowledge gap arises due to the limited number of studies that explicitly examine the implications of settlement expansion on the achievement of public RTH, including its relationship with environmental quality and spatial services at the sub-district level.

The novelty of this study lies in the emphasis of analysis on public RTH as the main focus, using the 30% RTH policy framework only as a normative basis, without claiming a thorough evaluation of the total RTH. This study not only maps changes in area, but also links the implications of shrinkage of public green space to environmental indicators and spatial services in Medan Johor District. This study aims to analyze the pattern and magnitude of settlement expansion in the 2015–2025 period, examine its impact on the availability of public RTH, identify implications for environmental indicators and spatial services, and formulate strategic recommendations for controlling land use to support the achievement of the 20% public RTH target. The entire analysis is limited to public green open spaces, while private RTH is positioned as a supporting context within the policy framework.

Method

This study uses a quantitative approach with an analytical descriptive method to examine the relationship between settlement expansion and changes in the availability of public green open space in Medan District, Johor. The analysis unit is the administrative

area of the sub-district and its six sub-districts, with a period of study of land use change in 2015–2025.

The spatial data used is in the form of land use maps for 2015 and 2025 processed from satellite images and thematic maps, as well as information on administrative boundaries and road networks. Non-spatial data includes population data, area area, and socio-economic characteristics obtained from official publications of the Central Statistics Agency of Medan City, especially the Medan Johor District document in Numbers and Regional Statistics of Medan Johor District. Policy documents such as the Medan City RTRW, Law Number 26 of 2007, and technical regulations related to RTH are used as the basis for normative interpretation.

The main analysis was carried out through an overlay of land use maps for 2015 and 2025 using the Geographic Information System device to identify changes in settlement area and RTH, with an emphasis on areas of public green open space that are accessible to the general public, such as parks, green paths, fields, and green areas of public facilities. The overlay results are used to calculate the change in area (ha), the percentage change, and the annual rate of change. Quantitative descriptive analysis was then applied to calculate the proportion of RTH to area area, RTH per capita, and the trend of declining green space relevant to public services.

Within the framework of RTH needs, 30% of the area is used as a policy reference, but the interpretation of the results is limited to the implications for the target of 20% of public RTH which is the main target of green open space services in urban areas. The analysis of environmental implications was carried out descriptively by associating the shrinkage of public RTH with changes in water catchment capacity, thermal comfort, air quality, and potential flood risk. The spatial analysis of spatial services includes the spatial distribution of public RTH to settlements, accessibility, and adequacy of green space per capita that can be enjoyed by residents.

Due to the limited availability of spatial data that explicitly distinguishes between public and private green open space (RTH), an analysis of land use changes in this study was carried out on the total RTH. The next interpretive emphasis is focused on the implications of the change on public RTH as a component that functions directly in space services and is under the responsibility of local governments. This approach is not intended as a comprehensive evaluation of total RTH, but rather as an analytical basis for understanding the pressure of settlement expansion on public RTH performance.

Results and Discussion

RESULTS

Land Use Changes and Settlement Expansion Patterns

The results of the overlay analysis of the land use maps for 2015 and 2025 (Figure 1 and Figure 2) show that there is a clear change in the spatial composition in Medan Johor District. Figure 1 depicts the initial distribution of residential areas, green open spaces (RTH), and water bodies in 2015, while Figure 2 shows the conditions in 2025 with the

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area of built-up areas becoming increasingly dominant. The expansion of settlements appears to be mainly following the main road corridor and developing towards the suburbs that were previously dominated by open land.

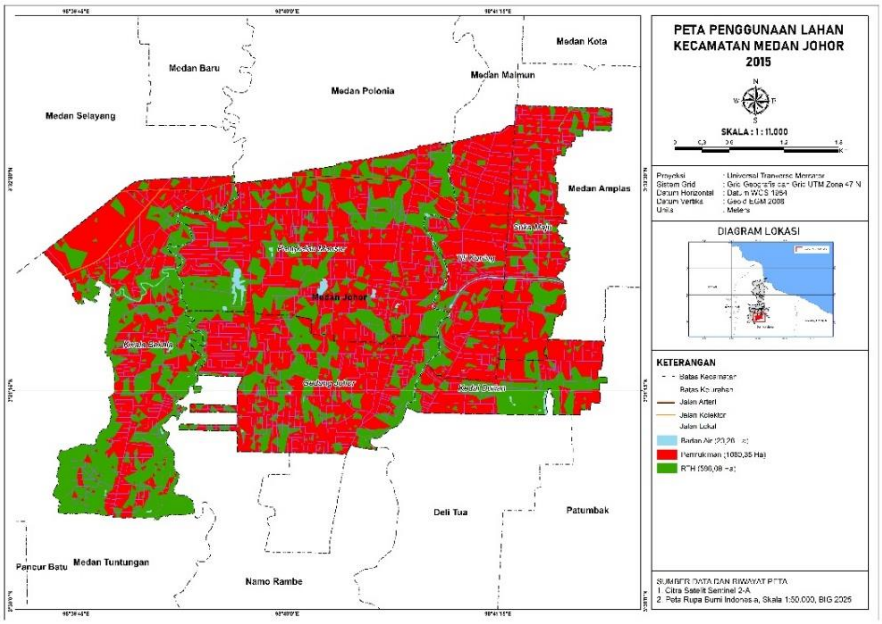

Figure 1. Land Use Map of Medan Johor District 2015

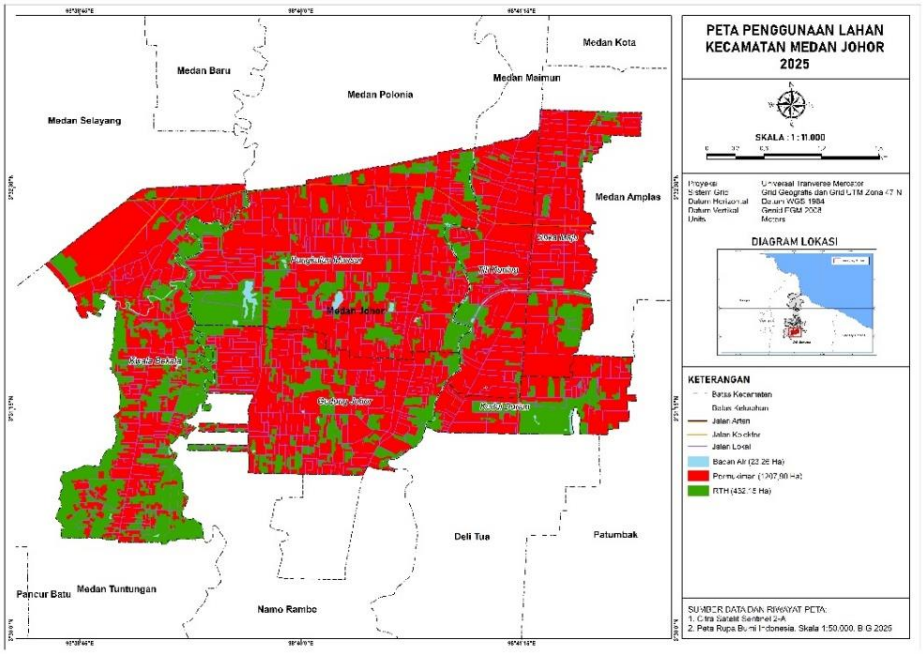

Figure 2. Land Use Map of Medan Johor District 2025

Quantitatively, Table 1 shows that the area of settlements increased from 1,080.35 ha in 2015 to 1,207.80 ha in 2025, or an increase of 127.45 ha (about 11.81%). In the same period, the area of RTH decreased from 596.08 ha to 432.15 ha, with a depreciation of 163.93 ha or around 27.50%. The area of the water body is relatively stable at 23.26 ha, so that changes in land use mainly occur in the relationship between settlements and RTH.

The small differences in the total area listed in Table 1 reflect technical differences in the mapping process, but do not affect the main direction and tendency of land-use change.

Table 1. Land Use Changes in Medan Johor District in 2015-2025

No.	Aspects	Year 2015	Year 2025	Changes (Ha)	Change (%)
1	Settlements	1.080,35	1.207,89	+127,54	+11,81%
2	RTH	596,08	432,15	-163,93	-27,50
3	Water bodies	23,26	23,26	0,00	0,00
	Total	1.699,69	1.663,21	-36,48	-2,15

Table 2 strengthens these findings by showing an increase in the percentage of settlement area to area from 63.70% in 2015 to 72.19% in 2025. This figure confirms that most of the space in Medan Johor District has been transformed into a built-up area. Spatially, the overlay results indicate that the most intense settlement expansion occurred in Kwala Bekala, Pangkalan Masyhur, and Titi Kuning Villages, especially on land that was previously in the form of vacant land, private RTH, and agricultural land on the edge of the main road corridor. This pattern is in line with the study of the dynamics of settlement expansion in urban areas that tend to follow transportation routes and areas with high accessibility (Sugiarto & Sari, 2024).

Table 2. Percentage of Settlement Area to Area

Year	Area (Ha)	Settlement Area (Ha)	Percentage (%)
2015	1.696	1.080,35	63,70
2025	1.673	1.207,8	72,19

Changes in RTH Availability and Quantitative Indicators

Changes in the availability of RTH in Medan Johor District are summarized in Table 3 and Table 4. Table 3 shows that the total percentage of RTH to area decreased from 35.15% in 2015 to 25.83% in 2025. In 2015, the area of RTH of 596.08 ha still showed a surplus of around 87.28 ha compared to the standard of at least 30% RTH. However, in 2025 the RTH area of 432.15 ha only covers 25.83% of the area, so there is a deficit of around 69.75 ha against the total standard of 30%.

Table 3. Percentage of RTH Area to Area

Year	Wide Region (Ha)	RTH Area (Ha)	Persenta (%)	Min.30% Standard	Surplus/Defi -sit (Ha)
2015	1.696	596,08	35,15	508,8	+87,28
2025	1.673	432,15	25,83	501,9	-69,75

Table 4 presents the change in the value of RTH per capita. With a population of 130,414 people and an area of 596.08 ha in 2015, the RTH per capita reached 45.71 m²/person. By 2025, with a population of 149,568 people and an RTH area of 432.15 ha, this value will decrease to 28.80 m²/person. Although both values are still above the WHO minimum standard of 9 m²/population, this downward trend indicates a reduction in the

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availability of green space that residents can potentially enjoy in the long term.

Table 4. RTH per Capita in Medan Johor District

Year	Total Population (souls)	RTH Area (Ha)	RTH Per Capita (m2/population)	WHO standard (m2/soul)
2015	130.414	596,08	45,71	Minimal 9
2025	149.568	432,15	28,80	Minimal 9

In terms of distribution, the results of the spatial analysis underlying Table 3 and Table 4 show that RTH is not evenly distributed between sub-districts. Kwala Bekala and Pangkalan Masyhur villages have a relatively larger proportion of RTH, while high-density villages such as Titi Kuning and Gedung Johor show limited green space. This inequality is in line with the findings of Zahari and Nuraini (2025) regarding the unequal access to public space and the challenges of community participation in the management of open spaces. Functionally, public RTH is identified as urban parks, green paths, public cemeteries, and sports fields, while private RTH is mostly in the form of yards and household gardens.

Field observations accompanying the data in Tables 1–4 indicate that the largest shrinkage occurred in open spaces that have the potential to serve the public, including green spaces around settlements and public facilities. At the same time, private RTH is also experiencing an intensification of development, with many residential units utilizing almost all plots thus reducing the area of green space.

Environmental Implications and Space Services

The results of the analysis show that RTH shrinkage has an impact on several key environmental indicators. Reduced vegetation cover and increased waterproofing surfaces in residential and commercial areas contribute to increasing surface temperature and strengthening the urban heat island phenomenon. These findings are consistent with research by Lin, Qiu, and colleagues that demonstrated the role of vegetation density in surface temperature mitigation in urban areas (Fu et al., 2024; Prinajati & Pratiwi, 2022). The decrease in the area of RTH also reduces the absorption capacity of air pollutants, especially along transportation corridors and congested commercial areas, as emphasized by Fu et al. (2024) regarding the contribution of RTH to air pollution mitigation and public health.

From a hydrological perspective, the reduction of RTH covering an area of 163.93 ha implies reduced rainwater infiltration capacity, thereby increasing surface runoff and the risk of inundation in the rainy season. This is in line with the technical guidelines for the development of urban RTH which places the infiltration function as one of the main roles of RTH (Ministry of Environment and Forestry, 2020). Socially, the reduction of public green open space limits the availability of spaces for social interaction, recreation, and sports, especially in urban villages that are already crowded and have little vacant land. The limited number of formal sports facilities is increasingly out of balance with the growing population, which reduces the quality of space services for the community. These

findings are in line with the study of Zahari and Nuraini (2025) which highlights the role of public space in improving the quality of life of the community.

DISCUSSION

Dynamics of Settlement Expansion and Pressure on Public RTH

The increase in residential area as shown in Table 1 and Table 2 reflects the strong development pressure on space in Medan Johor District. When linked to the maps in Figure 1 and Figure 2, it can be seen that the expansion follows a general pattern of urban development that moves along the main road corridor and encroaches on suburban lands that previously functioned as open spaces. This pattern is consistent with the characteristics of urban settlement expansion that follows a sectoral and concentric pattern as described in the studies of Sugiarto and Sari (2024) and Adiyanta in Chasanah (2023).

Within the framework of the 30% RTH policy (20% public, 10% private), the rapid growth of settlements without being balanced by the establishment and protection of public RTH zones makes green space in a depressed position. Previous research has shown that increased land demand, high economic value of land, and weak implementation of spatial planning are the main factors in RTH shrinkage in urban areas (Chasanah, 2023; Astriani, 2016). The findings in Medan Johor District as illustrated in Table 1 and Figure 2 show a similar dynamic, where previously open land is converted into settlements and commercial facilities without being compensated for the addition of adequate public RTH.

Position of Public RTH within the 20% Target Framework

The results in Table 3 show that the total RTH in 2015 is still above the 30% standard, so theoretically the target of 20% public RTH still has room for fulfillment. However, in 2025 when the total RTH is only 25.83% and the deficit against the 30% standard reaches 69.75 ha, then normatively all RTH components—both public and private—are in a state of shortage. In this context, public RTH faces two challenges at once: a decrease in the total area of green space and the competition for land use functions that is getting stronger, as also highlighted by Syafwardi (2025) regarding the implementation of RTH policies in Indonesian cities.

If the 30% standard is interpreted as a normative framework for maintaining ecological balance, then Table 3 can be read as an indication that the portion of public RTH of 20% is difficult to achieve without real intervention. Table 4 makes it clear that although the per capita RTH is still above the WHO standard, the downward trend from 45.71 m²/population to 28.80 m²/population illustrates the shrinkage of green space that is directly felt by the population. From the perspective of public RTH, this figure shows that the availability of green space that residents can access has the potential to continue to decline if the conversion pattern in Figure 2 continues. These findings are consistent with the study by Muazro and Nuraini (2024) which emphasizes that the quality and quantity of RTH are closely related to the welfare of the population.

Environmental Implications and Quality of Public RTH Services

Ecologically, the RTH depreciation recorded in Table 1 and Table 3 strengthens the indication of increasing environmental burden in Medan Johor District. Public green

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spaces that originally functioned as areas of infiltration, shade, and air quality buffer are decreasing, especially in areas that in Figure 2 are dominated by dense settlements. This is in line with the findings of Fu et al. (2024) and Rushayati et al. (2020) which show the role of RTH in lowering pollutant concentrations and improving air quality. Reduced RTH also contributes to increased surface temperature and decreased thermal comfort, as identified in a study by Lin, Qiu, and colleagues that highlighted the relationship between vegetation and the urban heat island effect.

From the perspective of spatial services, the inequality of RTH distribution reflected in the spatial analysis behind Table 3 and Table 4 shows that some areas—especially high-density urban villages—have more limited access to public RTH. This condition has the potential to reduce the social function of RTH as a space for interaction, recreation, and physical activity, as well as reduce the opportunity for residents to obtain health benefits from the existence of green spaces. Zahari and Nuraini (2025) emphasized that the quality of life of the community is greatly influenced by the existence and quality of public spaces, including RTH. In the context of Medan Johor, the limitations of sports facilities and children's play spaces recorded in secondary data show that the role of public RTH as a social infrastructure has not been optimal.

In relation to the 20% public RTH policy, these results indicate that the fulfillment of the target is not only measured by the total area of RTH, but also by the existence, quality, and reach of public RTH services in each village. Without strengthening land use regulations and establishing clear public green zones, the shrinkage trends depicted in Table 1, Table 3, and Figure 2 have the potential to widen the gap between the need and availability of public RTH. This is in line with the criticism of Astriani (2016) regarding the weak implementation of RTH policies in urban spatial planning

Implications of Public RTH Policy and Management

The empirical findings from Tables 1–4 and the map in Figures 1–2 point to the need to rearrange the spatial management strategy in Medan Johor District, especially in the context of meeting the target of 20% public RTH. First, the pattern of settlement expansion that erodes green open space requires the reaffirmation of protected areas and public RTH zones in spatial planning documents and the implementation of more consistent control of space utilization, as recommended in the RTRW and RTH technical guidelines (Ministry of Environment and Forestry, 2020). Second, the deficit to the total standard of 30% RTH in Table 3 can be used as a basis for arguing for prioritizing public RTH rehabilitation and intensification programs, for example through the restoration of green lanes, the use of residual land, and the development of environmental parks in high-density urban villages.

The downward trend in RTH per capita in Table 4 hints at the need for a long-term strategy to secure land reserves for public RTH amid projected population growth. In this case, the integration of public RTH into any new settlement development scheme is key to avoid the reproduction of the pattern in Figure 2 in the future. Fourth, because many public RTH are located around public facilities and road networks, improving the quality of maintenance, security, and accessibility needs to be part of the policy so that public RTH truly functions as a service space for the community, as emphasized in the study of Nuraini

et al. (2024) and Yusrizal et al. (2025) related to settlement planning and public spaces.

Overall, the combination of data in Table 1, Table 2, Table 3, Table 4, as well as Figure 1 and Figure 2 provides a strong empirical basis to conclude that the expansion of settlements in Medan Johor District has reduced the capacity of the area to meet the target of 20% public RTH within the framework of the 30% RTH policy. These findings are in line with various studies on the implications of land conversion on RTH (Chasanah, 2023; Syafwardi, 2025) and at the same time open up space for the formulation of spatial planning strategies that are more in favor of sustainability and fair access to public green space.

Conclusion

The increase in the area of settlements in Medan Johor District during the 2015–2025 period of around 127 ha reflects the intensification of built-up areas concentrated in main road corridors, suburban areas, and urban agricultural land. This expansion contributes directly to the shrinkage of green space that previously served as an ecological buffer and open space for the community.

The decrease in the total area of green open space from 596.08 ha to 432.15 ha caused the proportion of RTH to area to decrease from 35.15% to 25.83%, so that normatively it no longer meets the 30% RTH standard as mandated in the Spatial Planning Law. Considering that 20% of these provisions are intended for public RTH, this condition indicates that the achievement of public RTH in Medan Johor District tends to be below the required target. The decrease in RTH per capita from 45.71 m²/population to 28.80 m²/population shows a decrease in the capacity of green space services for the population, although the value is still above the WHO minimum standard.

The implications of the shrinkage of public RTH are reflected in various environmental aspects, including an increase in surface temperature, a decrease in air quality, a decrease in water catchment capacity, and a decrease in biodiversity and aesthetic quality of the area. In terms of space services, the limitation of public RTH has an impact on reducing space for social interaction, recreation, sports, and children's play, as well as limited disaster evacuation space in densely populated areas.

The main driving factors for the shrinkage of public RTH include pressure on the economic value of land, weak enforcement of spatial plans, low public awareness, and the lack of integration of the obligation to provide public RTH in daily development practices. Therefore, efforts to approach and achieve the target of 20% public RTH within the framework of the 30% RTH policy need to be directed at strengthening regulations and law enforcement, establishing and protecting public RTH zones at the sub-district level, intensifying and revitalizing existing green spaces, and providing incentives for developers who provide public RTH beyond the minimum provisions. The integration of public RTH planning with settlement and infrastructure development, accompanied by periodic monitoring mechanisms, is an important step in controlling land conversion and restoring environmental quality in Medan Johor District.

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