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Use of Big Data in Implementing the 15-Minutes City Concept in Indonesia (Case Study: Providing Ideal Locations for Public Green Open Space in the City of Surakarta)

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Abstract: The 15 Minute City concept aims to ensure that city residents can meet most of their daily needs within a 15-minute walk or cycle distance. This research investigates the application of big data to determine the ideal location of public green open spaces in Surakarta, Indonesia. By analyzing demographic, land use, accessibility and environmental quality data, this study aims to provide a data-driven framework for urban planning. The findings from this research identify important factors that influence the optimal placement of green spaces, supporting sustainable urban development and improving people's quality of life.

Keywords: Big Data, 15 Minute City, Green Open Space, City Planning, Surakarta

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1. INTRODUCTION

The 15 Minute City Concept is a modern urban planning strategy that aims to reduce carbon emissions, improve public health and improve the quality of life by ensuring easy access to most daily necessities within a 15-minute walk or bike ride. In Indonesia, especially in Surakarta, the application of this concept has the potential to overcome various urban challenges such as congestion, pollution and lack of green space. This research explores how big data can support the implementation of the 15 Minute City concept by identifying ideal locations for public green open spaces in Surakarta.

Urban planning based on the 15-Minutes City concept introduced by Carlos Moreno has attracted the attention of global researchers, especially in the context of post-pandemic urban planning (Allam et al., 2022). This concept aims to create a city where most daily needs and services can be reached within 15 minutes of walking or cycling without private vehicles (Moreno, 2021). This concept has received the Obel Award for its contribution to sustainable development from a social, environmental and economic perspective (Moore, 2023). For example, increasing accessibility for cyclists and pedestrians (Caselli et al., 2022), as well as reducing the use of private vehicles which has an impact on reducing pollution and greenhouse gas emissions (Sadler, 2023). Various studies also show that this concept can improve the quality of the urban environment, including the provision of public green open spaces (Mocák et al., 2022). Currently, 16 cities around the world have implemented this concept, and several other cities are in the process of implementation (Pozoukidou, 2022). A successful example is the City of Paris, which succeeded in connecting pedestrian paths with residential areas and transforming half of the 14,000 car parking lots and empty lots into green areas, playgrounds or bicycle parking areas that are integrated with residential areas (Bocca, 2021).

The city of Surakarta, as the strategic economic center of Subosukowonosraten, has experienced population growth of 6.2% in the last five years (BPS, 2023). Even though Surakarta is considered a livable city in Indonesia, its green space continues to decrease every year (Ministry of ATR, 2023). The need for public green open space in Surakarta is very urgent considering the impact of high urbanization (Hartanti, 2020). Based on research by Devinta (2020), public green open space in Surakarta only covers 515,381 ha or 11.70% of the total area, which does not meet the minimum standard of 20% according to Law no. 26 of 2007. The distribution of public green open space is not sufficient to meet the city's needs, so an expansion of 415.58 ha or 8.3% of the area is still needed. Apart from area, distance and travel time are also important in determining the location of public green open spaces to support social, economic and health functions (Corti, 2015). Research shows that the area and distance from the park influence people's visits (Tu et al. 2020). The distance of a green space may be more important than the size of the land, as seen in Los Angeles, where despite having more than 30,000 hectares of green open space, much of the land is located in the mountains and difficult to access from the city center (Harnik & Simms, 2004). Therefore, park site planning must consider a variety of activities and serve populations at diverse scales, from neighborhoods to entire cities (Giles-Corti, 2005). Currently, many countries, including Indonesia, have not implemented distance standards for public green open spaces.

In city planning, the use of Big Data is increasingly being taken into account because of its ability to collect data quickly, in real-time, and on a wide scale. Various literature shows that big data can be a bridge for governments in urban planning to achieve SDGs, especially goal 11 regarding sustainable cities, because big data can provide more complete, faster and accurate information for better decision making in spatial planning. . Therefore, this research will also utilize big data to support data collection and analysis, so that planning results are more effective and efficient. It is hoped that the results of this research can contribute and support the realization of a sustainable city as part of the SDGs target, as well as provide input for the Surakarta City government in formulating development policies that support the achievement of Sustainable Development Goals (SDGs).

Problem Formulation

This research is focusedto determine potential locations for providing public green open space in the city of Surakarta by implementing the 15-Minutes City concept to realize the SDGs of a sustainable city.There are several problems underlying this research. First, according to PUPR data, only 13 out of 174 cities in Indonesia have achieved the supply targetPublic green open space in metropolitan urban areasan area of 20% in accordance with the environmental pillar targets in the SDGs, one of which is the City of Surakarta whose green open space does not meet the standards set in Law no. 26 of 2007 and also the SDGs targets. Second, there is no policy that determines distance and travel time standards in determining public green open space. In fact, distance and travel time are very important factors in providing public green open space. Therefore, the 15-Minutes City concept is an interesting topic for literature study because it has been proven to be successful in several countries in providing public green open space and the concept is in line with the principles of sustainable cities in the SDGs.

Based on these two problems, the Surakarta City government has a role in increasing the area of public green open space so that it meets predetermined standards, but in increasing the area it is necessary to first determine the potential location of public green open space according to several aspects. Therefore, the following is the problem formulation in this research:

1. What are the dimensions of implementing the 15-minute city concept in the city of Surakarta?
2. How to identify the location of potential areas for providing public green open space in the city of Surakarta?

2. GOALS AND OBJECTIVES

Based on the previous background and problem formulation, the aim of this research is to examine the application of the 15-Minutes City concept in determining potential locations for providing public green open space in the City of Surakarta to realize Sustainable Development Goals (SDGs). To achieve this goal, several targets were prepared as follows:

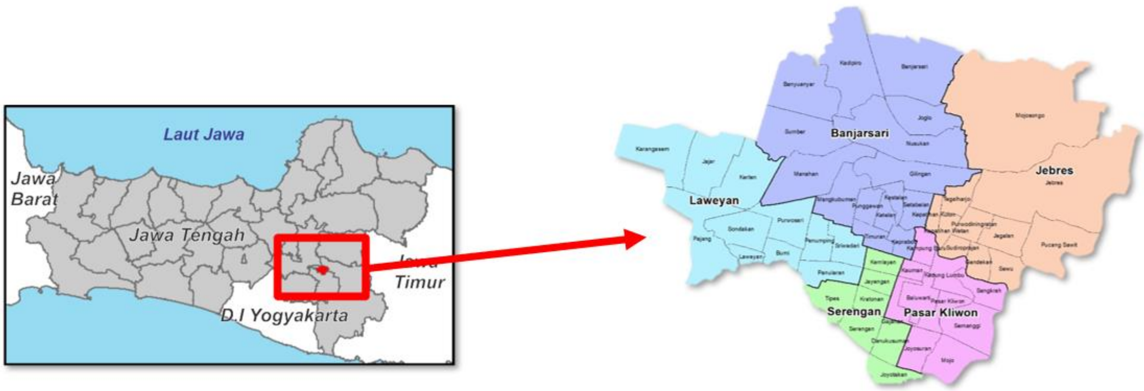
1. Identify the dimensions of implementing the 15-minutes city concept in Surakarta City using the implementation of Big Data in city planning;
2. Identify the availability of existing public green open space in Surakarta City using Indicator 11.7 SDGs to measure the need gap in the plan to provide public green open space; And

THE SCOPE OF RESEARCH

The scope of the research is divided into two sub-discussion parts, namely regional scope and material scope. The regional scope is the limit of the area studied in the research, while the material scope is the limit of discussion of the material studied in this research.

Regional Scope

The scope of this research covers the area and number of sub-districts in Surakarta City as the scope of the research area in applying the 15-Minutes City concept in determining the location for providing public green open space. The city of Surakarta is located in Central Java Province, Indonesia. The research area covers the entire area of Surakarta City, which has a total area of 44.02 km2. This city consists of 5 sub-districts and 47 sub-districts which will be the focus of this research.



Regional Scope

Source: Author, 2024

The city of Surakarta consists of 5 sub-districts, namely Banjarsari, Jebres, Laweyan, Pasirkliwon and Serengan sub-districts. This sub-district will be the unit of analysis in identifying public green open space needs and other related factors in implementing the 15-Minutes City concept. Data on population, land use and other relevant factors will be collected and analyzed within each sub-district.

This research will use Big Data to collect more complete, faster and accurate information about public green open space needs in the city of Surakarta. By utilizing Big Data, this research will identify population activity patterns, accessibility to green open space facilities, as well as social and environmental factors that need to be considered in determining potential locations for public green open spaces.

Scope of Material

The scope of material in this research includes:

- The discussion in this research covers the discipline of Regional and City Planning, other disciplines are only supporting disciplines which will be discussed in outline and aligned with the goals and objectives.

- The focus of this research is planning public green open space in urban areas with the 15-Minutes City concept which takes into account the spatial, accessibility, social and physical conditions of the area.
- The focus of this research is using big data as an implementation of planning analysis for the provision of public green open space with the 15-minute city concept.

3. LITERATURE REVIEW

Library Search Strategy

The literature search for this research used academic databases from trusted sources such as scientific journals, conferences, books, research reports and related policy documents. This literature search strategy allows researchers to collect up-to-date, diverse and reliable information to support research regarding the application of the 15-minute city concept in providing public green open space in the city of Surakarta to realize the SDGs.

The Covid-19 pandemic has changed many paradigms, one of which is in the perspective of urban spatial planning. One of them is the 15-Minutes City concept initiated by Carlos Moreno which has become the topic of interesting literature studies attention in the context of future city development post-pandemic(Allam et al., 2022). The 15-Minutes City concept promotes the concept of "chrono-urbanism", which states that the quality of urban life is inversely proportional to the amount of time invested in transportation, especially through the use of cars.(Moreno, 2021).

The idea behind this concept is to build the city in such a way that most daily needs and services can be reached within 15 minutes of walking or cycling without using a vehicle.(Moreno, 2021).The 15-Minute City concept could shape the future of net-zero cities, which is a vision to achieve zero carbon and resource emissions in cities. This concept can help reduce carbon emissions by minimizing travel time and reducing the need for private cars(Allam & Bibri, 2022). Apart from accelerating digitalization, the Covid-19 pandemic has also indirectly helped create the 15-minute city concept which is closely related to non-motorized accessibility, namely by implementing lockdown,where vehicle use has decreased drastically and bicycle lanes have been built to counter the impacts arising from restrictions on vehicle movement(Allam & Jones, 2020).

New York City saw bicycle use increase by more than 67% in March, the success of which led to New York City becoming a “bicycle city.”(Padmanabhan et al., 2021). In Beijing, bicycle use also increased by more than 150% as people tried to avoid public transport and adhere to restrictions on private car use(Shang et al., 2021). Even in Jakarta, based on data from the Institute for Transportation & Development Policy (ITDP), the number of cyclists traveling through Jakarta increased by up to 1,000% when the government implemented the PSBB. The city of Surakarta built a 25 km bicycle lane which is the longest bicycle lane in Indonesia as a response to the increasing number of cyclists during the pandemic.(Ifang, 2023). Additionally, other services related to public spaces, parks, and cultural services and facilities that were once often overlooked have increased in popularity and demand during the pandemic. The following is the development of urban services built during Covid-19.

Facility Development during the Covid-19 Pandemic

Country/Continent	City	Facility Development	Date	Source
Europe	Berlin	Bike Path	March, 2020	(Moreno, 2021)
	Vienna	Community Park and Bike Trail	April, 2020	
	Edinburgh	Bike Path	April, 2020	
`North America	Oakland	Bike Path	August, 2020	(Bocca, 2021)
	Philadelphia	Small Park and Bike Path	April, 2020	

Country/Continent	City	Facility Development	Date	Source
	Denver	Bike Path	March 2020	(Caselli, 2022)
South America	Bogotá	Bicycle paths and temporary houses for homeless people	April, 2020	(Barbieri, 2023)
USA	New York	Bike Path	April, 2020	(Jones, 2021)
China	Shanghai	Bicycle Path and Residential Park	August, 2020	(Shang, 2021)
Oceania	Vancouver	Bike Path	April, 2020	(Allam, 2022)
	Calgary	Bike Path	April, 2020	
Indonesia	Jakarta	Bike Path	August, 2020	(ITDP, 2020)
	Surakarta	Bike Path	September, 2020	(Ifang, 2022)

Source: Author's Analysis, 2024

Based on Table 2.1. It can be seen that many cities in the country are building infrastructure that supports cyclists and pedestrians to respond to international lockdown policies. This explains that indirectly the Covid pandemic has had an impact on implementing the 15-minute city concept(Jones, 2020).Infrastructure development during Covid-19 is just an example of the many infrastructure that can be implemented to realize the "15 Minute City" concept.The 15-Minutes City concept offers a mobility concept: fewer cars and more space for cyclists and pedestrians, safe paths for children, people with disabilities or the elderly, and public open spaces as places for social interaction(Graells-Garrido et al., 2021). This concept aims to develop an active city where the planning focus is on a sustainable and human-centered urban environment(Caselli et al., 2022). Benjamin Büttner, a mobility expert at the Technical University Munich, said that to create more sustainable cities, things like green spaces, sports venues, cinemas and shops need to be moved to where people live, not the other way around. This doesn't mean it has to be demolished and rebuilt, but existing public spaces need to be reorganized(Pajares et al., 2021).Apart from that, this concept can also improve the quality of life and strengthen social relations in the city environment(Jan, 2022).This concept received the Obel Award because it has contributed to sustainable development from a social, environmental and economic perspective(Moore, 2023). Balletto (2021)also explains someconclusion of the contribution of the 15-Minutes City concept in sustainable development from a social, environmental and economic perspective in Table 2.2. below this

Table 2.1. The 15-Minutes City's Contribution to Sustainable Development

Social	Environment	Economy
• Improving public health • Creating an inclusive and just community • Encourage social interaction • Reduce road accidents • Addressing spatial and temporal disparities in access to urban services	• Improved accessibility for cyclists and pedestrians • Reduce dependence on private vehicles • Reduction of greenhouse gas emissions • Preservation of green open spaces • Improved urban air quality	• Local economic empowerment • Decentralization of urban services • Reduce health costs • Reduced transportation and parking costs • Increased work productivity

Source: Balleto, 2021

There are already 16 cities around the world that have implemented the 15-minute city concept, or are working to make it a reality(Pozoukidou & Angelidou, 2022). One of the pioneers was the capital of France. After Carlos Moreno introduced the concept in 2016, Paris Mayor Anne Hidalgo presented it in her re-election campaign and began implementing it during the pandemic. The essence of the Paris concept views schools as “capital cities,” making them the center of every neighborhood. The school grounds are being renovated into a park to make it accessible for other activities after class and on weekends(Caselli et al., 2022). Paris is also reusing half of its 14,000 car parking spaces, turning them into green areas, playgrounds or bicycle parking spaces(Bocca, 2021). The target is for streets throughout Paris to be bicycle friendly by 2026(Barbieri et al., 2023). In 2021, Shanghai announced plans to introduce what it calls the "15-minute community life circle", a plan that will ensure all daily activities are within a 15-minute walk. And as many as 50 other cities in China are trying to implement this concept(Y. Yang et al., 2023). An initiative in the UK also aims to achieve a better quality of life for city residents. As part of a national renaturalization programme, the UK government announced plans to allow everyone to reach a green area or open water within a 15-minute walk of their home(Barbieri et al., 2023). The following is in Table 2.3. are several facilities that can be reached with the 15 minute city concept from references to several journals.

Table 2.2. Types of Facility Services in the 15-Minutes City Concept

Facility	Facility Type	Reference
Educational Facilities	School/University	(Allam, et al., 2022; Khavarian-Garmsir et al., 2023; Moreno et al., 2021)
Medical facility	Pharmacy	(Moreno et al., 2021; Pozoukidou & Angelidou, 2022)
	Clinic/Hospital	(Barbieri et al., 2023; Moreno et al., 2021)
Trading Facilities	Mart	(Balletto et al., 2021; Moreno et al., 2021)
	Market	(Allam, et al., 2022; Graells-Garrido et al., 2021)
Recreation and Social Facilities	Community Garden	(Bocca, 2021; Moreno et al., 2021)
	City Forest	(Allam, et al., 2022; Bocca, 2021)
Transportation Facilities	Stop	(Caselli et al., 2022)

Source: Analysis Results, 2024

In the current era where the world is experiencing the fourth industrial revolution marked by the widespread application of Information and Communication Technology (ICT) and accelerated digitalization due to the Covid-19 pandemic, the 15-minute city concept is seen as timely.(Moreno et al., 2021). This is true because ICT is now seen as offering a series of solutions to various urban challenges, especially through the Smart City concept. In particular, the 15-minute city concept is very much in line with the Smart City concept, which was one of Moreno's inspirations in conceptualizing the 15-minute city. Carlos Moreno in his journal explains that the dimensions in applying this concept are density, closeness and diversity(Moreno et al., 2021).From several literature studies, there are several dimensions that need to be added to this concept, such as digitalization(Allam, et al., 2022).and also quality(Caselli et al., 2022). The following are the dimensions of the 15-minutes city concept: a) Density, b) Proximity, (c) Diversity, (d) Quality and (e) Digitalization.

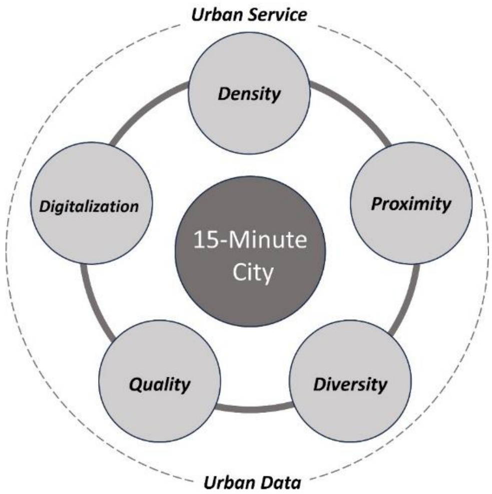


Figure 2.1.Dimensions in the 15-Minutes City Concept

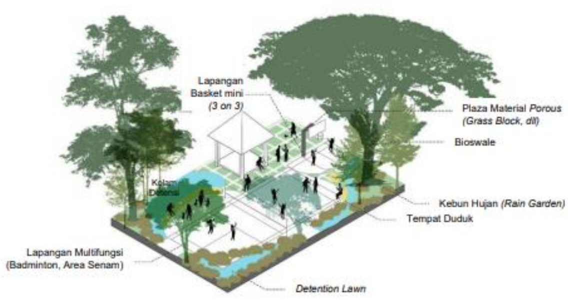
Source: Literature Synthesis, 2024

Provision of Public Green Open Space (RTH) in Urban Areas

Green Open Space has different definitions and typologies in each country(Stanley et al., 2012). Green open spaces in Singapore are generally defined as publicly accessible green areas that include a variety of natural spaces and landscapes. These spaces include gardens, nature parks, parks, and park connectors. The focus of green open spaces in Singapore is not only providing recreational areas but also enhancing the urban environment and biodiversity, contributing to the aesthetic quality of the city, and improving the well-being of its residents.(Nochian et al., 2015). However, in Australia green open space is more focused on nature conservation and sustainability. This includes city parks, conservation areas, and open spaces on the edge of the city which are used for recreation and habitat preservation(Hunter & Luck, 2015). Meanwhile, in Japan and several countries in Europe, the concept of urban green space is explored beyond parks, gardens and forests but also includes areas such as abandoned land, wilderness and unplanned spaces in urban areas.(Kim et al., 2020). In Indonesia, Green Open Space (RTH) is defined as an area or region consisting of open land intended for public use and has an ecological function in providing human and environmental needs. RTH includes various types of land, such as city parks, recreation parks, playgrounds, sports fields, open spaces around buildings, and other green areas that can be used for social, recreational, cultural activities and improving environmental quality. Green open space also includes land with natural features, such as urban forests, lakes, rivers, or agricultural land that functions as an ecosystem buffer (ATR Ministerial Regulation no. 14). The following are the typology rules for public green open spaces in Indonesia.

Types of Typology and Minimum Area of Public Green Open Space

Types of Typology	Minimum Area	Picture
City Jungle	100,000 m2	
City Park	50,000 m2	

Types of Typology	Minimum Area	Picture
		
District Park	15,000 m2	
Village Park	5,000 m2	
RW Park	350 m2	
RT Park	250 m2	

Source: ATR Ministerial Regulation no. 14 of 2022 concerning Provision of RTH

Sustainable Cities in Sustainable Development Goals (SDGs)

From 2000 to 2015, the United Nations (UN) has completed implementing a development program initiative known as the Millennium Development Goals (MDGs). After the MDGs ended, the UN continued its efforts by introducing the Sustainable Development Goals (SDGs) program which was officially approved at the end of September 2015.(Browne, 2017). The SDGs concept was designed with the aim of creating a series of targets that can be applied universally to achieve a balance between the three dimensions of sustainable development, namely environmental, social and economic.(Idowu et al., 2020). This agreement has been reached by 193 UN member states to adopt the SDGs as a framework for development agendas and political policies over a 15 year period, starting from 2016 to 2030(Sachs, 2012). SDGs represent a shared agenda that has been agreed with the aim of achieving peace and prosperity for global society, both now and in the future. Holistic implementation of the SDGs is expected to be able to overcome various global challenges currently faced, including poverty, inequality, climate change, environmental degradation, peace and injustice.(Hák et al., 2016). The SDGs consist of 17 goals and 169 targets which are valid from 2016 to 2030. The following are details of the 17 SDGs goals, namely: 1) No Poverty; 2) No Hunger; 3) Healthy and Prosperous Life; 4) Quality Education; 5) Gender Equality; 6) Clean Water and Adequate Sanitation; 7) Clean and Affordable Energy; 8) Decent Work and Economic Growth; 9) Industry, Innovation and Infrastructure; 11) Sustainable Cities and Settlements; 12) Responsible Consumption and Production; 13) Handling Climate Change; 14) Ocean Ecosystem; 15) Land Ecosystem; 16) Peace, Justice and Strong Institutions; and 17) Partnership to Achieve Goals(Bappenas, 2020).

SDGs cover various aspects of development with the aim of achieving comprehensive completion of each existing target, including sustainable urban development. One of the prominent SDGs goals is to realize Inclusive, Safe, Resilient and Sustainable Cities and Settlements (Sustainable Cities and Communities), which emphasizes the role of cities as centers of sustainable development amidst increasing urbanization.(Geraghty, 2020). United Nation Habitat defines a sustainable city as a city where development in the social, economic and physical fields is carried out over a long period of time. This means that in the process of sustainable city development, it is necessary to pay attention to the sustainable supply of natural resources by considering their carrying capacity, carrying capacity and sustainability.(Robert et al., 2005). In the context of this research, the concept of sustainable development is to create a sustainable city in the midst of rapid regional growth such as the City of Surakarta. According to ICLEI Local Governments for Sustainability, a sustainable city is a city that is environmentally, socially and economically healthy and strong for its residents without compromising sustainability for future generations. The main goal of a sustainable city is to build places to live that have minimal impact on the environment(Cohen et al., 2021). Based on the UN report in 2013, a sustainable city can be realized by strengthening its four main pillars, namely social development, economic development, environmental management and urban governance (United Nations, 2013). In achieving this goal, active participation from local governments as parties who have authority and make policies is very important. Global issues faced by people in various countries require joint action so that they can be handled effectively(Shinwell & Cohen, 2020). Indicators for sustainable urban development include three main pillars: 1) Economic Pillar, 2) Social Pillar, and 3) Environmental Pillar(Apriyanto., 2015).

This research will focus more on analyzing sustainable city indicators from the environmental development pillar. In the context of the environmental pillar, there are three main components, namely: First, land use, which includes three indicators: (1) changes in land use, (2) conservation areas, and (3) green open spaces in urban areas.Second, water resources, which consist of two indicators: (1) water balance, and (2) water quality. Third, environmental quality, which consists of two indicators: (1) waste management, and (2) air quality. In the environmental development pillar of the Sustainable City goal, target 11.7 can be seen below.

Targets and Indicators of Environmental Development Pillars, Sustainable City Goals

Target	Indicator	Method
11.7 By 2030, provide public spaces and green open spaces that are safe, inclusive and easily accessible, especially for women and children, seniors and people with disabilities.	**11.7.1**The number of green cities that provide green open space in metropolitan urban areas and medium-sized cities.	$RTP = \frac{RTH + RTNH + RJ}{LP} x\ 100\%$ RTP : Proporsi Ruang Terbuka Perkotaan RTH : Luas Ruang Terbuka Hijau (Ha) RTNH : Luas Ruang Terbuka Non Hijau (Ha) RJ : Luas Ruang untuk Jalan (Ha) LP : Luas lahan terbangun di perkotaan (Ha)

Source: SDGs Indicator Metadata

Based on Table 2.9. Target 11.7 isprovide public spaces and green open spaces that are safe, inclusive and easy to reach, especially for women and children, seniors and people with disabilities. One indicator is the number of green cities that provide green open space in metropolitan urban areas and medium-sized cities.In 2012, the UN through UN-Habitat introduced the Global Public Space Program (GPSP) as a step to meet target 11.7 in providing public spaces with certain standards to achieve sustainable cities.(Cramwinckel, 2019). UN-Habitat research shows that a quality city has around 50% of its total area dedicated to public space, with 30% allocated for roads and sidewalks and 20% for green open space and public facilities. Unfortunately, only a few cities can meet these standards(Andersson, 2021).

Global Public Space Programme(GPSP) was introduced by UN-Habitat in 2012, involving local governments, non-profit organizations and other partners to implement public space projects around the world. Currently, GPSP is active in more than 30 cities in various countries, including collaboration with the City of Surakarta (UN Habitat 2017). The following are the objectives of GPSP:

1. Promoting public space is an important element in sustainable urban development, improving the quality of life of urban residents, as well as being a key instrument in implementing the new urban agenda and achieving SDG 11.7 targets.
2. Strengthen knowledge, approaches, tools and methodologies related to public spaces and ensure their accessibility, especially for the public.
3. Involve a wider network of partners in the creation of policies and practices related to public spaces.
4. Demonstrating through pilot projects the importance of public space in various aspects, such as social, economic, environmental, and others so as to create a higher quality city.

GPSP emerged as a response and solution to the challenges of urbanization, where many cities tend to prioritize material development and land use without considering the need for public space for social interaction and relationships with the environment (UN Habitat, 2017). As a guide, GPSP offers guidelines for cities around the world in providing public spaces that suit the needs of urban communities, including a 20% allocation for green open space according to UN Habitat recommendations.(Lehner & Blaschke, 2021). Likewise, Law Number 26 of 2007 concerning Spatial Planning states that the minimum area of Public Green Open Space (RTH) in a city is 20% of the area. However, in fact, according to PUPR data, only 13 out of 174 cities in Indonesia have participated in the Green City Program and have a Green Open Space (RTH) portion of 20% or more (Dwihatmojo, 2016). Likewise in the city of Surakarta, where green open spaces still do not meet standards. Therefore, this research will examine the determination of potential public green open space locations in the City of Surakarta to realize the environmental pillars of the SDGs of a sustainable city. One of the concepts that will be used in providing green open space is the 15-minutes city concept. Because several previous literature studies have examined that this concept is a new concept but its aims are in line with the principles of Sustainable Development Goals (SDGs) Target 11 Sustainable Cities in various fields, including transportation and the environment.

Application of Big Data in City Planning

*Big Data*is a term used to describe data that is very large, numerous and complex so that processing it requires complex methods(Allam et al., 2019).In urban planning, the use of Big Data is starting to be taken into account because the collection process is faster, the data is real-time and has a wide reach and scale(Kandt & Batty, 2021). The use of Big Data for planning is increasingly widespread when smart devices are connected and terms such as smart city and smart mobility appear(Brauer et al., 2021). Apart from being able to detect movement via satellite-connected devices, image and text mining can also be carried out as a substitute for direct primary surveys(Huang et al., 2021). Nevertheless,(Kandt & Batty (2021)emphasized that the use of Big Data in planning cannot yet replace the role of Small Data because there are several sets of Small Data needed to be able to build a geotemporal pattern and create a hypothesis.

In regional and urban planning, data collection is essential. This is because data plays a crucial role in planning results. Often planners experience difficulties in the data collection process. These various difficulties include data that is not available, surveys that take a long time and cost a lot of money, and limited access to data(Brunsdon & Comber, 2020). Therefore, research that tries to explore data sources such as Big Data is a new input for the science of regional and urban planning as well as for planners themselves. The utilization and proven use of Big Data for planning means that planners can save time and costs in collecting data so that planning products can be produced more efficiently than statistical data collection and limited sectoral approaches(Abdul-Rahman et al., 2021).

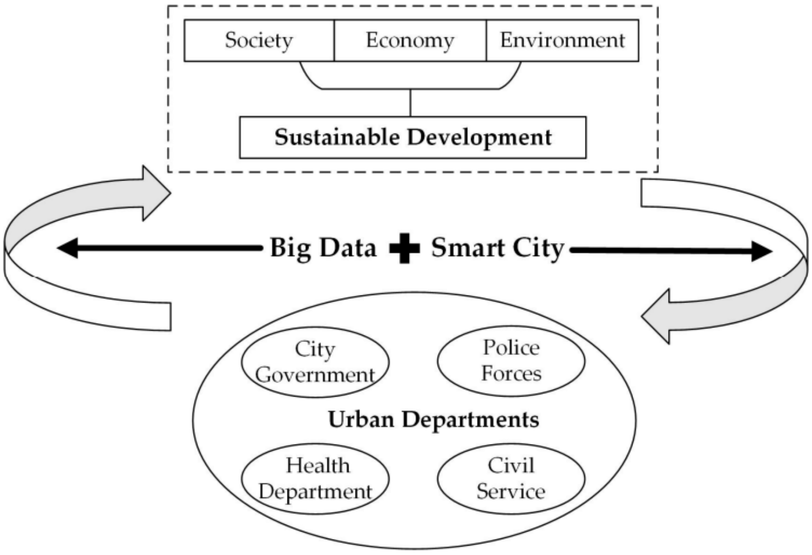


Figure 2.2.The Role of Big Data in City Planning

Source: Kudva & Ye, 2017

Based on the frameworkKudva & Ye, (2017)explained that big data is the government's bridge in realizing sustainable development from a social, economic and environmental perspective.In the era of rapid urbanization, the use of Big Data has become the main key in city planning to achieve Sustainable Development Goals (SDGs)(Kudva & Ye, 2017).In that case*big data*can be used as supporting data for the government, government agencies and community service providers in monitoring the SDGs. This shows that Big Data provides more complete, faster and accurate information and can help planning more effectively and efficiently (Comber, 2012). Big data provides the ability to collect, analyze, and understand societal behavior patterns, infrastructure, and the environment as a whole. By utilizing the information collected, city governments can design more effective and sustainable policies, such as optimizing public transportation and improving environmental quality(Comber & Wulder, 2019). The application of Big Data in city planning not only enables smarter and more efficient urban development, but also supports the achievement of sustainable development goals, one of which is goal 11, namely sustainable cities.

Therefore, research tries to use Big Data to helpidentify the application of the 15-Minutes City concept in determining the location of public green open space in the city of Surakarta to realize Sustainable Development Goals. In this research, several research variables from previous literature studies taken from big data will be used. Big data has been proven to have contributed a lot to the planning and development of a region and also to solving various problems. Utilizing and testing the use of Big Data for planning can save time and costs in collecting and processing data so that planning products can be produced more efficiently than statistical data collection and limited sectoral approaches. By using big data in this research, it is hoped that data collection and the results produced will be more effective and efficient.

4. RESEARCH METHODOLOGY

Approaches in Research

This research adopts a spatial quantitative research approach using GIS and descriptive analysis. The quantitative approach used is spatially based on Big Data as the basis for modeling Kernell Density Estimation, Spatial Clustering Analyze, Countring Analyze, Spatial Network Analysis, and Sentiment Analysis to identify dimensions in the 15-minute city concept in Surakarta City and also to calculate gaps in public green open space conditions towards SDGs Indicator targets based on the SDGs metadata formula. Meanwhile, literature-based descriptive analysis will be used to look at the variables that influence the determination of potential public green open space locations. By combining these two approaches, it is hoped that this research can provide recommendations for implementing the 15-minute city concept in determining potential public green open space locations in the city of Surakarta to realize the SDGs.

Data Requirements and Data Collection Techniques

The following are some of the data requirements needed in the analysis, namely:

Table 3.1. Data Requirements Table

No	Data	Form	Source	Collection Method
1	Road and Pedestrian Network	*Vector Polyline*(.shp)	*Open Street Map*	*Scrapping*
2	Total population	Tabular (.csv)	BPS	*Scrapping*
3	*Digital Elevation Model*	*Rasters*(.tiff)	DEMNAS	*Scrapping*
4	Sentinel-2 Satellite Image Map	*Rasters*(.tiff)	*USGS Earth Explorer*	*Scrapping*
5	Walking and Cycling Activities	*Rasters*(.tiff)	*Strava Heatmaps*	*Scrapping*
6	*Google Street View*	Image (.jpg)	*Google Maps*	*Scrapping*
7	Distribution of Urban Facilities	*Vector Points*(.shp)	*Google Maps*	*Scrapping*
8	Disaster Prone Map	*Rasters*(.tiff)	BPBD/Inarisk	*Scrapping*
9	Surakarta City Land Plot Map	*Vector Polygons*(.shp)	ATR/BPN	Surveys
10	Spatial Pattern Plan Map	*Vector Polygons*(.shp)	ATR/BPN	Surveys
11	Twitter Perception Data	Tabular (.csv)	Twitter	*Scrapping*

Source: Author, 2024

In research on the application of the 15-Minutes City concept in determining potential locations for green public green space in the City of Surakarta to realize the SDGs, various data were used with different sources and collection methods. The following is a description of the use of this data:

1. **Surakarta City Road and Pedestrian Network Data:**This data was obtained from Open Street Map using scrapping techniques. This data is used to understand the structure of the road network in Surakarta City and assist in analyzing connectivity between zones.
2. **Data on the Population of Surakarta City:**This data was obtained by scrapping using API BPS in tabular form and later a spatial model was created for regional population density by combining spatial data on building density with the Kernell Density Estimation Model

3. ***Digital Elevation Model*****Surakarta City:**DEM (Digital Elevation Model) in Surakarta City was obtained from the DEMNAS website. This data is used to understand the characteristics of slopes in Surakarta City which can affect ease of accessibility.
4. **Sentinel-2 Satellite Image Data:**Satellite image data was obtained from USGS Earth Explorer in the form of sentinel-2 imagery in 2023. This data was used to analyze visual and spatial aspects in viewing residential areas, potential land locations, and accessibility in providing public open space in the city of Surakarta.
5. **Walking and Cycling Activity Data:**This data was obtained by color segmenting the Strava heatmap in the form of people's walking and cycling activity levels in the city of Surakarta. This data is used to see the gap in the availability of bicycle and pedestrian paths towards community activities.
6. ***Google Street View:***Google Street View data was obtained from Google Maps on several samples on arterial roads, collector roads and residential areas. This data is used to analyze the level of greenness using the Green View Index method to see the quality dimension as a factor in pedestrian comfort.
7. **Surakarta City Urban Facilities Data:**This data is obtained from scrapping Google Maps. This data is used to map and analyze the distribution of urban facilities in the city of Surakarta.
8. **Disaster Prone Data**: Disaster risk data was obtained from BPDP/Inarisk as variable data for determining the location for providing potential public green open space locations in Surakarta City.
9. **Surakarta City Land Plot Data:**This data was obtained by ATR/BPN through virtual surveys and scrapping techniques. This data is used to see the land status of potential land that will be developed into public green open space in the city of Surakarta.
10. **Surakarta City Spatial Pattern Plan Data:**The Spatial Pattern Plan data from the Surakarta City RDTR was obtained by ATR/BPN through a survey. This data is used to view spatial plans as variable data for determining the location for providing potential public green open space locations in the city of Surakarta.
11. **Twitter Public Perception Data:**Public perception data was taken using a scrapping technique using the Twitter API. This perception data is used to see sentiment related to digitalization conditions in the city of Surakarta.

5. Results

1.1 **Identification of the Dimensions of the 15-Minutes City Concept in the City of Surakarta**

The identification of the 15-minutes city concept in Surakarta City is seen based on 5 dimensions which are the basis of reference for a city to be able to increase its effectiveness in creating areas that can receive urban facility services more quickly and efficiently. The following are the dimensions of the 15-minutes city concept: a) Density, b) Proximity, (c) Diversity, (d) Quality and (e) Digitalization

1.1. **Density Dimension**

The density dimension in the 15-minute city concept is not only limited to building density, but also takes into account overall population density. This is important because the main goal of this concept is to create an urban environment that can accommodate the maximum number of residents in order to optimize the use of urban services. In this dimension, it will be identified which areas have a building density with a high population density so that it can then be compared with other dimensions. By taking into account these two aspects of density, it is hoped that the implementation of the 15-minute city concept in Surakarta City will be more spatially and functionally integrated. Identification of this density dimension uses spatial analysis, namely Kernell Density Estimation using data on the distribution of residential areas and also population data for each village in Surakarta City for later comparison between these 2 aspects of density.

Kernell Density Analysis of Residential Areas

The first Kernell Density Estimation analysis is to look at the density of residential areas. This analysis uses existing residential area data taken from Sentinel 2 satellite imagery. Then the area data is clipped with the road network to form residential lots in each area. From each housing plot, polygon features were carried out to point to see the point distribution of the residential area and the distribution of settlements in the city of Surakarta was obtained, namely 4,679 points. The largest distribution of settlements is in Banjarsari and Jebres Districts with 1,587 and 1,324 settlement points respectively.

Table 5.1. Settlement Density per District of Surakarta City

Subdistrict	Number of Settlements	Area (km2)	Residential Density
Banjarsari	1,587	15.26	104.00
Jebres	1,324	14.38	92.07
Laweyan	849	9.13	92.99
Kliwon Market	539	4.88	110.45
Serengan	380	3.08	123.38
Total	**4,679**	**46.73**	**100.13**

Source: Analysis Results, 2024

Figure 5.1. Surakarta City Housing Density Graph

Source: Analysis Results, 2024

Based on the results of Kernell Density Estimation in Figure 5.1. The density of residential areas found that the density of settlements in Surakarta City with high density tends to be in the outskirts, namely in the northern area in Banyuanyar, Kadipiro, Banjarsari Villages in Banjarsari District and then in Mojosongo Village, Jebres District, the northern part which borders Karanganyar Regency. High density is also found in the south in parts of Serengan and Pasar Kliwon subdistricts, specifically in Serengan, Danukusuman, Joyosuron and Semanggi subdistricts, which are the border with the Solo Baru area which is the center of new urban development. Apart from that, residential density is also high in the west and east, specifically in parts of Jebres Village, Jebres District and Karangasem Village in Laweyan District. The density of settlements in the two sub-districts is influenced by the existence of 2 universities with large numbers of students, namely Sebelas Maret University (UNS) in Jebres District and Surakarta Muhammadiyah University (UMS) in Laweyan District. Meanwhile, housing density in the city center tends to be lower than in the suburbs, one factor is that land prices are relatively more expensive compared to suburban areas.

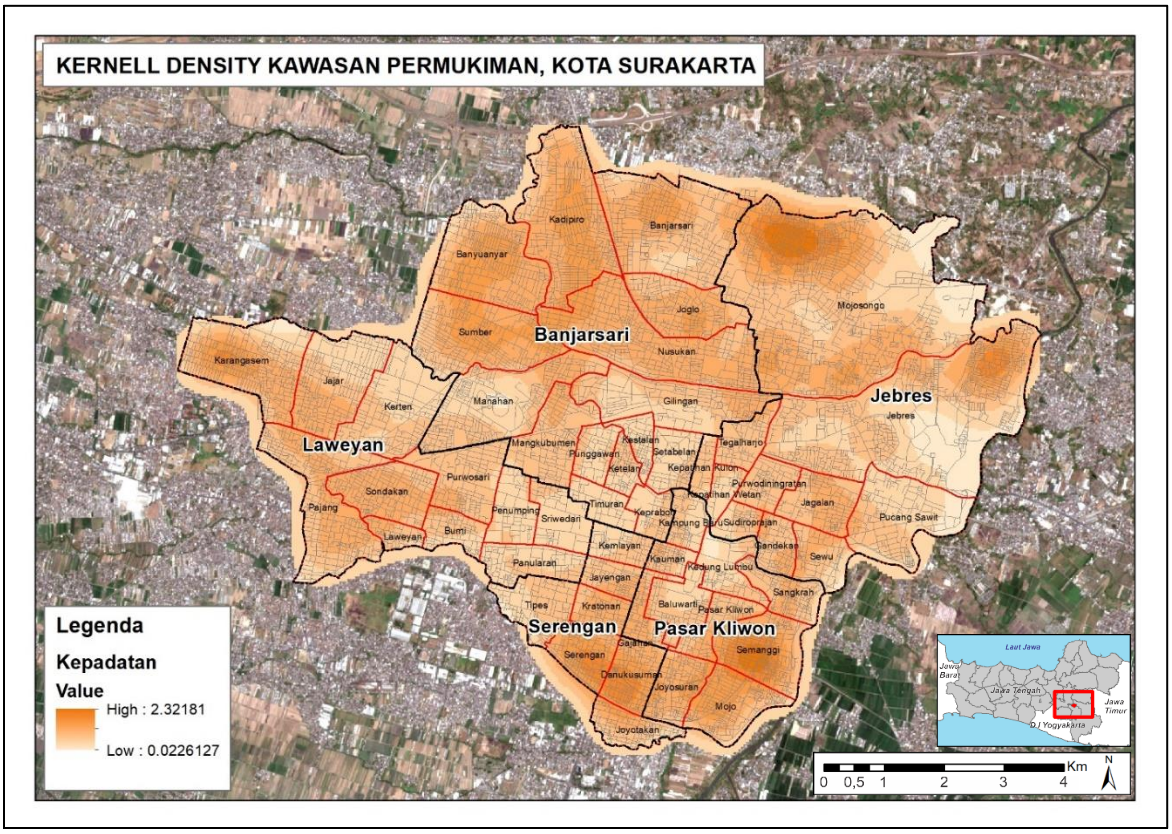


Figure 5.2. Kernell Density Estimation Map of Housing Density

Source: Analysis Results, 2024

Population Density Kernell Analysis

The next kernell density estimation analysis is to look at population density in the city of Surakarta. This analysis uses existing population data per sub-district taken from BPS data for Surakarta City in 2023. The largest population is in Banjarsari District, namely 168,949 people, followed by Jebres District with a population of 138,921 people. The large population in these two sub-districts is due to their area size which is also the largest sub-district in the city of Surakarta. Meanwhile, the three other sub-districts have populations below 100,000 people. From the population distribution data per sub-district, population density is identified tabularly by comparing it with the area per sub-district before looking at spatial density using kernell density.

Table 5.2. Population Density per District of Surakarta City

Subdistrict	Total population	Area (km2)	Population density
Banjarsari	168,949	15.26	11,071
Jebres	138,921	14.38	9,661
Laweyan	88,617	9.13	9,706
Kliwon Market	78,600	4.88	16,107
Serengan	47,921	3.08	15,559
Total	**523,008**	**46.73**	**11,192**

Source: Analysis Results, 2024

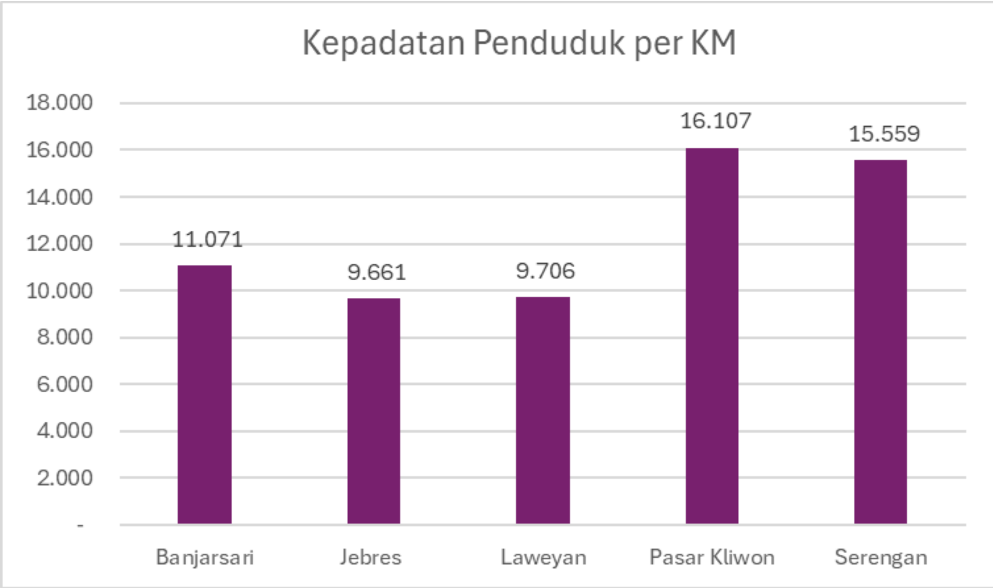


Figure 5.3. Surakarta City Population Density Graph

Source: Analysis Results, 2024

Based on the results of Kernell Density Estimation, population density can be seen in Figure 5.3. The population density per kilometer shows a significant difference. The most significant population density is concentrated in the north, namely parts of Banjarsari District, specifically in Kadipiro Village, Nusukan and parts of Banjarsari Village. This shows that the majority of the population of Surakarta City lives in the northern area. Then to the south there is a high population density in Semanggi Village, Pasar Kliwon District. Meanwhile, population density in the west and east tends to be less high than population density in the north and south. To the west, population density is moderately concentrated in parts of Pajang Village, Laweyan District. However, in the east there is no concentration of population density even though the population distribution in Jebres District is the second largest population distribution after Banjarsari District. This explains that the available land area in Jebres District can still accommodate the population more effectively than Banjarsari District. This also shows the potential for population development in the future to expand towards the east, especially in the Jebres District area.

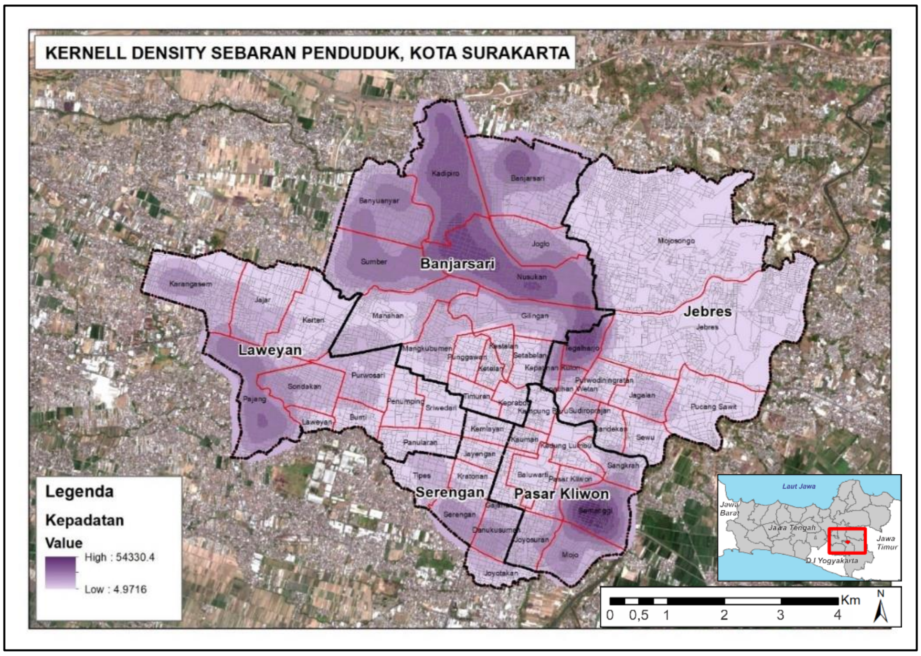


Figure 5.4. Kernell Density Estimate Population Density Map

Source: Analysis Results, 2024

Then, based on the Kernell Density Estimation results, residential density and population density will look for a correlation between the density results using a scatter plot. Based on the scatter plot correlation results in Figure 5.5. If you look at the trendline, there are two types of correlation, namely correlation that tends to be high positive and low positive. Scatter plots that show a high positive correlation are in Banjarsari, Pasar Kliwon and Serengan Districts. A high positive correlation shows that the relationship between the two densities is directly proportional, that is, when the population density is high, the residential density in the sub-district is also relatively high and vice versa. Meanwhile, the scatter plot that shows a low positive correlation is in Jebres and Laweyan Districts. This shows that there is a positive relationship but it is not very strong. There are still several areas with high populations living in low-density residential areas, which means that there is still available residential land, each of which has not yet been filled with a population density commensurate with the residential density. This shows that there is potential for the development of new settlements in these two sub-districts.

Diversity Dimension

The Diversity dimension in the "15 minute city" concept highlights variations in facility services in an area, especially in residential areas. Service facilities are a key element in implementing the 15 minute city concept. Before discussing the accessibility of facility services in the City of Surakarta, it is necessary to first analyze the availability of facilities based on population size and the diversity of facilities that serve the community in an area. This approach supports the achievement of closeness of facilities, optimal density of facility services, as well as the provision of infrastructure that supports the mobility of pedestrians and cyclists.

In this dimension, two analyzes will be carried out, namely a standard analysis of facility availability based on population in the city of Surakarta and a pixel diversity analysis which looks at spatial variations in facility services in certain pixels. The standard analysis of facility availability in the City of Surakarta is based on the importance of identifying service coverage per population before looking at it spatially. In several countries, population size is the basis for determining the need for facilities in urban areas.

The facilities that will be identified include education, health, transportation and recreation facilities in accordance with the existing facility services in the 15 minute city concept. The number and distribution of facilities in the city of Surakarta to analyze the dimensions of diversity were taken from Google Maps using the scraping method. Many journals discuss that the comfort of public facility services is influenced by the number of residents in a city. A population that exceeds facility standards will reduce population satisfaction with facility services and cause service inequality in a city. In this analysis, the standard for facility availability is based on the number of residents in each administrative unit in accordance with SNI.

Proximity Dimension

The Proximity dimension in the "15 minutes city" concept was identified to assess the effectiveness of urban facility services from a spatial perspective. Proximity in this concept is seen from the range of facilities that people can access within 15 minutes from residential areas without using motorized vehicles. This distance is calculated based on walking or cycling time, taking into account social diversity factors such as children, the elderly and women. The slope or contour of the area is also taken into account because it influences travel time.

Identify this dimension using Spatial Network Analysis (SNA) analysis to see the range of services in the 15 minute city concept, including education, health, trade, transportation and park facilities. In the Service Area tool, road network accessibility data and slope data from DEM data are used as accessibility inhibiting factors.

The choice of Service Area analysis using SNA compared to buffer tools because it considers the accessibility and connectivity of the road network. SNA analysis is used to assess facility services by considering the accessibility and connectivity of the road network as well as obstacles from slope slopes. This SNA analysis is applied to each facility in the city of Surakarta to assess the percentage of 15 minute service coverage in the surrounding residential areas. The 15 minute time span is calculated assuming a walking speed of 50 meters/minute or 0.8 meters/second based on WHO speed standards for elderly and children, and a cycling speed of 2.7 m/s or 10 km/hour.

Quality Dimensions

The Quality dimension in the "15 minute city" concept focuses on the quality and availability of supporting infrastructure such as sidewalks and bicycle lanes. This dimension is important because the quality and availability of sidewalks and bicycle lanes greatly influences people's comfort in supporting this concept. The identification of this dimension is divided into two analyses: first, analysis of the availability of sidewalks and bicycle lanes compared to the walking and cycling activities of the people of Surakarta City taken from the Strava website to see the gap between availability and community activities in the City of Surakarta. Strava is a real-time tracking application that can record user activities spatially while exercising. This analysis uses walking and cycling activity data to identify road locations in the city of Surakarta that are most frequently used by the public for non-motorized activities.

The second analysis uses Computer Vision to assess the quality of pedestrian paths by looking at the Green View Index on pedestrian paths via Google Street View.

Discussion

The research results show that big data plays a significant role in implementing the 15 Minute City concept in Surakarta. Analysis using Geographic Information Systems (GIS) and big data enables more data-based urban planning, especially in determining optimal locations for public green open spaces.

1. **The Role of Big Data**: Big data enables the integration of multiple information sources, such as satellite imagery, demographic data, and land use data, providing a comprehensive picture of urban conditions. The use of GIS in this analysis makes visualization and spatial understanding easier, and helps in making more accurate decisions.
2. **Compatibility with the 15 Minute City Concept**: Identification of ideal locations for green spaces supports the principles of 15 Minute Cities by improving accessibility and quality of life for residents. The selected areas demonstrate the potential to provide easily accessible green spaces within 15 minutes of residence, in line with the main objective of the concept.
3. **Community Needs and Preferences**: Surveys and interviews with residents and city planners reveal that green open spaces are very necessary in areas that are densely populated and lack green facilities. These findings emphasize the importance of considering community needs in green space planning, and emphasize the need for participatory approaches in urban development.
4. **Challenges and Opportunities**: Although big data provides many benefits, challenges such as limited data available and difficulties in integrating data from various sources still exist. This research shows that collaborative efforts between government, communities and planning experts are needed to overcome these challenges and take advantage of existing opportunities.

The essence of the discussion and results

The results of the analysis of the identification of the 15-minute city concept based on its 5 dimensions were obtained from the density dimension, namely the correlation between population density and settlement results, there are several areas that have a positive correlation, indicating the potential for developing new residential areas. From the diversity dimension, it is found that the standard of recreational facilities, namely public green open space, still does not meet the standard of the population, namely 27.1% and the ratio of the distribution of public green open space facilities to other facilities is 1:25. From the proximity dimension, it is found that the 15-minute public RTH service coverage is still 26.3% of the total residential area. From the quality dimension, it was found that the gap in the availability of pedestrian paths and bicycle paths for non-motorized community activities was still low, namely 48.9% and the results of the GVI analysis from 917 samples in Surakarta City were 0.1064 or 10.6%. Furthermore, the results of the gap analysis of existing and planned public green open spaces against the target indicator 11.7 SDGs were found to be 14.11% for existing public green open spaces and 17.8% for planned public green open spaces. This shows that to meet the SDGs target, it is necessary to provide public green open space covering an area of 217.8 Ha. And from the results of identifying potential public green open space locations based on spatial aspects, 15-minute city dimensions and natural physics, it was found that there were 3 types of potential public green open space land locations with a total area of 233.8 ha with various park types identified as a result of conformity with the spatial pattern planning policy.

6. Conclusion

This research confirms that big data has great potential in implementing the 15 Minute City concept in Surakarta by increasing the efficiency of planning and developing public green open spaces. Some of the main conclusions from this study are:

1. **Benefits of Big Data**: Big data provides a strong basis for data-driven decision making in urban planning, enabling the identification of the most suitable locations for public green spaces with more in-depth and accurate consideration.
2. **Implementation of the 15 Minute City Concept**: By identifying ideal locations for green open spaces, this research supports the implementation of the 15 Minute City concept which aims to improve the quality of life and accessibility for residents. It also highlights the importance of considering community needs and preferences in planning.
3. **Recommendations for Further Development**: Further steps are needed to implement the recommendations on a wider scale and ensure that developed green spaces truly meet community needs. Future research should focus on monitoring the long-term impacts of newly developed green spaces and explore more data sources to improve urban planning strategies.
4. **Need for Further Research**: To improve the outcomes and impacts of public green spaces, further research is needed to explore the effectiveness of green spaces in improving the quality of life and well-being of residents, as well as to overcome challenges that arise during implementation.

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