Evaluation of Pedestrian Accessibility within a 15-minute Walking Circle in the Core Area of Transit-Oriented Development (TOD) in Tokyo

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Research background

Social background

The UN Sustainable Development Goal 11 is a constant reminder of the increased demands and challenges that cities will face in the future, as well as the increasing pressure that they will face by 2050, when over two-thirds of the world's population will be living in cities. As the Ecological footprint continues to grow and the Earth's overload day is approaching[1], there is significant progress to be made in terms of sustainable urban development[1].

Green space in cities is playing an increasingly important role. As mentioned by Nathalie Röbbel, urban green areas offer opportunities for positive change and the sustainable development of cities[2]. Walkability is an important part of people-centered development and is closely related to green urbanism. The "15-minute city" proposed by Carlos Moreno in 2016 and later promoted by Paris Mayor Anne Hidalgo, also illustrates the importance of walking for city dwellers[3].

In Tokyo, the metropolitan government bureau of urban development has emphasized the importance of urban space visualization in its "Urban Redevelopment Guidelines" (都市再開発の方針) released in 2021[2], as well as building more effective pedestrian circles and enhancing greenery in and around major stations. Moreover, the increasing amount of underutilized housing and land in Tokyo has created more space and possibilities for improving walkability and greenery.

Academic background

In terms of the impact of walkability on sustainable urban development, Haruka French-Colombian scholar Kato analyzed the statistical causal relationship between the Walkability Index and the Ecological Footprint to Biocapacity (EF/BC) ratio of each residential cluster[4]. The authors' quantitative data analysis demonstrates the impact of walkability on the sustainability of the Metropolitan Fringe Area. However, the areas around stations and pedestrian-friendly main streets are under-represented, and the daily pedestrian population in these areas is large. Furthermore, the significance of green space as a sustainable urban development impetus in areas where walking is a rigid demand has yet to be studied[5]. However, Faysal Kabir Shuvo et al. found that the relationship between walkability and greenness was not easily compatible and may even be negatively correlated; furthermore, a higher level of compatibility between the two is necessary. As such, exploring and more effectively integrating walkability and greenness becomes an important issue for sustainable urban development.

In urban green space visualization research, there have been a number of previous research advances that demonstrate the feasibility and significance of street visualization research[6],

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[1] The epidemic subsided during the epidemic, but people still need "1.75" of the Earth's renewable resources. https://www.overshootday.org/newsroom/press-release-june-2022-chinese-simp/

[2] 都市再開発の方針の概要 https://www.toshiseibi.metro.tokyo.lg.jp/seisaku/master_plan/master02.htm

which has further explored the impact of street greening on the environment[7].
Compared to traditional overhead view remote sensing-based methods, street-level images, which present the view that people have of greenery, provide a more human-centric way to quantify street tree canopies. Li's study made ample use of visual concepts and explored the impact of street green view on walking[8]. However, most research[9] has focused only on a flat perspective, ignoring the presence and significance of urban vertical greenery.
In terms of measuring walkability, a number of walking indices have been developed around the world and linked to behavioral and health outcomes elsewhere, though they have not been used comprehensively across countries and regions. Lam et al. aimed to develop a theory-based and evidence-informed Dutch walkability index[10]. Similarly, Tokyo needs a more comprehensive, locally adapted walkability index.
Accordingly, there is a lack of comprehensive studies on the impact of visual walkability of green spaces, including three-dimensional greenery, on residents' walking activities. As the trend of population aging continues to increase in Tokyo, a study of the impact of walking activities that may correspond with the needs of residents of various age groups is necessary.

Research purpose

This research focuses on the pedestrian accessibility within 15-minute walking radii of Tokyo's Transit-Oriented Development (TOD) cores, specifically around rail transit stations with high daily pedestrian traffic. The study will provide rational suggestions for urban renewal development in conjunction with the SDG's sustainable development goals and enable policy makers, investors, and more urban regeneration participants to meet environmental, social, and corporate governance (ESG) standards in order to address upcoming challenges, including urban shrinkage, aging population, and increased urban vitality.

Research methodology

There is ongoing research in the field of street view and community, focusing on various aspects such as community engagement, urban design, and spatial analysis. One area of research is using street view imagery to better understand and analyze the built environment of communities, including issues such as pedestrian accessibility and urban green spaces. Another area of research is using street view data to engage with community members and gather information on their perceptions of their neighborhood and identify areas in need of improvement. Additionally, some researchers are using street view data to study how different urban design elements affect the social cohesion and sense of community in neighborhoods.

Traditional street evaluation systems refer to the methods and tools used to assess the condition and performance of streets and roadways. These systems typically involve manual inspections and assessments by trained professionals, who use tools such as rulers, levels, and visual inspection guides to evaluate various aspects of the street, such as its pavement condition, drainage, and signage. A common traditional street evaluation system is the Pavement Surface Evaluation and Rating (PASER) system, which is used in the United States to assess the condition of rural roads and streets. PASER is a visual rating system that assigns a numerical rating to a street based on its surface condition, including factors such as cracking, potholes, and surface roughness.

These traditional systems have been widely used for many years, but they have some limitations, such as the subjectivity of the inspection and the need for manual data collection and analysis. In recent years, there have been efforts to develop more advanced systems that can automate the data collection and analysis process and provide more accurate and objective evaluations of street condition. These new systems use technologies such as laser scanning, ground-penetrating radar, and drones to collect data on the street and then analyze it using machine learning and computer vision techniques. Based on the above descriptions of the various elements and measurement dimensions, the evaluation system of this study was established.

This study is based on simulating pedestrian perceptions of streets based on spatial elements of street subjective perception of the street. The spatial elements include: road, sidewalk, building, wall, fence, pole, traffic light, traffic sign, vegetation, terrain, sky, person, rider, car, truck, bus, train, motorcycle, bicycle, and so on. Combining the elements of subjective psychological perceptions of pedestrians on the street environment from existing studies, the subjective perceptual characteristics of pedestrians can usually be categorized into several dimensions such as safety and comfort. In this study, based on the previous studies, the evaluation system is established by integrating and adding the four dimensions of safety, comfort, activity and fluidity, each further divided into two or three sub-dimensions.The results are visualized to provide a detailed analysis. An AHP hierarchical analysis will be used to construct the model, and R language will be used to realize automatic calculation of index weights and consistency tests to determine weights.

The visual walkability of the green space of the street will be assessed based on the definition of the area and selection of specific study objects. Publicly available data from Google Street View will be selected as the data source and obtained using a Python crawler script. In order to match the human eye observation perspective, the street view fragment images from each viewpoint (including elevation) will be automatically stitched into one panoramic street view image. The PSPnet model algorithm and deep learning dataset (Cityscapes Dataset) will be then used to identify the road, pedestrians, cars, plants, walls, and other elements in the panoramic street view. The percentage of the required specified elements will be counted, and statistics will be linked to the corresponding streets and areas for analysis through ArcGIS.

Expected results

We present an in-depth examination of the pedestrian environment around Tokyo's TOD core rail stations, assessing their characteristics, strengths, and weaknesses. The findings lead to well-founded recommendations for future development priorities in the neighborhood environments, contributing significantly to urban planning and pedestrian-centric urban design. Dr. Timothy Beatley, proponent of green urbanism, states the following in Green Urbanism: Learning from European Cities[11]:

Indeed, it seems that cities hold the greatest hope for achieving a more sustainable future for our planet. Any effective agenda for confronting global climate change, biodiversity loss, and a host of other environmental challenges must necessarily include cities as a key, indeed the key, element.

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