DESIGNING A FOSS4G-BASED WALKABLE LIVING AREA PLANNING SUPPORT MODULE TO ASSISTS THE KOREAN 15-MINUTE CITY

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ABSTRACT

In Korea, there have been conversations about promoting the planning of walkable communities based on Chrono-Urbanism, a concept that is the foundation of the 15-minute city, in which residents can get services necessary for their daily life in the same place where they live. Chrono-Urbanism-based planning support assesses the walkability of services for various age groups based on the distance to reach physical activity centers such as walking and bicycling from small living area units, and places essential living infrastructure or urban amenities. Using Free and Open Source Software for Geospatial (FOSS4G), we create a tool that supports the evaluation of walkability and the distribution of urban amenities while taking age groups, walking, bicycle, and public transportation accessibility into account. In conclusion, this tool can measure and distribute urban amenities based on walkability providing a way to create healthier, more equitable living areas. Implementing the tool to produce a range of alternatives will help planners to learn about desirable walkable urban amenity options from the alternatives.

1. INTRODUCTION

In recent years, the concept of a 15-minute city has gained appeal, with inhabitants having access to urban goods and services only 15 minutes away. Support for the construction of a walkable living area plan based on Chrono-Urbanism, a core concept of a 15-minute city that allows residents to acquire services necessary for living in daily residential areas, is also being explored in Korea. At the neighborhood level, planning support based on chrono-urbanism deploys necessary neighborhood infrastructure such as urban amenities by measuring walkability that various age groups can receive based on the distance-time that can reach the center of physical activities such as walking and bicycles. A bottom-up plan method, such as the walkable neighborhood, can use network analytic tools to learn about the surrounding environmental circumstances.

However, implementing this concept requires the development of tools based on Free Open Source Software for Geospatial (FOSS4G) technologies necessary for spatial planning. Existing studies have developed FOSS4G using Open Street Map (OSM), QGIS and Python libraries are effectively used in urban spatial planning (Boeing, 2017; Mathew, 2019). This study aims to develop tools to measure accessibility considering age groups as well as walkability for walking, bicycles, and public transportation using pedestrian network data and FOSS4G Software. To that end, the study investigates the notion of walkable living area, as well as associated research trends, and produces a design plan for a FOSS4G-based walkable living area zoning and urban amenities distribution and redistribution planning support module specializing in network-based spatial planning and analysis.

2. CONCEPTS AND RELATED RESEARCH

2.1 Walkable Living Area Planning Support

In Korean cities, due to the increase in non-face-to-face industries such as commercial transactions, there is an increasing need to establish a walkable living area plan based on Chrono-Urbanism that can provide services necessary for life within N minutes in daily residential spaces. The concept of walkable living area based on Chrono-urbanism is that it combines physical activity-based walking, bicycles, and public transportation to provide necessary living facilities within daily areas within the distance that can be reached by various age groups. The existing Korean living area plan is a spatial scope where residents' daily activities such as commuting, shopping, leisure, friendship, work, and public services are carried out, and aims to materialize and synthesize the contents of the abstract basic urban plan by living area.

The walkable living area plan, which provides daily urban services within an n-minute distance, has a direction of inducing planning from a top-down method to a bottom-up method by resident participation. To this end, a model based on pedestrian mobility data is effective for a complex behavior-based pedestrian accessibility model in small living units such as walkable living areas to reflect behavior such as accessibility of residents. Therefore, we intend to quantify unstructured and qualitative decision-making methods in the urban planning field using spatial data and develop a support module for walkable living area planning as a bottom-up plan approach that reflects changes in citizens' demand and living conditions such as population decline and elderly population growth.

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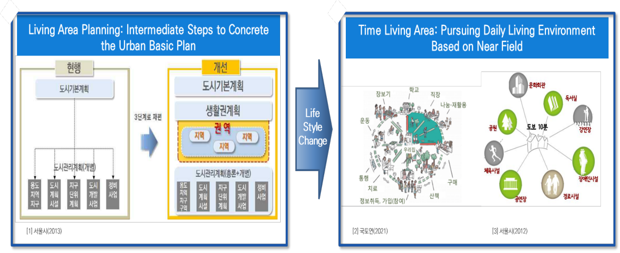


Figure 1. Walkable Living Area Planning Support

2.2 Related Planning and Research

Walkable living area plans that introduce pedestrian-centered Chronos-Urbanism include 20-minute streets in Melbourne, Australia, Barrios Vitales in Bogota, Colombia, and 15-minute cities or Walkable living area plan in Busan and Seoul in Korea.

	Seoul	Melbourne	Bogota
Area(㎢)	605.2	9,993.0	1,587.0
Population (10,000)	997.6	515.1	1,134.4
Density	16,483	515	7,148
Concept	Walkable Living Area	20-minute Neighborhood	Barrios Vitales
Plan	2040 Seoul Plan	Plan Melbourn 2017-2050	POT

Table 1. Case related to Walkable Living Area Plan

Gispo Ltd (2022) investigated that other urban factors such as the density of street networks, accessibility to services using roads, open space, air quality, and traffic also affect urban walkability. To this end, a method of analyzing the structure of the urban street network by calculating the intersection density and an analysis of the entire city's route to see access to urban functions by walking were used. OSMnx, Pandana, and Geopandas Python libraries were used for analysis.
Matthew (2019) developed a walking time measurement method from all address points in downtown Toronto to the nearest Toronto Transit Commission (TTC) stop. The analysis performed network distance calculations using Python libraries such as NetworkX and Pandana based on a new open dataset called "Pedestrian Network" to better understand walking access to various urban amenities across Toronto.

3. METHODOLOGY

3.1 Designing Walkability

We design walkability, including pedestrian walkability, bicycle accessibility, and transit accessibility, based on each home-based or residence-based trip. To measure the walkability of a city, we need to consider pedestrian-friendly urban infrastructure elements such as sidewalks and crosswalks. When designing for measurement, design a pedestrian network that provides information on the physical characteristics of the pedestrian network and a database that contains the distribution of residents by gender and age. By analyzing data based on the pedestrian network for different age groups, it is possible to determine the level of walkability in different urban space conditions. Similarly, the same data can be used to measure bicycle accessibility, taking into account bike lanes, bike parking facilities, and other factors. Access to public transportation can be measured using data from transportation agencies, including data about the frequency and routes of public transportation.

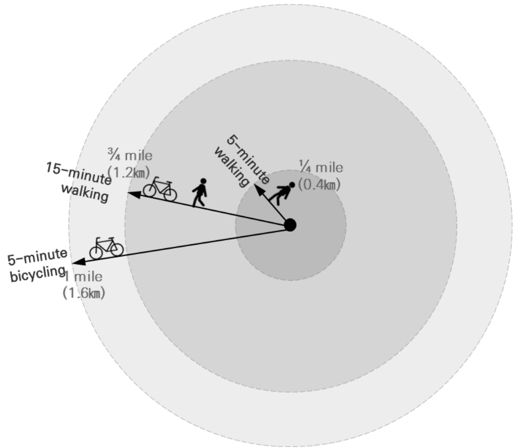


Figure 2. Walkability According to Mobility Mode

3.2 Designating Walkable Living Area

In Korea's urban master plan, the walkable living area can be designated around the base by the Central Place System or the Neighborhood system. The type of walkable living area can be designated by using the type of base and conditions of hinterland.

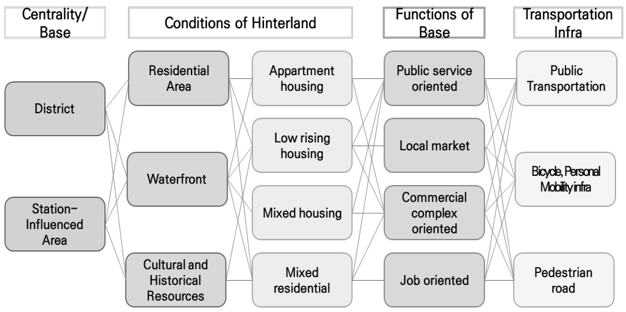


Figure 3. Classifying Walkable Living Area using Base, Hinterland and Transportation Infra(Seoul Institute, 2023)

3.3 Measuring and Distributing Urban Amenities

In this step, we design a module to measure accessibility to urban amenities based on Python and distribute the location of urban amenities according to accessibility. We develop a module that integrates data such as walkability, bicycle accessibility, and public transportation accessibility to determine the best locations for urban amenities. A network-based method of minimizing travel costs will be used to determine the locations. The module will be developed using QGIS and the Python programming language. The module is designed by considering various parameters such as resident and traveling population, distance from existing amenities, and urban environment in various living areas.

Time – Mobility (distance)	Type of facility and services
5-minute walking (0.4 ㎞)	Various housing types and neighborhood centers (mixed-use main street and public square), small-scale commercial and business facilities
15-minute walking (1.2 ㎞)	Massive parks used by grocery stores, pharmacies, shops, schools, and several neighborhoods
5-minute bicycling (1.6 ㎞)	Services to meet daily and weekly needs

15-minute bicyling (4.8 ㎞)	Cultural facilities, medical institutions, institutions of higher education, large regional parks, units with jobs It is possible to move within the region by public transportation, and more special services are also available.

Table 2. Mobilities according to urban service (Seoul Metropolitan Government, 2023)

3.4 Evaluating the walkable living area

The module is used to evaluate local 15-minute cities. The implemented module is designed to be used and evaluated by officials, planners, and researchers working on 15-minute cities. The module can be used to identify areas that need more urban amenities and to deploy existing amenities in ways that enhance walkability. The module can also be used to determine the feasibility of locating new facilities such as parks, community centers, and other public spaces. In addition, the module is designed to be customizable to meet the environmental needs of different cities.

4. DESIGNING A PLANNING SUPPORT MODULE

4.1 Planning Criteria and Data

Set the planning criteria for the planning support module and the appropriate planning data depending on this. The planning criteria are split into walkability, kind of walkable living area, layout and rearrangement of urban planning amenities and living convenience facilities, and functions and characteristics of the pedestrian living area. The relevant planning data were derived in this study based on each planning standard.
The data required for the planning standard criteria citizens' behavior using floating population and commercial district consumption data extracted from telecommunication and credit card information, and maps population information by building to analyze pedestrian network accessibility to each urban planning facility or urban amenity.

Category	Planning criteria	Planning Data
a. Walkability of Walkable Living Area	Walkability accommodating citizen's changing life style	Commercial zone data, Park statistics, population data by age, number of births, pedestrian-only road standard data, living population data, aging index
b. Type of Walkable Living Area	Classification of area such as residential, business, consumption, leisure, and culture	Credit card and floating population data
c. Urban Planning Facilities and Amenities	Required facility analysis and optimal distribution and redistribution	Youth education and welfare facilities, multicultural support facilities, facilities for the disabled, welfare facilities for the elderly, daycare centers
d. Function and Characteristics of Walkable Living Area	Central Place System (Neighborhood system)	Growth axis, Household Travel Survey, Standard data of n-minute living area, activity total index, elementary / middle school location
	Characteristics of Hinterland	Major/Attracting facilities, Number of cultural infrastructure facilities, Park Accessibility, Walking Friendly Index
	Type of Residential Area	Number of houses by type, housing status and penetration rate
	Type of Base(Station Influenced Area, etc.)	Road network, number of people getting on and off the subway, share by means of public transportation
	Major transportation infrastructure conditions to the base	Travel data by means of transportation

Table 3. Planning Criteria and Data

4.2 Database design

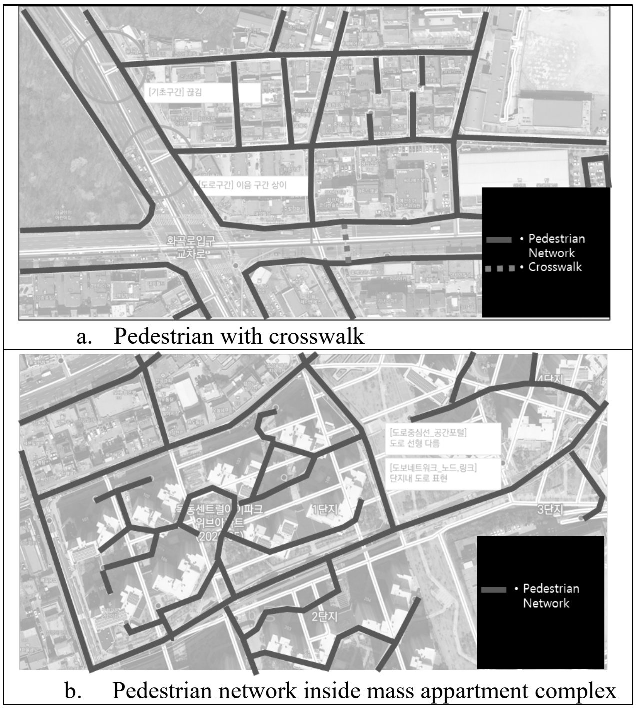
Open Street Map (OSM) or open data released by urban governments are also used for analysis for walkable living area planning. If the city is mapped in detail, basic analysis is possible only with OSM. In the latter case, urban governments such as Toronto and Seoul also pedestrian network as an open various pedestrian network data to open data.

Category	Dataset	File type	topology	Source
Aggregation unit	Administrative Boundary	SHP	Polygon	National Spatial Data Infrastructure(NSID) portal
	Grid	SHP	Polygon	Statistical Agency
	Census aggregation unit	SHP	Polygon	NSDI portal
	H3 indexing			Uber
Network	Street address Network	SHP	Line	Street Address
		SHP	Line	Street Address
		SHP	Polygon	Street Address
	Road centreline	SHP	Line	NSDI portal
		SHP	Line	NSDI portal
	Standard Node-Link	SHP	Line	National Transportation Information Center
		SHP	Point	
	Pedestrian Network	CSV	Line	Seoul Open Data
		CSV	Point	
	Sidewalk location	CSV	Line	
	Sidewalk (Street light	CSV	Point	National Open Data

Category	Dataset	File type	topology	Source
	installation) location			
Building	Building (Street Adress)			Street Address
Facility	Urban Planning Facility	SHP	Point	NSDI portal
	Urban Amenities	SHP	Point	NSDI portal

Table 4. Type of dataset

Figure 4 shows Seoul's pedestrian network and crosswalk data, which are being disclosed as Seoul open data. In the case of large-scale apartment complexes, a walking network inside the complex is also established, so it can be explored similarly to the path in reality.



a. Pedestrian with crosswalk

b. Pedestrian network inside mass appartment complex

Figure 5. Seoul’s Pedestrian Network and Crosswalk

4.3 Functions of Walkable Living Area Planning Support

4.3.1 Diagnosis: Diagnose the current state of the pedestrian living area plan and select the administrative area to be included in the analysis.

The main derivable functions are as follows.

1. Choose a city for analysis, if the city is conurbation with adjacent city, then the city also selected.
2. Display grid-based statistical information on the grid on and analyzed information of the network on the map.
3. Grid display in conjunction with statistical indicators
4. Display of results analyzed through pedestrian network in advance.
   Ex) Displaying network analysis results starting from all households and moving for n-minutes.

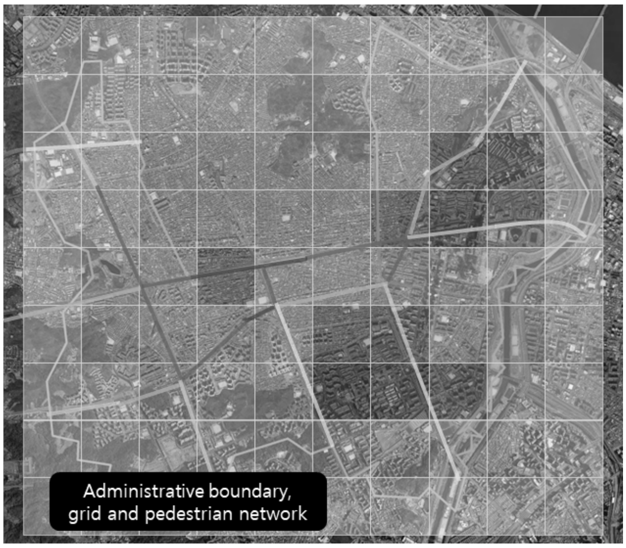


Figure 4. Diagnosis

4.3.2 Walkability According to Mobility Mode: Based on the base, the service area is set by analyzing the network-based accessibility using walking, bicycle, personal mobility (PM), and public transportation (town bus).

The main derivable functions are as follows.

1. Indicate the spatial information necessary for the analysis in relation to the means of transportation analysis or the complex (transfer) between mode.
   Example) Network and base information for each means of transportation.
2. The vacant places that are not covered by pedestrian accessibility are connected by public transportation such as village buses.
3. Expansion of the area if public transportation is selected as a combined mode.

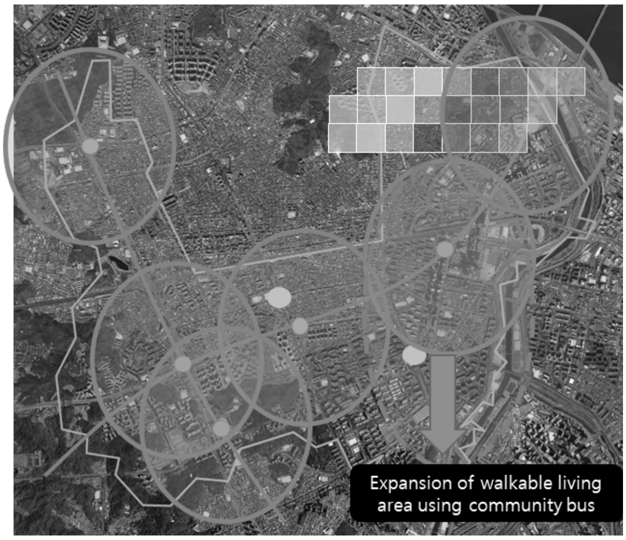


Figure 6. Walkability According to Mobility Mode

4.3.3 Walkability According to Gender/Age: Calculate the isoline showing the average walking speed and accessibility by gender and age group and display it on the map.

The main derivable functions are as follows.

1. Display walkability isoline by gender and age settings.
2. Select mobility and walking speed.

Figure 7. Walkability According to Gender/Age

4.3.4 Prioritizing Walkable Living Area: Based on accessibility analysis, the boundaries of the walkable living area are derived by selecting gender/age and mode of transportation centering on the base. In addition, the characteristics of each area are objectified through indicators and prioritized.

The main derivable functions are as

1. A jurisdiction may extend beyond adjacent administrative districts.
2. Areas can be overlapped.
3. The results of regional analysis and indicators are displayed, and priorities can be derived according to the overall score.

Figure 8. Prioritizing Walkable Living Area

4.4 Applying FOSS4G to Walkable Living Area

4.4.1 Exploring Python Library for the Module

Python libraries required in three stages of data management, diagnosis, and analysis were analyzed to develop a network-based pedestrian living area planning support module. OSMnx is effective in network analysis or urban facility location feasibility analysis for pedestrian analysis, but there is a limit to the use of OSM data in Korea due to a lack of data construction. Therefore, it was found that a library configuration is needed to analyze open data using NetworkX or Pandana libraries used in OSMnx.

Step	Application	Python
Data Management	Spatial data management	Geopandas
Diagnosis	Pedestrian Network Analysis	OSMnx
	Analyzing and Visualizing Network Structure	Pandana
		NetworkX
Analysis	Urban Mobility Analysis	AequilibraE
		MovingPandas
		scikit-mobility

Table 5. Python Libraries for Developing the Module

4.4.2 Pilot Analysis using OSMnx

For the analysis, the network density on the walking network was analyzed using OSMnx, Geopandas, and Pandana. The analysis was performed using OSM data from Yangcheon-gu, Seoul.

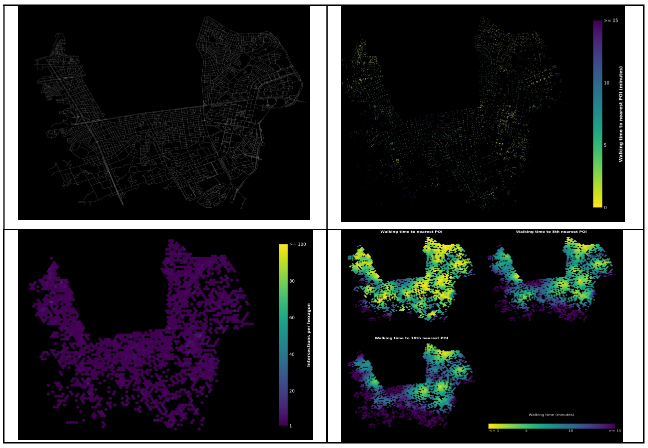


Figure 9. Pilot Analysis using OSMnx(Yangcheon-gu, Seoul)

4.4.2 Function and Architecture using FOSS4G

A module that analyzes pedestrian accessibility to urban amenities through network analysis based on a pedestrian network was developed as a Python library like OSMnx. In addition, there are many cases that have been analyzed and used using Pandana and NetworkX. In order to analyze the pedestrian living area in consideration of gender and age conducted in this study, it will be necessary to precisely manipulate the population cohort for the population class to analyze accessibility according to the situation.

Therefore, in research, an architecture is needed to benchmark OSMnx functions and build it using Python's network and spatial analysis library. In addition, it will be necessary to review the mixed use of R statistical packages to support various statistical analysis.

5. CONCLUSION

By developing a FOSS4G-based urban convenience distribution tool based on walkability measurement, the following benefits can be provided. First, it provides a data-driven approach to the deployment of urban amenities related to age and facilities so that convenience facilities are located in areas where citizens are easily accessible to citizens. Second, it presents a spatial structure that can promote the use of sustainable transportation such as walking, bicycles, and public transportation. Third, more inclusive urban development can be encouraged by ensuring that convenience facilities are distributed in a more equitable manner.

In conclusion, the development of FOSS4G-based urban convenience distribution tools can play an important role in realizing the concept of the pedestrian living area, a 15-minute urban concept in Korea. This tool can measure and distribute urban amenities based on walkability, bicycle accessibility, and public transportation accessibility, providing a healthier and more equitable way to create a living area. By implementing this tool, in the process of creating various alternatives, planners will be able to learn desirable alternatives to urban convenience facilities in the pedestrian living area through alternatives. And open-source tools for city planners and practitioners make it easy to run data-driven, and learn and innovate from the results of others' execution. By transparently checking the planning process, citizens can not only understand the planning process and facilitate cooperation with the plan, but also participate in part of their planning process.

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