A Network Analysis Of Plaza-Streets In Barcelona, Taking Into Account The HistoricalDevelopment Process And Pedestrian Activity Zones.

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Introduction

- In the old cities of Europe, we can see squares filled with a variety of activities. These squares were not developed in a planned manner but were the result of the spontaneous growth of cities in the Middle Ages.
- modern Japanese cities, there are many squares are deserted with no people to be seen.
- when planning **a plaza** → we do not have a method to properly evaluate the location. In most cases, the evaluation is made **qualitatively based on the proximity of the layout and the continuity of the space**.
- Focus point of study is " **pedestrian zone activity** "

Pedestrian behavior in a city consists of **1- the superposition of several areas of different sizes,**

2-purpose of the activity

- frequent errands as close as possible, but if they have a strong purpose, they go out of their way to travel farther.
- considering the "action zone" in the extraction of routes, find different **concentration points for each walking scale**

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Aims and purpose of study

- this study proposes a new index for evaluating locations that considers pedestrian activity zones and evaluates them from the perspective of network characteristics using spatial data.
- **validity of the index** is discussed by examining the relationship and consistency between the **results of the analysis** and the **historical formation** process of the city.
- This paper **aims** to **obtain suggestions for contemporary plaza planning** from a study of the medieval plaza in the Old Town of Barcelona.

Network modification in 19^{th} -20^{th}

represented by the construction of linear boulevards, contrasts with the latter, which is a type of conservation and rehabilitation

maintains the street form while creating squares, and the network characteristics of the medieval city can be relatively understood by comparing the changes caused by the two types of alterations

The network characteristics of medieval cities can be understood relatively by comparing the changes caused by the two types of alterations and the differences between the network characteristics of newly created streets and squares.

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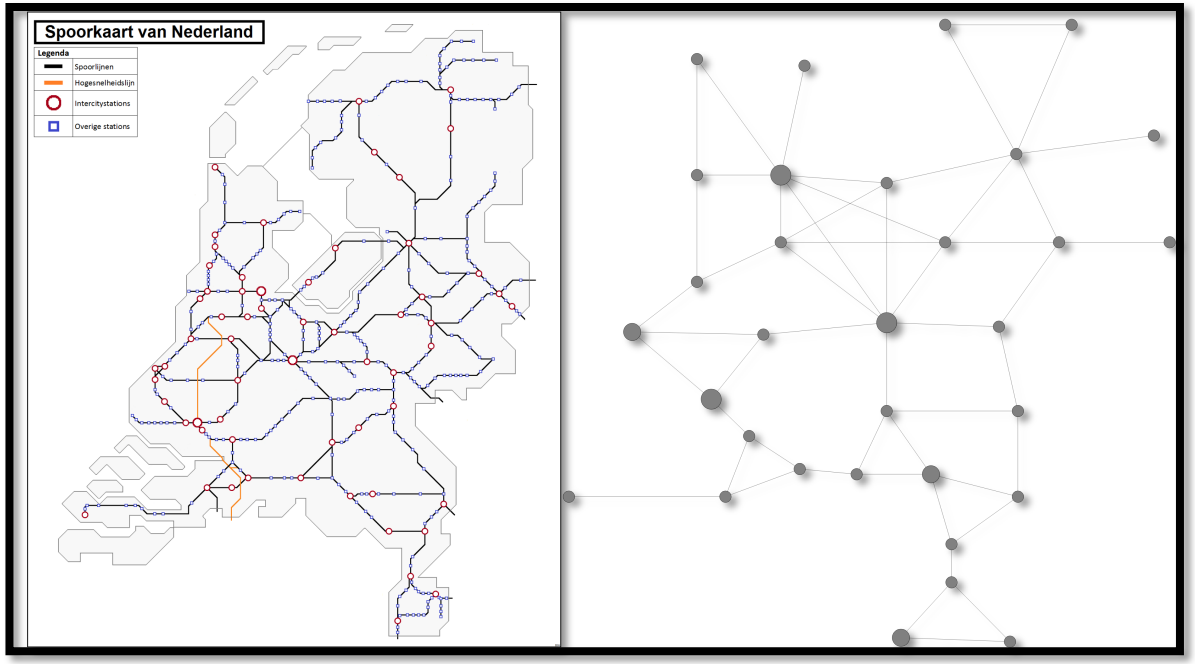
➢**Study envision** :

evaluation index that can be used **in small-scale** developments conducted by **single developers**, such as open spaces planned on building sites.

➢employ **network analysis** based on **graph theory** as a method for **"quantifying the degree of concentration of pedestrian"**



Source : https://www.networkpages.nl/graph-theory/

Graph theory has been theoretically established as a method for capturing the structure of relationships among components, and various indices representing network characteristics have been proposed.

Apply median centrality

1-that takes into account the action zone of pedestrians
2- consider understanding the characteristics of the distribution of places where walking routes tend to concentrate,
3-which is caused by the structural characteristics of street networks

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Comparison of analysis method using Network

Space syntax

Analysis geometric relationship between streets based on graph theory
Axial lines are nodes
Intersection are link
Adjacency is adopted as main index

Strength point

Index expresses the potential of place can be calculated only by geographical information

weakness point

Pedestrian path length not taken into account as a factor
Also, geometry of streets

Network analysis

Analysis geometric relationship between streets based on graph theory
Intersections are nodes
Streets are links
Adopted intermediary as an index

Strength point

Walking path is taken into account
Geographic data can be used as index to present potential of places

weakness point

Factors other than streets geometry are not considered

Routes selection model

Modeling individual behavior on street networks
Estimation of parameters based on running motion data

Strength point

Considered various factors that affects routes choice
Results represent actual behavior

Weakness point

Requires collection of large amounts of behavioral data

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the analysis based on the mediating centrality clearly revealed the *skeletal streets of the city*, but it was limited to understanding the overall structure of the city.

space syntax by Hillier et al

the target of evaluation is the topological relationship between street elements, and the physical length of the street is not considered.

Routes choice by Takegami and Tsukaguchi

focuses on human behavior in a space and derives model equations that express the relationship between various route choice factors and route choice probabilities based on observed behavioral data

Multi layered understanding

In this articles approach is applied as following box

consider that walking distance has a large influence on walking behavior, streets are links and intersections are nodes, and walking distance can be taken into account

Network analysis by Takamatsu et al

analyzed traffic accidents using space syntax and mediational indices6) and found that the relationship between accidents and these indices.

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Indicators used in this study

- New indicator → Mediating centrality → based on shortest path selection for each pedestrian zone
- It has been shown in previous studies that **route length is a major factor** in route selection, and in the case of activities with clearly defined destinations, which account for a large portion of travel activities.

Shortest path

⬇

the shortest route is often selected because the route is known and the possibility of selecting an efficient route is high.

⬇

The proposed metric is based on the betweenness centrality of the network analysis

betweenness centrality equation

$$C_b(k) = \sum_{i \neq j \neq k} \sum_{j \neq i \neq k} \frac{g_{ij}(k)}{g_{ij}}$$

Cb : degree to which a node is located on the shortest path

gij: is the number of shortest paths between nodes i and j

gij(k) is the number of shortest paths between nodes i and j

K : is a node that has potential to be passed as a shortest path

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Indicators used in this study

centrality of streets calculated by :

the edge betweenness centrality ***Ceb*** *is expressed as in Equation :*

mediational centrality of the links instead of the nodes.

node i on the network be the starting point

node j be the destination that can be reached in the shortest distance less than or equal to the distance

L set as the action zone

gij(l) be the number of shortest paths between i and j that pass-through link l

$$C_{eb}(l) = \sum_{i \neq j} \sum_{j \in V_i, j \neq i} \frac{g_{ij}(l)}{g_{ij}}$$

Where:

Vi : the set of nodes that can be reached within the shortest distance L from node i.

i and j : Two nodes from starting point to destination

l : is link between nodes

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the cases shown in Figure-2 and Figure-3 for a one-dimensional network of length L1

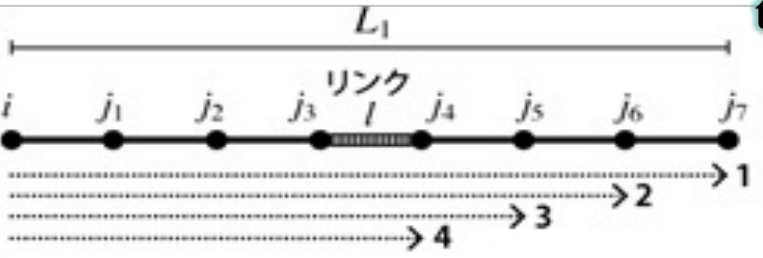


Figure-2 One-dimensional network

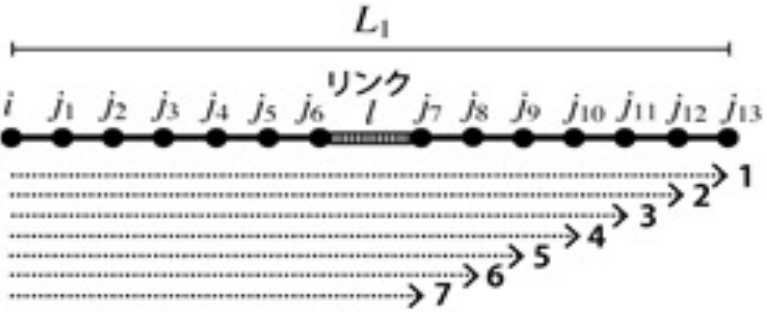


Figure-3 One-dimensional network (14

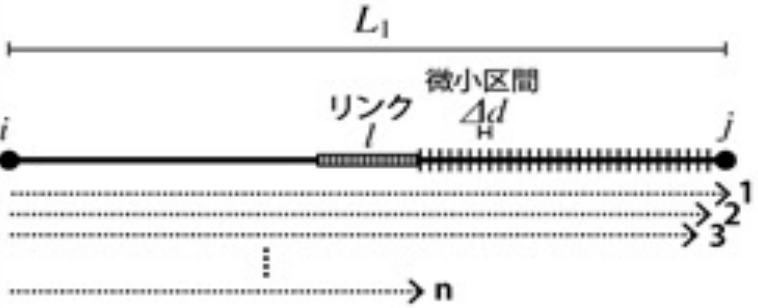
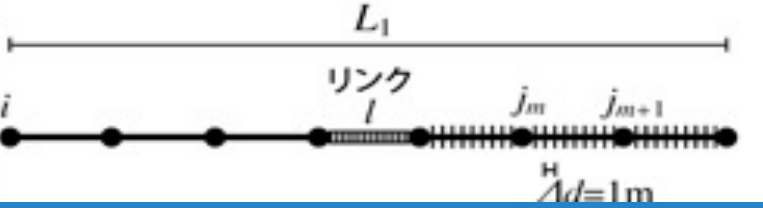


Figure-4 One-dimensional network (when



The **number of paths of length L1** or less that **start at node i** and pass through link l in this network is the number of paths that would be taken if one of the nodes on the right side of link l were selected.

In this study :
Streets are links
Intersections are nodes

In reality

the intersections are not the only points of origin and destination of movement

the mediator centrality is calculated by considering a small section of the network as a node

each micro-interval between nodes **jm *and* jm+1** isregarded as a node
the number of shortest pathsbetween **them and i**
the number of paths thatpass through **link l**

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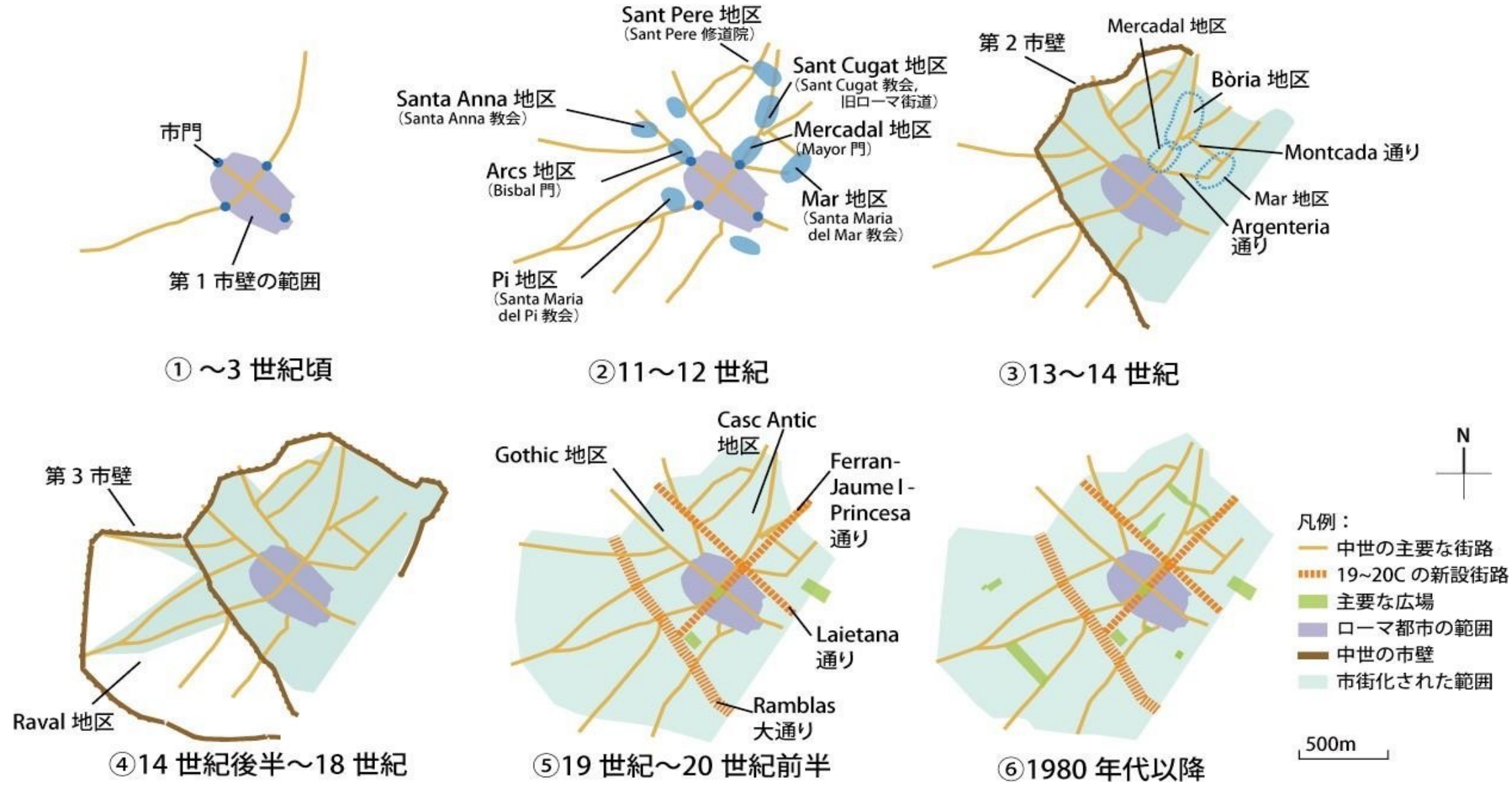
Barcelona’s historic Urban formation



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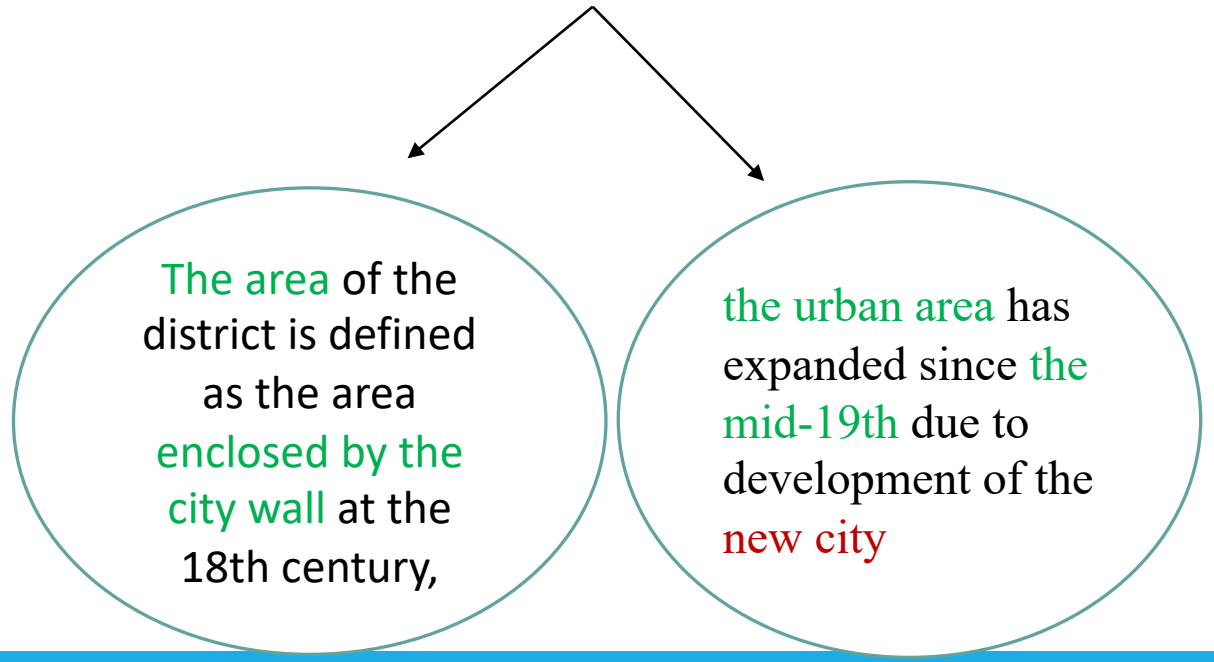
Period Segmentation and District Coverage for Analysis

the old city of Barcelona has been modified in two different ways

1) by urban planningmethods in the first half of the 19th century tothe first half of the 20th century

2) by porous plaza development in the 1980s and later. In order to understand the network characteristics of naturally occurring street forms and plaza locations



Result in

the social disparity has prevented the residents of the old city from expanding their sphere of activity through the boundary with the new city, and the **flow of people from the new city** is considered to have been limited to a few main streets such as Boulevard Ramblas and Avenue Laietana.

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Establishment of walking area

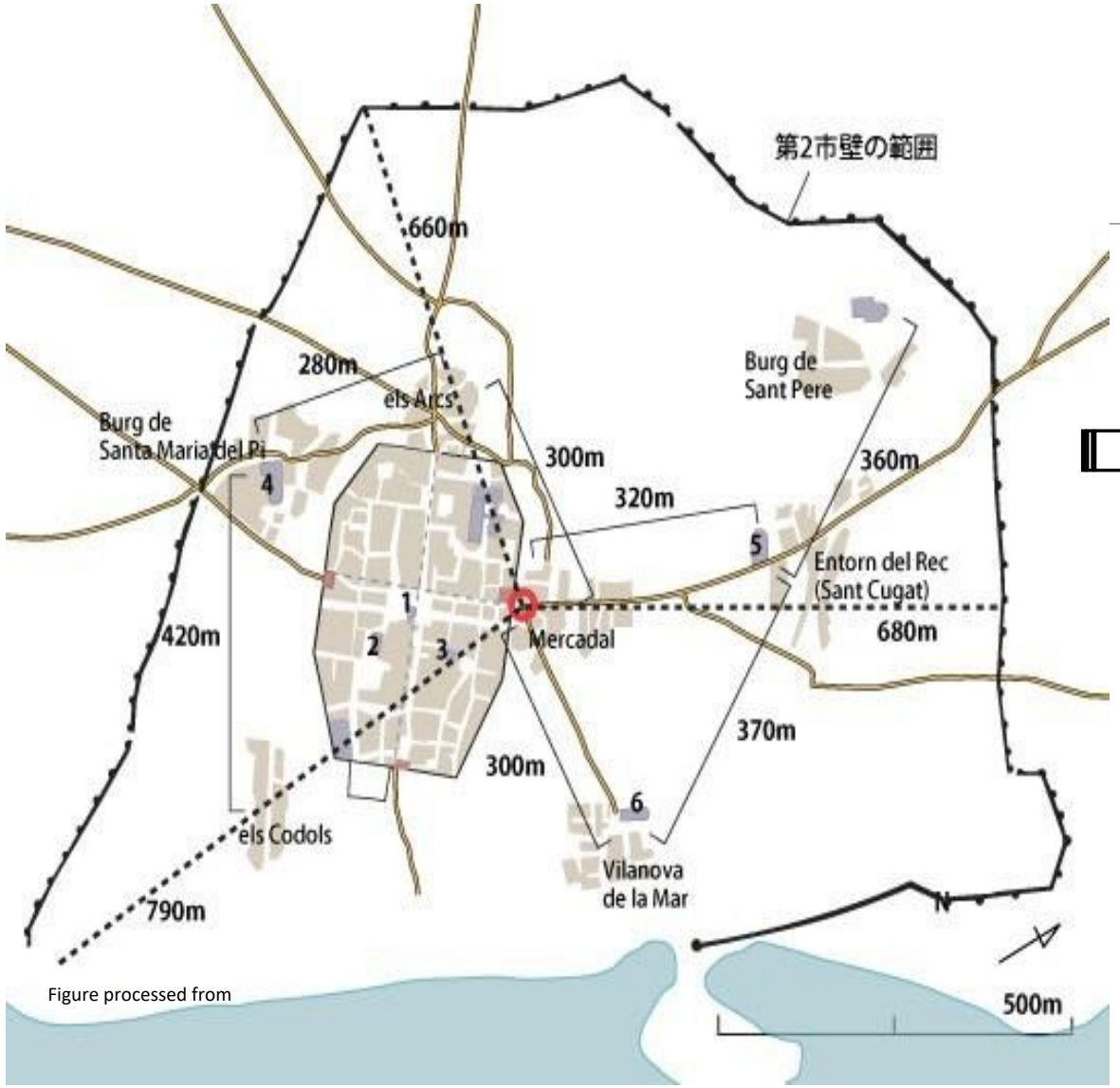

Figure processed from

As figure shown

1-the linear distance between the centers of adjacent new neighborhoods was approximately 300~400m.

2- road distance within a city is approximately 1.3 times the linear distance

3- the road distance between the centers of adjacent new districts to be approximately 400~500m

4- Assuming that the size of each neighborhood is about the same, the road distance from the neighborhood to the center of a neighborhood can be about 250m.

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Street network analysis

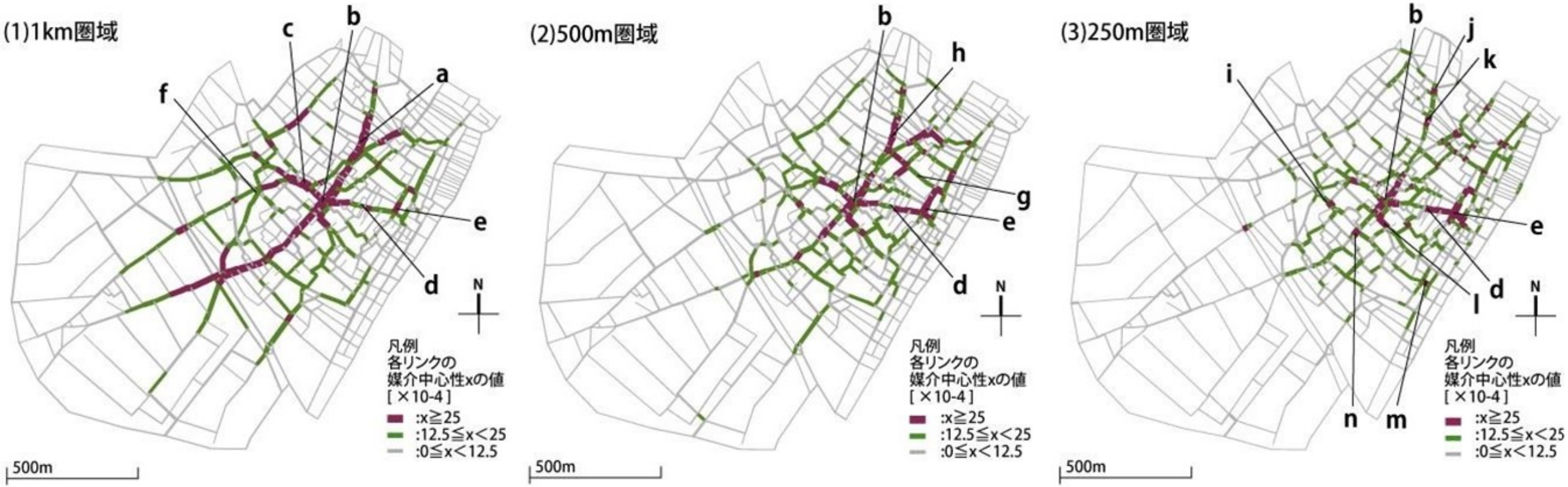

Figure-8 Results of mediation centrality analysis of the

Figure shows the results of the mediating centrality analysis of the G18 street network in the early 18th century for each walking area.

From **point b**, streets with **high mediating centrality** extend widely outward from this street.

Point b is the east gate (Mayor Gate) of the first city wall, where the market was located and flourished

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Street network analysis

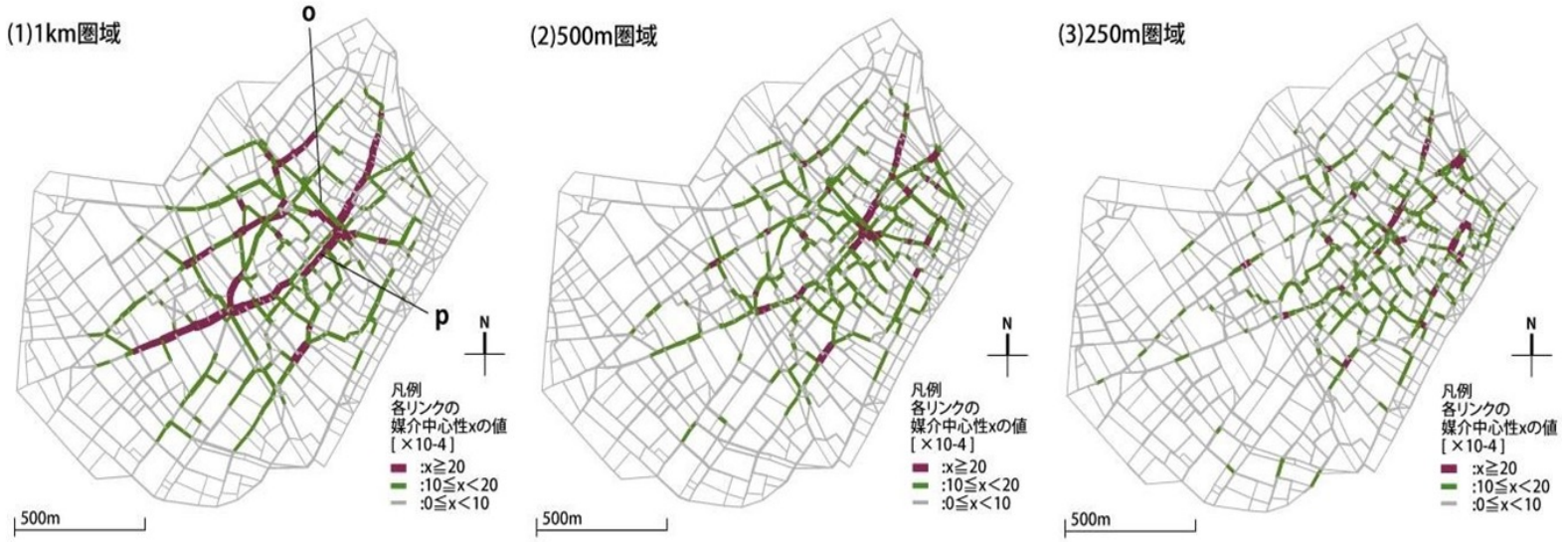

Figure-9: Results of the mediating centrality analysis of

the results of the analysis of the G20 network after the urban planning street modification in the 19th century and the first half of the 20th century

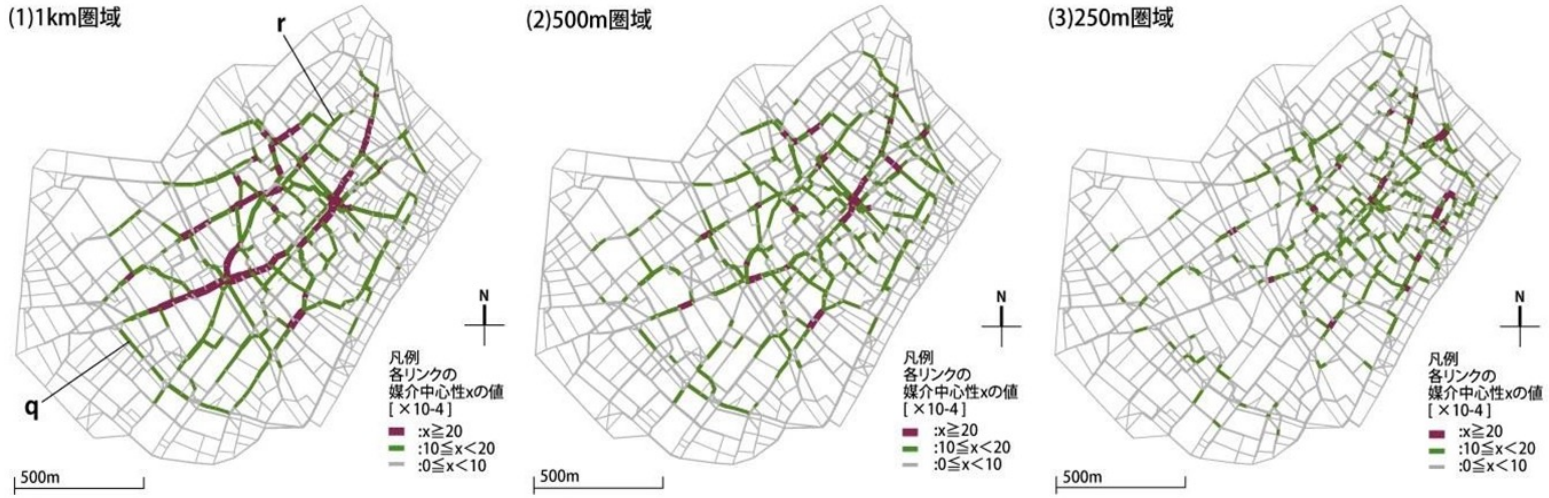

Figure-10 Results of mediation centrality analysis of the current street network (G21)

shows the results of the G21 network after the porous plaza modification in the 1980s and later

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Figure-13 Classification of each link by

図-14 各リンクの歩行圏域別分類（現在）

Based on Figure-13 and Figure-14, **each class linked by the area with the largest index value**, we can see that the Gothic and Casc Antic areas have changed since the early 18th century. In contrast, the Raval area has grown in size Become densely populated.

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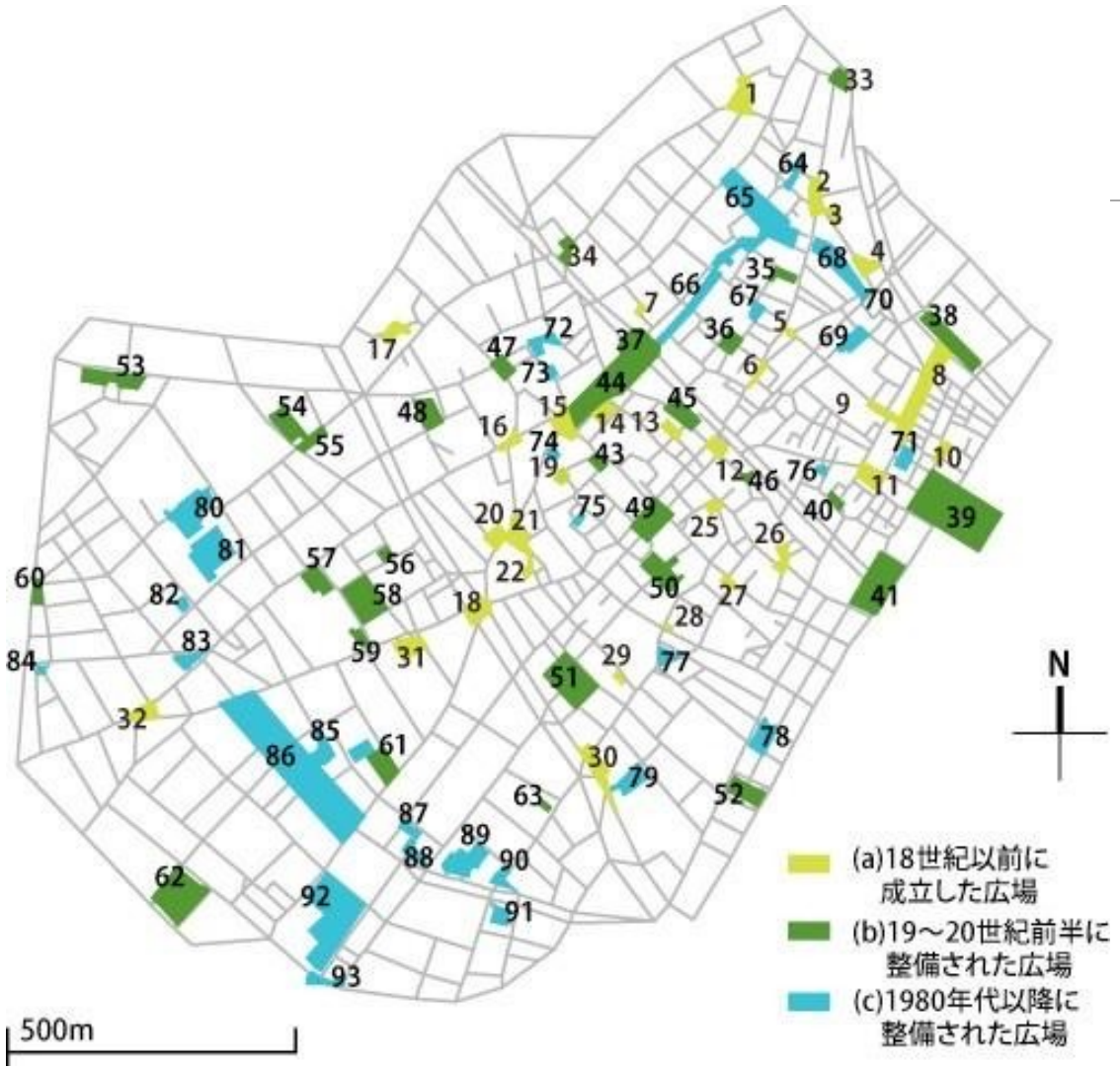
Street network analysis



The plazas scattered in the old city of Barcelona, whose names can be identified on current maps

The location characteristics of these squares are discussed in relation to the results of the street network analysis conducted in the previous section.

Classification of squares in Barcelona :
1- before 18th century
2- 19th to early 20th
3- since 1980s

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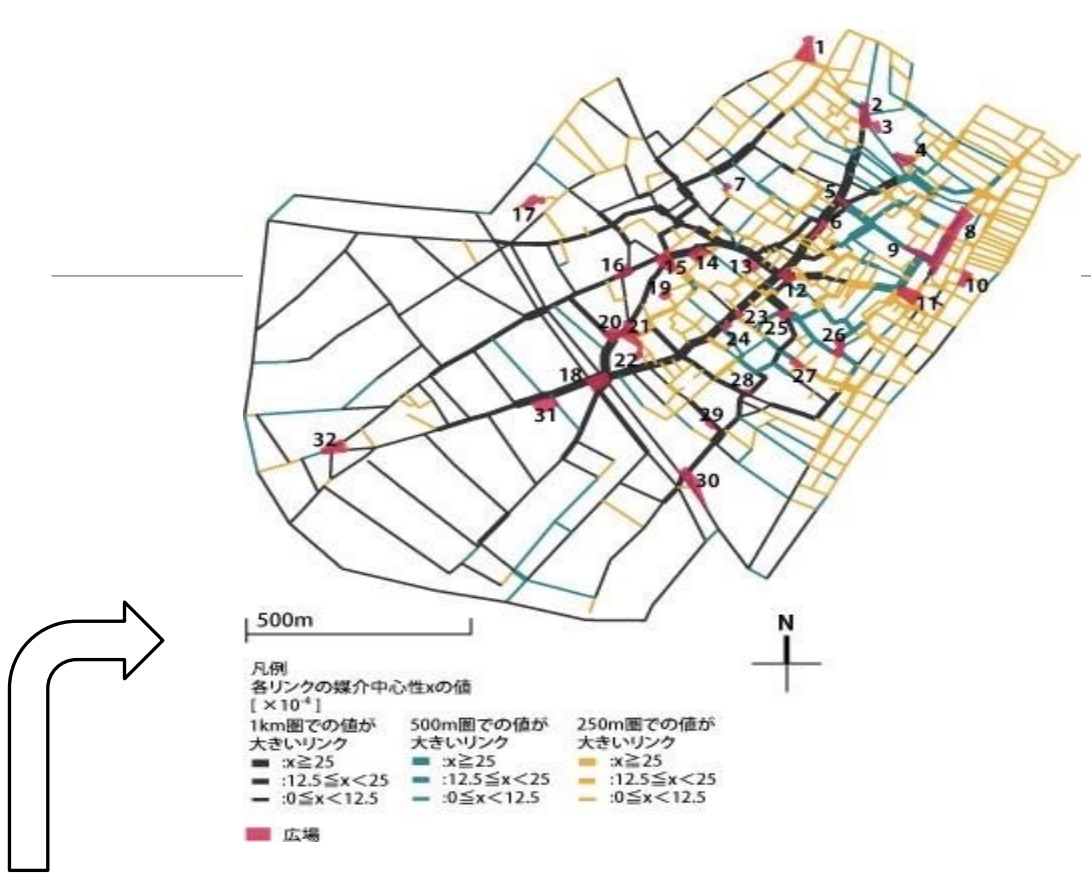
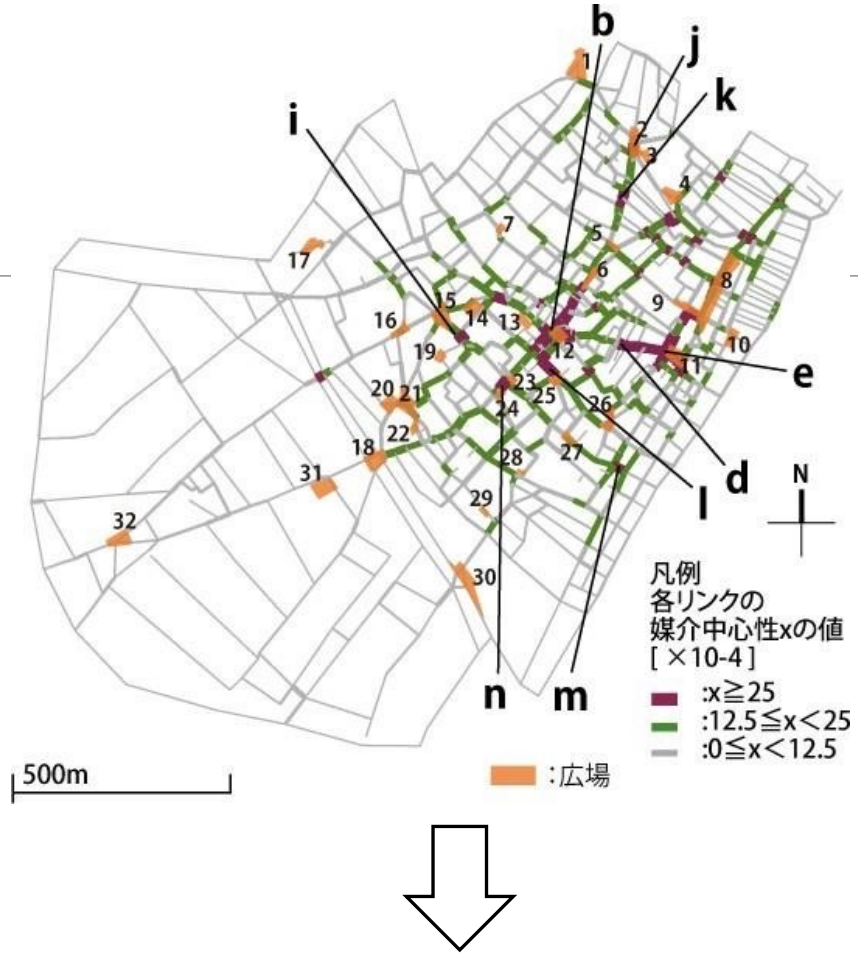
Street network analysis





the **mediating centrality** of the streets of the squares that are thought to have been established before the 18th century, classified according to the area of high centrality, overlaid with the location of the squares

therelationship between the mediating centrality ofthe square's 1km radius and the 250m and 500m radiuses.

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Summary

1. This article examined the streets in the Old Town that were established spontaneously before the 18th century by establishing three walking zones of 1 km, 500 m, and 250 m. The findings revealed a hierarchical structure of functional divisions: skeleton streets, streets connecting skeletal streets to neighborhoods, and streets connecting neighborhoods to each other.

2. In the street network described , squares were positioned at the nodes of important roadways with high mediating centers, such as between skeleton streets and at intersections between skeletal streets and streets going to nearby districts. These squares featured a considerable number of linked roadways and had hub features

3. Although squares established before the 18th century were located in areas with high mediating centers, many squares erected during the 1980s as part of urban redevelopment efforts are placed in areas with low mediating centers. This conclusion supports the goal of regeneration efforts to promote transparency by putting squares in stagnant regions towards the back of the city.

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Thanks for time and attention

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