

Opportunity to a Place: How Street Network Structure Affects the Acquisition of Riverfront Spaces at Minia City

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Abstract Urban form is defined as the physical characteristics that make built-up areas, including the shape, size, density, and configuration of settlements. Many researchers defined urban forms by the morphological attributes of urban areas at all scales, from localized to broader scales. Generally speaking, the street network is the most significant attribute in understanding urban morphology, as it affects and determines the urban form: shape, size, hierarchy, ...etc. The researchers assume that the street network structure, its connectivity, depth, and permeability, also, influence the opportunity of using the riverfront spaces "Urban Space Acquisition". This phenomenon usually leads to emerging changes in public space formation. This paper tries to understand the influence of street network characteristics on the formation of riverfront spaces by testing street network accessibility, permeability, and modes of mobility at the widest and/or longest riverfront space in Egypt, at Minia City. The research methodology depended on surveying the uses and activities over the riverfront space and understanding their relationship with the riverfront-spaces' depth, including links, nodes and access points. It reads the whole riverfront space as a series of spaces/segments, each of which has its own configuration of urban space acquisition. The preliminary street network analysis indicates that there is a considerable relationship between the mentioned factors, by which the city's urban morphology can be understood.

Keywords Riverfronts, Urban Space Acquisition, Urban Morphology, Street Network Structure, Minia City

1. Introduction

In cities' daily life, walking pedestrians explore cities and tactically deal, participate in, or create many physical activities over public spaces. One of these public spaces is the river-front spaces that are created for people's physical activities, especially pedestrians. Similarly, other types of river-fronts users try to gain the most benefits from such spaces, such as developers, street vendors, and municipalities. The purpose of each user is usually different and varied. For example, the developer tries to find an appropriate location/s for his proposed project/s. The street vendor, as well, tries to allocate himself/herself at a location where people can easily access and merchandise the offered goods. Conversely, the municipality tries to provide a good urban public space for city inhabitants and manages the relationships between the different stakeholders' needs. These processes create such a phenomenon in which users, simply, seek to acquire space to gain benefits.

Research significance

Rivers, as an urban component, link city dwellers to nature through landscape [1], and green urban corridors, especially rivers have great potential to act as a major component of the city's green infrastructure [2]. In Egypt, the new development process that occurred in 2015 has focused on the expansion of the road network and the development of public spaces in general. Some of these developments took place over riverfront spaces in many cities, such as Cairo, Bani-Suef, and Minia City, under the umbrella of the ambitious national project of (Mamsha Ahl Misr). The development process of the riverfront in these cities and many other cities focused on creating and improving public spaces by renewing materials, adding furniture, redesigning walkways, and bikeways, and allocating static commercial activities. On the other hand, street vending activities (as informal activities) dynamically have the ability to acquire some places of the riverfront, resulting in shaping, unexpected forms of urban space use especially in new renovated projects. Accordingly, the researchers expect that reading and analyzing the relationship between riverfront configuration and the abutted street structure would definitely help in more understanding of the mechanism of the urban system in such places. Recently, many researchers analyzed the relationship between characteristics of urban structures, and the uses possession of urban places [3] the researchers investigated the street vending distribution and street network at the small resolution of the street network of Chinese city districts by analyzing the integration of street network using space syntax, the study revealed that there is strong evidence of relation of vendors distribution with high integrated streets with high numbers of pedestrians. They used space syntax as a tool for street network analysis. However, our research is focusing on the distribution of vending activities on one main route from the network and examines this distribution in accordance with the street network structure in the depth of the riverfront route. Examining the relation between the nodes characteristics and the length of streets with the distribution of vendors and activities.

Furthermore, the urban waterfront has a significant relation to the city's street networks in general, street network structures are considered as the urban depth of the river as they can determine the forms of accessibility and hence resulted activity patterns of the front. Many Egyptian researchers studied riverfront, public spaces [4], and street structures [5] separately. Furthermore, there is a big gap in studying and understanding the relation of types of acquisition of vendors to riverfront spaces and street structure [6] [7] [5].

Research objectives

This paper describes the potential correlation between

street network characteristics and the concentration of physical activities along with the riverfront space by analyzing some of the street network characteristics such as accessibility, permeability, and depth. Through the followed methodology, the researchers expect to achieve some secondary objectives as follows:

- Mapping and determining the distribution of physical activities along with the riverfront space.
- Measuring the influence depth of the access points of all streets along with the selected space.
- Describe the phenomena of space acquisition in the selected case.

Riverfront space classification

Silva et al. understood the riverfront spaces according to their aesthetics and visual aspects [8]. In that book, they consider the quality of urban space and activities in the riverfront among the major aesthetic assessment values of riverfront. Another classification by Duran, et.al. [9] Proposed a classification of urban riverfront parks and walks through which they could read the riverfront spaces from many sides; space design, spatial characteristics, integration with the river, and use of the space. The study led to two major keys of classification of these spaces. One of these keys is physical accessibility from open space to the river [10]. This refers to the significance of studying both the riverfront and physical activities typology as major components of classifying riverfront spaces.

Street structure

With the dramatic expansions of urbanism and cities' relevant studies that explore economic, demographic, and social aspects of the urban environments [11], streets become the focus of many studies and research over the last decades. Streets have always been and still play a major role in a city's life [7], [12], not only as a connection for people and city sides, but also as a theater of dwellers' daily behavior and interactions. These interactions occur by letting people access public spaces through street networks [4]. This represents streets' lives as scenes of daily human social interactions that appear in walking, seating, shopping, entertaining, exploring the urban space, ...etc. Because of that, the street networks are complex urban components and cannot be easily studied or graphically represented. Streets, as a field of study, attract researchers from many disciplines; urban designers, landscape architects, sociologists, economists, geographers, and environmental psychologists. Also, studies on streets vary from physical street network characteristics, such as; connectivity, typology, grading, ...etc., to the social and psychological influence of the street environment on humans, such as; perception, and visual studies.

Accordingly, the mathematical calculations and the

appropriate graphic representation method is a key to getting the correct result [5], [13]. S. Marshall [14] mentioned various methods of street network representations of network modelling which are normally embedded in a specific phenomenon, the researchers used the simple network analysis tool analysing the street structure.

As the researchers try reading the street structure of the case study and highlight potential correlations with the physical activities at the riverfront space, the selected case includes two types of street forms according to Trancik [15]. He classified streets into hard spaces and soft spaces. The hard space is the one that is bounded by walls, and the soft space is usually integrated with nature. In the selected case, the study deals with the two types; the city street network (as hard spaces), and the waterfront walkway/corridor (as soft space)

Although many studies have used Space Syntax analysis of the urban form, the researchers relied on the analysis using the simple network analysis in order to understand the role of the street network structure, especially the one that expresses the urban depth of a main backbone of the city, as in our case; the waterfront space of Minia City. Accordingly, the streets were shortened to a network of links and nodes.

2.1. Case Study

Along the 900 kilometers between Aswan and Cairo lies a series of settlements located in the Nile Valley. Where 21000 inhabitants per square kilometer in this region are residing in those settlements [16], reaching a level of population density similar to the most densely populated urban areas in the world. One of those significant cities is Minia City.

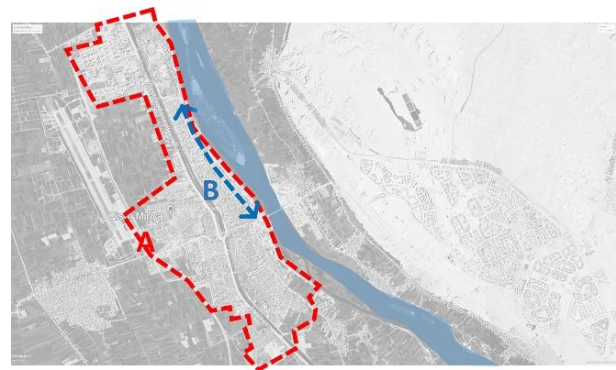
Minia is one of the medium-sized cities in Egypt. It is the capital of El-Minia Governorate whose urban fabric has a linear shape parallel to the River. The origin of the city urban zone has been, and still, expanding in parallel to the river line creating and stretching one of the widest public spaces on the River Nile in Egypt. The existing riverfront space length exceeds 6.0 km with average width ranging from 26 m to 75 m approximately.

Minia City represents an agglomeration of several contrasting urban tissues. Each has possessed unique physical and environmental characteristics, governed by its location on the river and the chronological development that enforced producing it. Accordingly, the city became highly distinct by the heterogeneity of its urban form and the nature of its resulting public space pattern. This resulting pattern is multi-layered assimilation of several political, social, and economical influences [6].

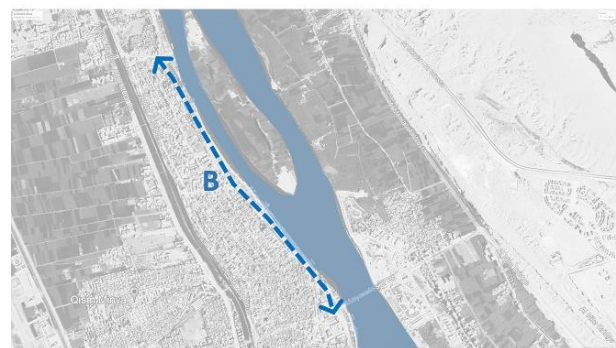
4. Research Methodology

The survey area:

The research selected a distinct area from the city riverfront to study the land uses and the physical activities. The researchers believed that the significance of the research area came from the recent regeneration project of the riverfront located from *Al-Ikhsas* District at the north side, starting from *Grand Aton Hotel* to *Minia Civil Forces Campus* in *Al-Habashy* District, at the south. The survey area is naturally bordered by the Nile River bank at the east side, and extended to *Al-Ibrahimeya Canal* at the west side, crossing the whole city from east to west by many crossing streets. (figure 1). shows the survey area boundary.



(A)



(B)

Figure 1. the location of the study area **B** in relation to the city boundary **A** (1) the study area **B** (2)

Survey timing and procedures

During four months (from October to January) in 2021 and 2022, the researchers targeted the working-days of the week (Sunday to Thursday) and conducted the survey five times in the evening time (varies from 18:00 to 21:00). The temperature ranged from 14 to 22 degrees and the wind speed ranged from 8 to 11 km/h.

The residents usually walk to enjoy/use the riverfront spaces for many purposes; necessary, optional, and social purposes. So, moderate people capacity and various physical activities are highly expected to be found.

Physical activities over the river-front

During the survey days/times, many activities were found over the targeted space, such as; sports exercise, vending, drawings, contemplation, family gathering, eating, and teenagers hanging-out. The researchers focused on the constant occurring commercial activities and found the following list:

Coffee trucks	Sweet potatoes vendors
Walking beverage vendors	Fishing
Street photographers	Sailing
Toys/Balloons vendors	Boat renting
Shami Hummus “Halabessa” vendors	Fruit/Vegetables trucks
Car cleaning service	

Activities have been observed constantly at the same location/s during the survey time. The study area has 3 kilometers length with varied types of water front uses from public such as (*Salon Garden* and *most of The Corniche Park*), semi-public such as (*Mermaid Floating Cafe*), semi-private to private land uses such as (*Police Officers’ Club* and *University Staff’s Club*), each of these uses has its own area cut from the riverfront space.

Research methodology:

The research is attempting to describe the phenomena of land uses and activities acquisition in public spaces at the waterfront in accordance to urban depth.

The research methodology is mainly divided into two stages, **the first stage** is the case study description and analysis, the research attempted to describe and analyze the two spectra (land use and physical activities) and the other is the structure of urban depth of the riverfront **the second stage** is finding the potential correlation between physical activities and urban depth (figure 2).

The first stage

This stage has two domains: The first domain has two attributes (land uses and physical activity), reading land uses at the riverfront and classifying these uses according to their degree of publicness (public uses, semi-public uses, semi-private uses, and private uses) alongside the riverfront is the first, the second attribute is classifying activity sittings wither were commercial and non-commercial.

Variables of the first spectrum are identified through a large set literature, such as **concentration degree** of activities, which can represent the degree of acquisition in river front public spaces, which in turn gives a likeness of the integration with urban depth. (Figure 3 B).

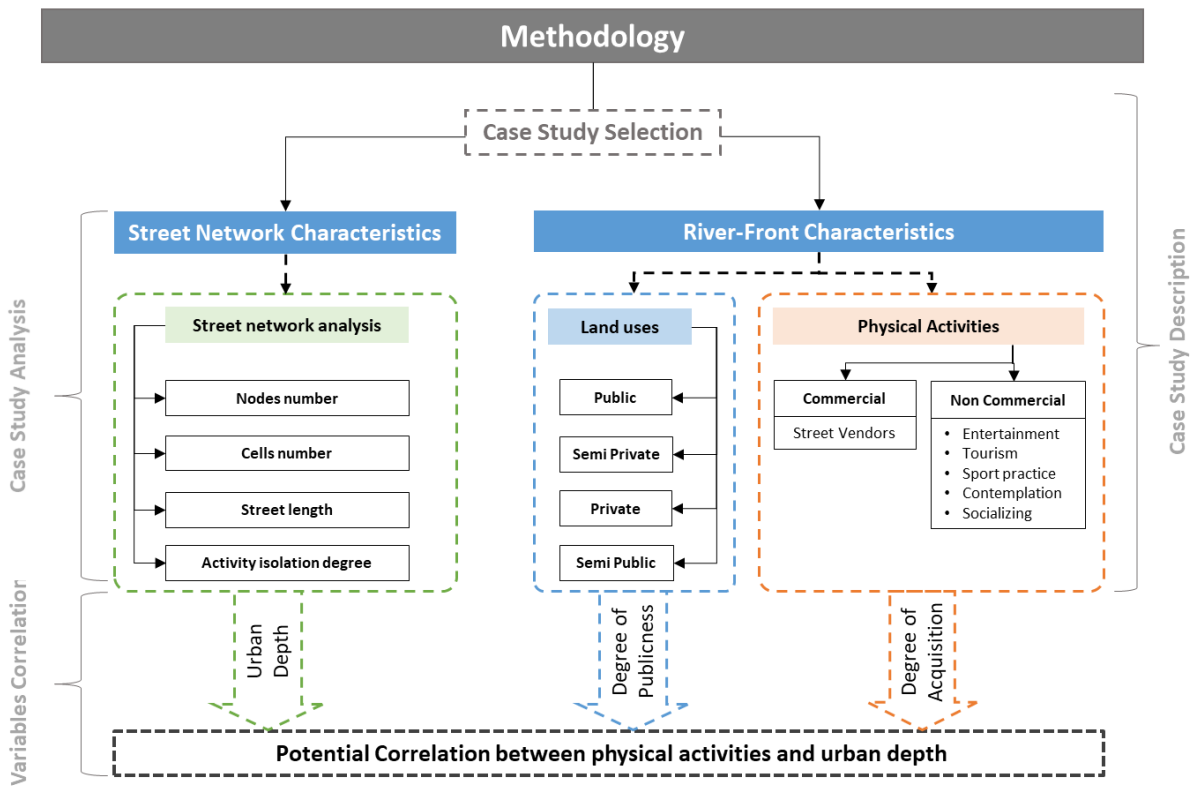


Figure 2. research methodology

The second Domain describes the urban depth structure of the riverfront, the attributes of street network structure such as the number of intersections, length of streets, and the block size can mainly describe the permeability of the urban layout, which in turn can describe the accessibility and the connectivity of the riverfront to its depth.

Reading urban layout of the urban depth is through simplifying urban street network to simple network which will be used in this research (figure3 A)

The second stage

The second stage will test the potential correlation between physical activities and its relation to riverfront urban depth that will require reading the characteristics of street network variables with the distribution of physical activities and land uses, the research expects that the

characteristics of street structure of urban depth have influence on physical activity concentration and acquisition.

Data collection and site survey

The data gathered through the site survey for the 3000 m of River front length, physical activity distribution have been surveyed in week days and plotted on a recent open street map using ArcGIS program, land uses are plotted on the map and classified into public semipublic, private and semi-private.

Street networks have been generated through the recent open street map using ArcGIS program simplified into links and nodes, the data from surveys have been plotted on the street network map (figure3A)

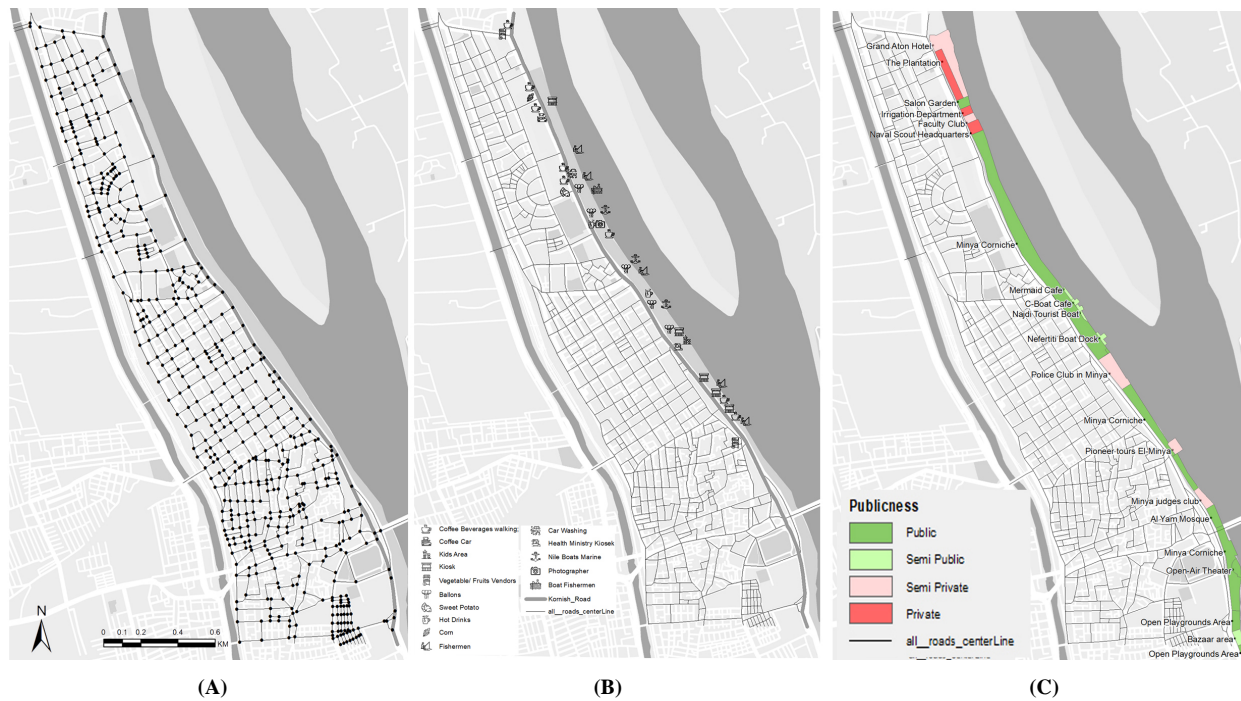


Figure 3. Case Study variables (A: Street network's links and nodes, B: Activities concentration, and C: Degree of Publicness)

Measurements

Sanctuary zone area (m²) “SA”: calculated as the total area of the polygon that is drawn by connecting the ends of 400 m walking distances from the access point into the branched street network.

Street length (m) “SL”: calculated as the sum number of all street lengths at each sanctuary zone.

Nodes number “NN”: calculated by counting the number of cells at each sanctuary zone.

Cell number “CN”: calculated by counting the number of complete cells at each sanctuary zone.

Street ratio “SR”: calculated by dividing the total street lengths by the area of the sanctuary zone, as shown in the following formula:

$$SR = \frac{\sum SL}{SA}$$

Node ratio “NR”: calculated by counting the total number of nodes at each sanctuary zone, as shown in the following formula:

$$NR = \frac{\sum NN}{SA}$$

Cell ratio “CR”: calculated by dividing the total number of cells on the total street length at each sanctuary zone, as shown in the following formula:

$$CR = \frac{\sum CN}{SA}$$

Activity isolation degree “AID”: calculated by measuring the distance between the access point “AP” and the nearest node in the urban depth “UD”. The long distance indicates a higher degree of isolation of activities, as shown in the following formula:

$$AID = \sqrt{(X_{AP} - X_{UD})^2 + (Y_{AP} - Y_{UD})^2}$$

Concentration of access points “CAP”: calculated by measuring the average distance between a certain access point and the previous and next access points, as shown in the formula below.

$$CAP = \frac{\text{Distance to previous point} + \text{Distance to next point}}{2}$$

Mapping and analysis

The main goal of this stage is to read the distribution of activities in accordance with land uses of riverfront and the structure of streets, the quantified variables of street network structure such as node numbers and street link lengths and cell number can represent, to some extent, the permeability of urban layout and the integration of the urban depth to river front.

By measuring the 400 m distance (commonly known as 5 min. walking distance) from riverfront axial line we can draw the **sanctuary area** of the river front, which means that every point in this region is more likely to be integrated and to be easily accessed to the riverfront space and benefit from activities. (Figure 4)

Another perspective of generating the sanctuary area, which is the 400 m access region generated around every node on the riverfront space line (mainly the research call it access point to the river front), by reading the numbers of nodes of these regions and the total length of streets, it can represent the role of every node (access point) in linking the river front to its depth and consequently the influence on the distribution of activities can be expected.

Through these notions, the characteristics of street network around the nodes such as total street lengths, total node numbers and total number of cells (urban blocks) can be compared with the distribution of activities to give a likeliness of the activity distribution trends and patterns.

This will help in identifying the potential influence of urban structure characteristics on activity distribution and river front acquisition.

Another variable measured is the degree of isolation for the access point on Corniche line, which is the distance between the nodes on the river front and the second node in the urban depth that can depict the degree of connectedness of the urban depth, these variables are gathered and recorded in XLS sheet.

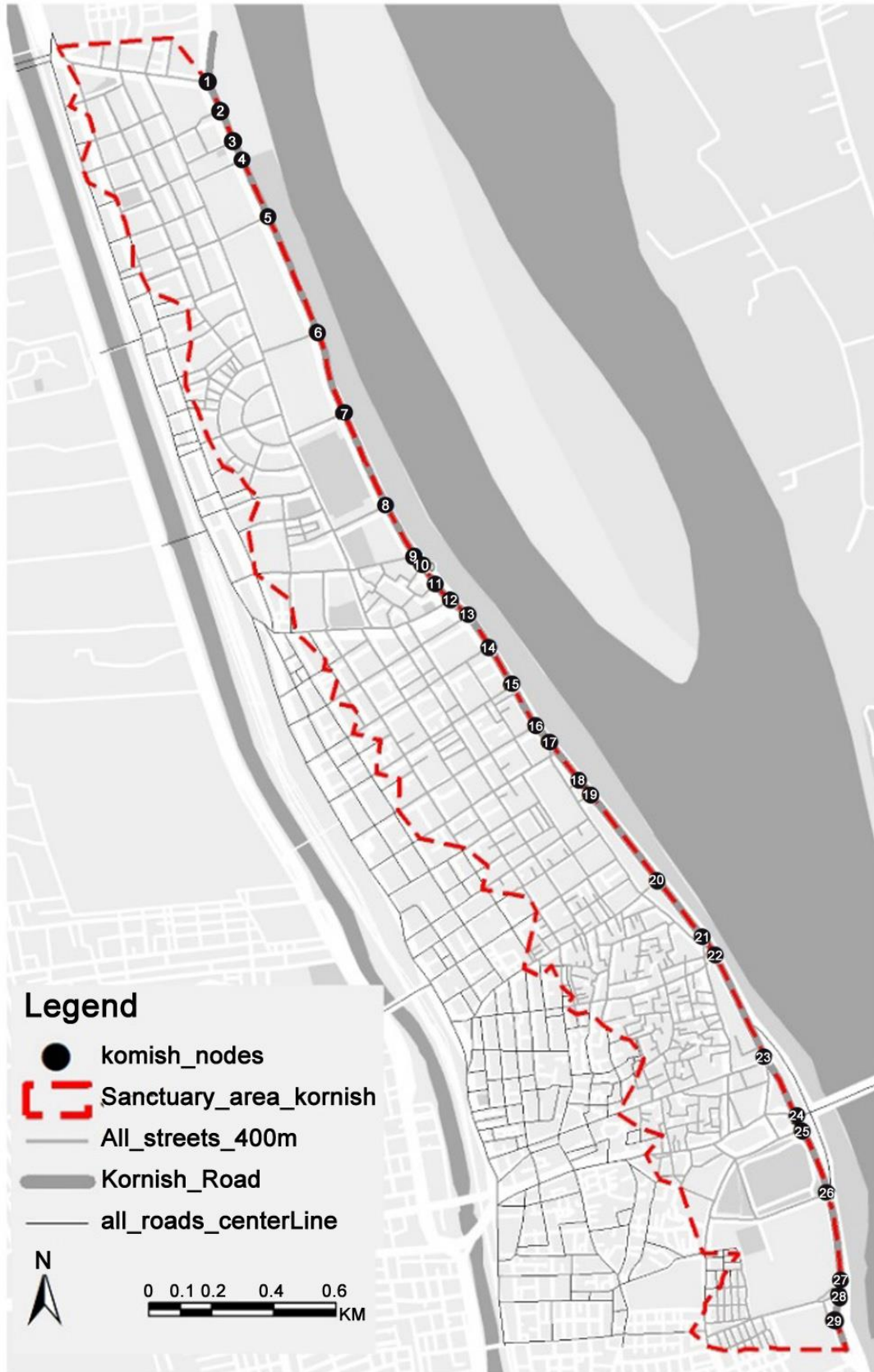


Figure 4. The sanctuary area

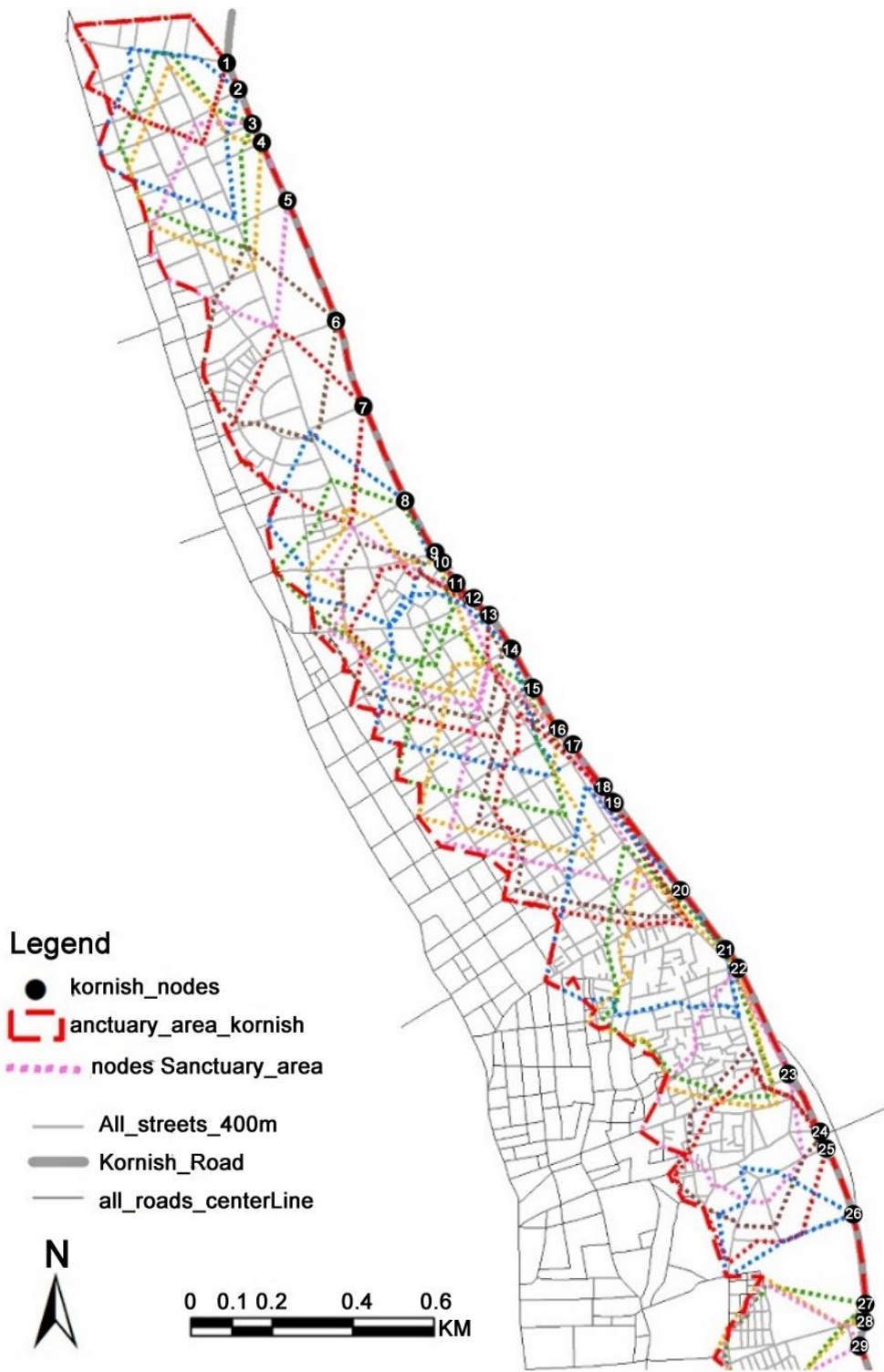


Figure 5. Sanctuary areas of nodes

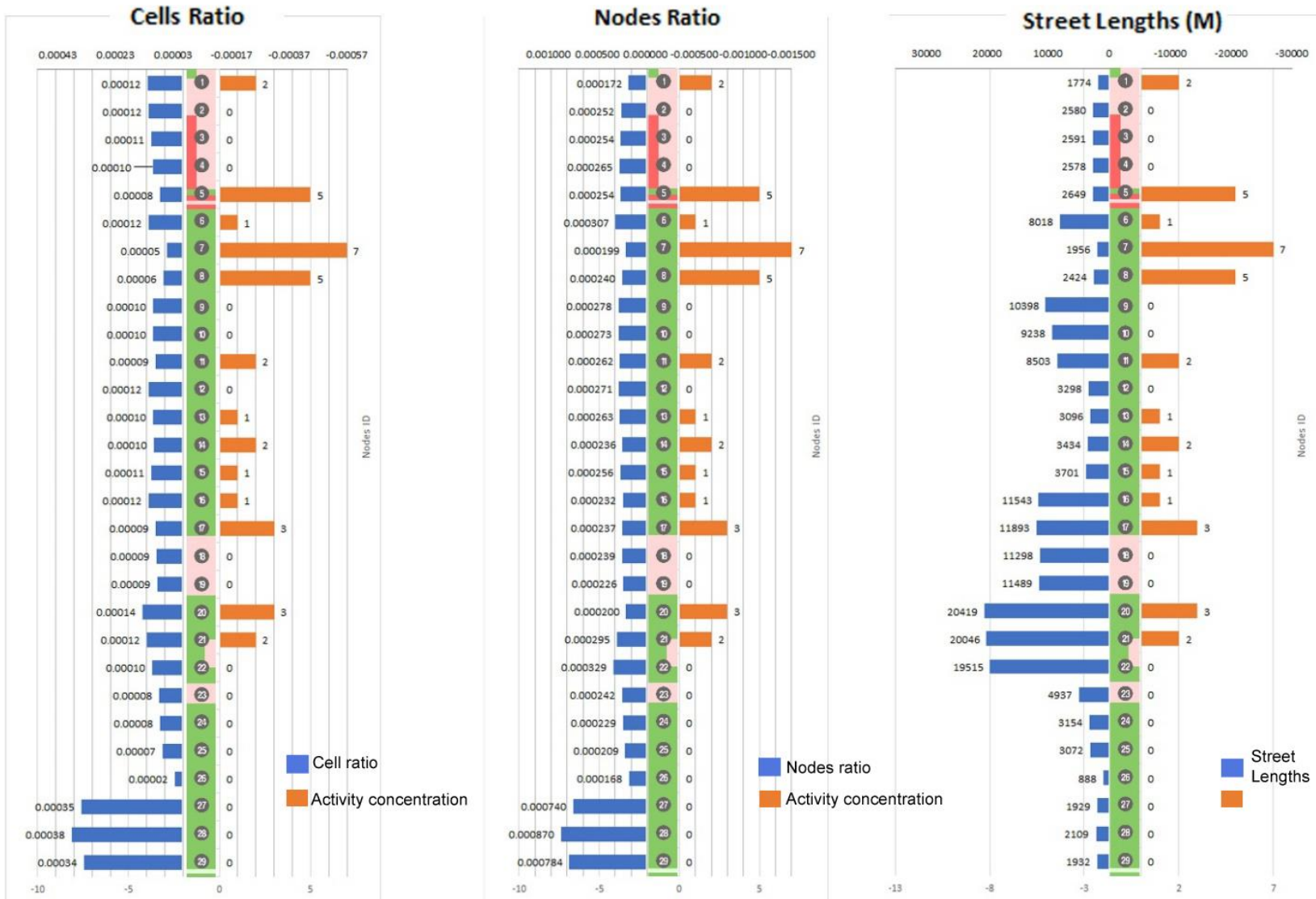


Figure 6. Relationship urban depth structure (cells ratio, Nodes ratio and street lengths) with activities distribution

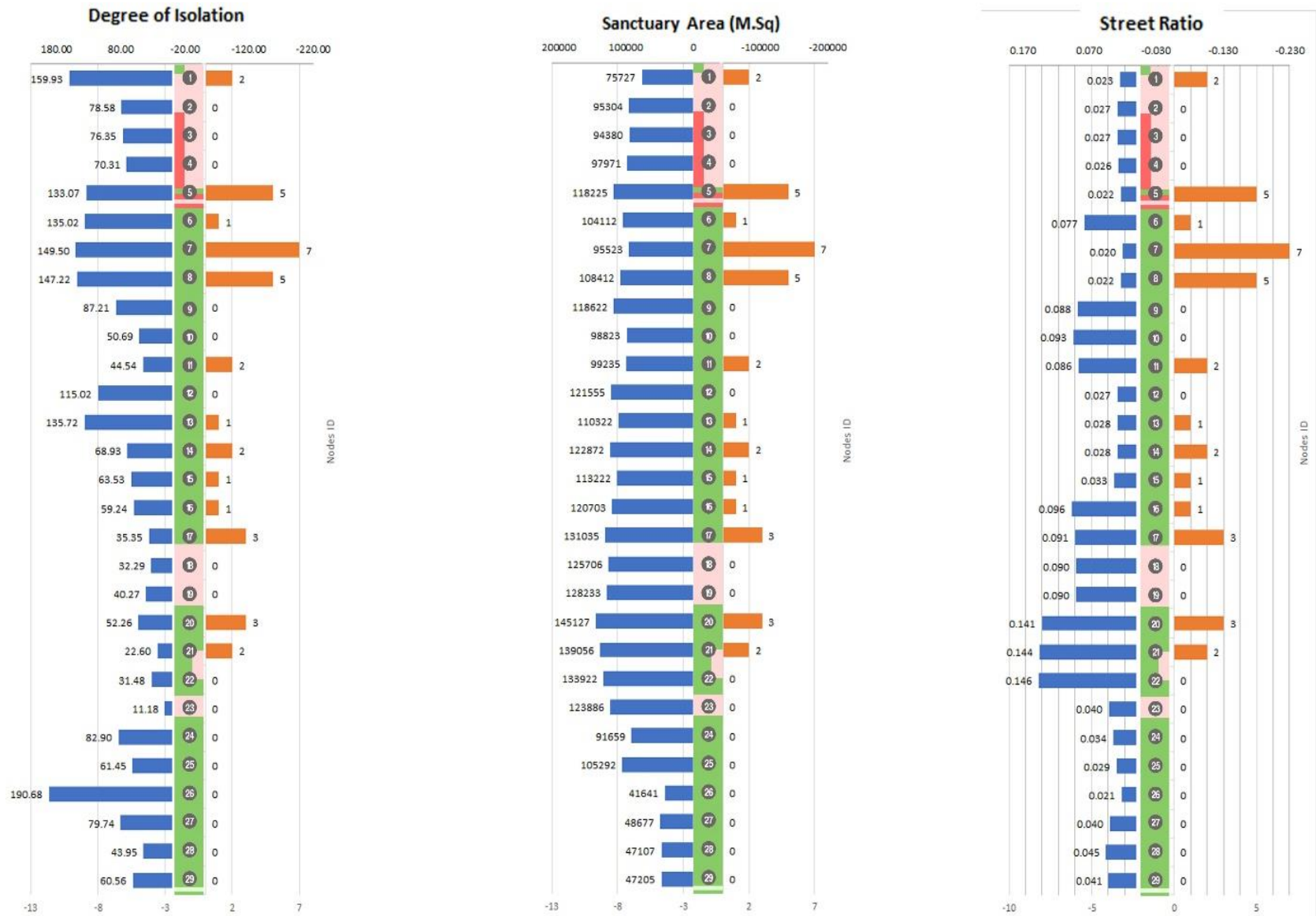


Figure 7. Degree of isolation, sanctuary area and Street ratio

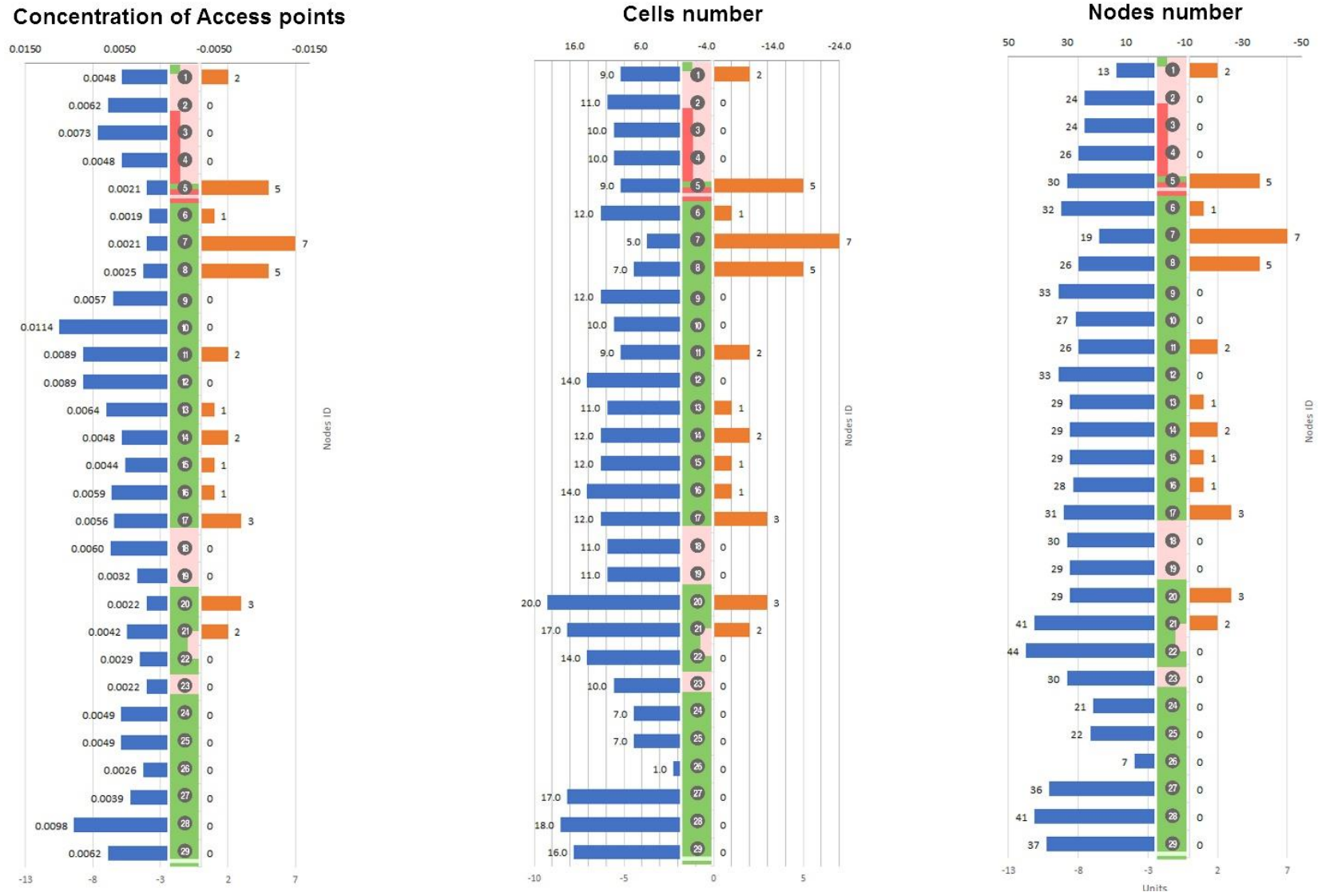


Figure 8. Concentration of access points, Cells ratio and Nodes numbers

5. Results

The research resulted in the reading of the urban street structure and its relation to the concentration of physical activities along with the riverfront. The results are shown in a typical diagram that shows the 29 access points in the middle with background colors show the degree of river-front spaces' publicness. The right bar chart with orange shows the number of concentrated activities as surveyed in nearby each access point. The left blue bar chart shows the variable attribute with its values, as explained in the previous section. The main features of reading the case study can be concluded in three major relations as shown and explained in the following points:

5.1. Non-related Attributes

Some attributes were shown in diagrams with no emerged relations that can indicate the potential relationship with the concentration of physical activities. As shown in Figure 6, the relationship between the physical activities and Node Ratio, Cell Ratio, and Street Ratio recorded no relationship. This may indicate the fine-grained structure of the street network abutted to the riverfront space.

5.2. Respectively Related Attributes

The only relationship with respective correlation with physical activities was recorded with the **degree of isolation**. It can be assumed that the isolation of the street network away (in distance) of the waterfront causes a sort of activity compensation over the riverfront space, especially that these zones have been observed without commercial river facades. Figure 7 shows this relation.

5.3. Conversely Related Attributes

Most of the attributes recorded converse relationship with the concentration of physical activities. These relations can be explained as follows:

- Street lengths, Cell Numbers, and Node Numbers are conversely related to the concentration of physical activities as they refer to the actual depth of the street network, which was determined by the walking distance of 5 min or 400 m, shown in (Figure 4 and 5). Which means that vendors and space acquisition phenomena are highly expected to be occurred at the zones where people walk less distances. Meanwhile the acquired space at these zones are more accessible.
- The Sanctuary Area also recorded the converse relationship as it refers to the influence depth of the street network. This is expected to appear because of the same reason; space accessibility. (Figure 6) shows this relationship chart.

- The Concentration of Access Points is an additional attribute that recorded the same relationship, which was confirmed on the previous results. It strongly refers to the influence of accessibility on space acquisition over riverfront spaces, as shown in Figure 8.

6. Discussion

The research results helped to understand the riverfront and its relationship to the characteristics of street network structure, which were affected by the size of the urban blocks, the lengths, and densities of the streets, and the number of nodes and intersections.

This is expected to affect the planning of the urban environment of riverfronts through several levels:

The first level is the development plans, the results indicate that the characteristics of the street network structure surrounding the riverfronts should be studied to determine the urban depth and accordingly the expected patterns of activities, their locations, and the degree of their concentration and acquisition.

The second level is the management of the built environment, the results also indicate the importance of the study in developing the features of urban management on the riverfronts, which will affect

- a) The distribution of uses and activities on riverfronts
- b) The degree of publicness for activities and uses, and therefore determining the economic values of the river spaces as well as the economic values of the plots on the riverfront
- c) Defining the features of the transit network, including defining transit routes and transit stops

The third level is Understanding the mechanisms of the informal activities on the riverfront, where the understanding of the phenomenon of concentration and acquisition of activities in spaces and its relationship to the structure of the street network helps in organizing these phenomena and taking into account development plans by acquiring restrictions and regulations with detailed plans of the riverfronts.

In general, the authors see that the street vendors, as one of the main users who acquire urban space, can readably observe and predict people movement and behavioral needs in public spaces. They can also prioritize the access points and urban nodes to allocate their settings over attractive and reasonably valuable spaces. However, the authors assume that these phenomena occur subconsciously based on the vendors' experience over public spaces.

It should be declared that in the selected case the urban fabric was originally planned without considering the studied variables, and, seemingly, the planner had no expectations of how the futuristic phenomena of space acquisition might happen. This may put two significant questions on the table, such as:

- (1) What is the actual role of the informal vending activities over public spaces in development process and decisions?
- (2) How can we understand the dynamics of urban space acquisition phenomena?

On the other hand, the researchers see that the simple network analysis can be used in the selected case study, and similar cases as well, in order to understand human behavioral phenomena, such as: informal street vending, outdoor physical activities, ...etc.

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